For Thursday dated papers, October 11, 1945, others thereafter:

ATOMIC SCIENTISTS OPPOSE HASTY LEGISLATION ON ATOMIC BOMBS

The Atomic Scientists of Chicago, an organization whose membership includes more than 90% of the scientists who are at present working on the atomic energy project at the University of Chicago, view with concern the possibility of hasty legislation concerning the control of future work in the field of atomic energy. We believe that before any hearings are held on any specific bills, members of Congress ought first to have ample opportunity to acquaint themselves with all the relevant facts and considerations. An opportunity to explore all aspects of the problem could be provided by the setting up of a non-partisan committee for this purpose. Such a committee could be set up by the Senate, by the House, or possibly jointly by both Houses.

The War Department, by releasing the Smyth Report, has made available a wealth of technical data on methods for making atomic bombs. On the other hand, information is not generally available which is needed to enable the citizens to think intelligently about the situation which now confronts the United States. Up to now the scientists who are able to furnish this information have not felt free to do so. Hearings held both in open and executive session before some newly set up committee in the Senate or in the House would afford an opportunity to make available the pertinent information to members of Congress.

These views appear to be shared by the Association of Oak Ridge Scientists, representing 90% of the scientists who worked on the atomic bomb at Clinton Laboratories. The text of a telegram which their executive committee sent yesterday to Senator Barkley says that they "recognize the urgent pressure for discussing bills relating to atomic energy. However, it is believed that no hearings should be held on any such bill until there has been ample opportunity to discuss all aspects of the problem before a bipartisan committee which may be set up for this purpose by Congress."

The development and use of the atomic bomb has created a situation filled with uncertainty for our nation and the world. Only a full understanding of the new situation will enable the members of Congress and the citizens of this country to solve intelligently the problems which now face us. If a wrong course is taken it could mean the destruction of our cities, death for millions of our people, and the possible end of our nation. We doubt that our country can steer a steady course in this situation unless Congress and the citizens of this country take time to familiarize themselves with all the facts and considerations that are involved.

~~Pending a thorough examination by Congress of all aspects of the atomic energy problem, Congress could provide for continuity of the work by authorizing the Manhattan Project to carry on its current activities until, for instance, June 30th of next year.~~

For the Executive Committee,
H. H. Goldsmith, Secretary

Please do not use my name.

Dr 3365

Jacobi

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[redacted]

For the Executive Committee,
H. H. Goldsmith, Secretary

Please do not use my name.

We, the members of the Atomic Scientists of Chicago and the Association of Oak Ridge Scientists at Clinton Laboratories, have carefully considered the provisions of the bill now pending in Congress known as the "Atomic Energy Act of 1945". We are strongly opposed to passage of the bill.

It delegates to a Commission and an Administrator, not responsive to the electorate, the authority and duty of determining and formulating, in addition to enforcing, all national policy in regard to atomic energy. Neither the Commission nor the Administrator are responsible in the making or enforcement of policy to the President or any other authority. Further, they are virtually immune from outside criticism or review because their security regulations may prevent the disclosure of the actions or policies subject to criticism.

Some of the specific features which make the proposed bill objectionable are pointed out below.

(1) Complete and arbitrary authority and power over all aspects of atomic energy, whose release has ushered in a new era of our civilization, is placed by the bill in the hands of nine Commissioners who, once appointed, are practically speaking immune from removal.

(2) Under the broad powers contained in the bill, the proposed Commission and the Administrator selected by it may restrict all scientific and industrial research in this revolutionary field to Government agencies, may place no restrictions whatever on such research, or may take any intermediate policy.

(3) In the new fields, whose importance to our economic life can not yet be foreseen, the proposed Commission and the Administrator may completely ban private enterprise, or may completely turn over development, exploitation, and patents to private interests.

(4) The proposed Commission may allow full and complete revelation of all present and future knowledge in the field of atomic energy, or may promulgate security regulations so stringent as to prevent discussion and interchange of information, the life-blood of scientific progress, even between co-workers in the same laboratory, public or private. The scope of such regulations is not limited to those necessary for military security.

(5) Under the proposed bill, the Commission has the absolute power to make grants to any person on such terms or conditions as the Commission or Administrator deems appropriate to its purposes.

(6) The directives contained in the bill admonishing the Commission and the Administrator to use their broad and undefined powers for the promotion of general welfare and the advancement of science are unimplemented. No method is provided for their enforcement.

(7) According to the bill, the Administrator and Deputy Administrator, who are responsible for the administration of both military and non-military aspects of atomic energy, may be commissioned officers of the armed forces on active duty.

We believe that there is a great danger under the proposed bill of retarding the research and development of atomic energy.

As citizens and as scientists who have worked to bring to fruition the promise of atomic energy, we believe that controls should and must be exercised by an administrative agency of our government. The controls must be exercised for the military security and general welfare of our people, subject to international agreements for the preservation of world peace. We believe, however, that the limits and objectives of these controls must be defined by the people through their elected Congress. This may be accomplished only by a law drafted after the fullest discussion, in Congress and out, of the meaning and possibilities of atomic energy and atomic bombs. It requires full presentation of the views of the armed forces, scientists, industry, commerce, labor, agriculture and others whose lives and interests will be affected.

We propose that the present bill be abandoned and that steps be taken to prepare a new bill based on extended hearings and investigation. It should embody enforceable objectives and limitations on the controls to be exercised. If the demands for continuity of the work and military security require immediate action, we propose that Congress pass interim legislation enabling work and security to be carried on for six months in the present wartime manner.

H C Urey

Some Suggested Changes in Proposed Legislation

--

1. Have the Administrator appointed by the President with the advice and consent of the Senate. He should serve at pleasure of President.

2. Have the members of the Commission appointed by the President to serve at his pleasure; perhaps cut down the number of members of the Commission. The Commission's functions will be advisory.

3. Have the Secretary of State, the Secretary of War, the Secretary of the Navy, the Attorney General and the Secretary of the Interior constitute a Security Council.

4. The Administrator will get all title to United States property and interests in the atomic power field as he does under the proposed bill, but he should be required to make available materials for research and experimentation when such materials are not otherwise available. In case of a shortage, in consultation with the Commission, he should prepare a plan of equitable distribution of the amount allocated for research and experimentation, and this program should be made public.

5. All patents owned by the government should be licensed to everyone save for such security regulations as may be promulgated by the Security Council.

6. All patents owned by private persons shall be subject to compulsory licensing for research and experimentation in this field. Such licenses, of course, will be subject to security requirements set down by Security Council.

7. The Administrator, in consultation with the Commission, is to prepare a program in aid of research and experimentation in the field of atomic power. This program shall provide for (1) research and experimentation by the government directly, and (2) contracts and grants in aid to research institutions and to business enterprises doing research work. This program shall not become effective until it has been before the Congress for a thirty day period, but the present powers of the War Department to continue as research until then. The legislation shall provide that quite apart from this program, however, private research not directed by the government shall be permitted and only limited by (1) security regulations which must provide safeguards in order to permit private research, and (2) the rationing program if there is a shortage in which case some amount must be permitted for this type of research.

8. The Administrator is to submit to the Security Council a set of security regulations believed to be necessary solely from the standpoint of military security and safety. Such regulations shall provide that the Administrator shall have the right of inspection and observation of all work in the atomic field and the right to require inventories and reports. The regulations shall not prohibit scientific discussion of data otherwise publicly available and shall not prohibit criticism of the policies of the administrator or any federal agency. The regulations are not to become effective until they have been promulgated by the Security Council which is not authorized to promulgate any regulation not required by military security and safety.

9. The Administrator in consultation with the Commission is to prepare a report to Congress within a year making recommendations as to legislation to control the industrial use of atomic power. The Administrator may report that no recommendations can be made because the possibilities of industrial use are not sufficiently advanced. Until further legislation the Administrator shall have no control over the industrial use save as provided for in the security regulations and by such rationing control as is required.

10. All expenditures and grants of the Administrator to be made public save those that the Security Council certifies should be withheld solely for purposes of military security and safety.

EUC:DEK

NATIONAL BUREAU OF STANDARDS

November 20, 1945

Dr. Leo Szilard,
Kings Crown Hotel,
New York, N. Y.

This is to confirm that you are expected to testify before the Senate Committee on Atomic Energy Thursday, November twenty-ninth. Please have a prepared statement in our hands by Tuesday, November twenty-seventh for mimeographing. The Committee desires this be done.

Condon & Newman

CONFIRMATION COPY

SPECIAL COMMITTEE ON ATOMIC ENERGY

UNITED STATES SENATE

November 29, 1945

Major General L. R. Groves.

. . . I testified before the House committee, in response to a direct question on that point, that one nation could catch up and produce a bomb, if they did it in complete secrecey, probably within from 15 to 20 years -- more likely the latter. If they did it without secrecy and with a great deal of help from the United States and from England and Switzerland -- and I say Switzerland because she is a manufacturer of precision machinery -- it could be done in 5 to 7 years, probably seven. x x x
I believe it would take them 2 years to get to the point where it would be feasible to get into the actual development of plants, start that phase of it, and to me that is the fundamental knowledge.

The Chairman.

You have two other estimates. You say that if we gave help it would take them 5 to 7 years. What do you mean by giving help, which would reduce it from the estimate of 15 to 20 years?

General Groves.

I mean this: We would give them various engineering developments, how to make certain things, how certain machinery was made, the exact design and exact specifications, the metallurgical processes, as well as the analyses -- everything that a man has to know in order to do the job.

The Chairman.

Well, it seems to me if we gave that, they would be able to go ahead and do it in a very much shorter time.

General Groves.

No; the only way they could do that would be to have us send over American labor to do the job for the.

The Chairman.

This 15 to 20 years, 5 to 7 years, and 2 years -- just so that we will have the record straight -- are estimates by you?

General Groves.

Yes, sir, it is a guess.

The Chairman.

A pure guess?

General Groves.

It is my guess, based on my knowledge of what it took us, and I certainly had the opportunity to have a better basis for the guess as to what it took us than any other individual.

I would also like to point out that when you say my guess may be in error -- which I admit fully, naturally -- it may be in error in the other direction. It may be that instead of this being 20 years it should be 40 or 50. A good many people who know and have been in some of these countries tell me they don't think they could ever build it, because they could never get, under their present system, men with courage enough to go in and make the mistakes that are necessary to produce such a thing as this.

STATEMENT PREPARED FOR THE SPECIAL COMMITTEE ON
ATOMIC ENERGY OF THE SENATE
December 8, 1945
Leo Szilard

SECTION I.

Having attended most of the hearings at which scientists testified before your Committee, having listened to the testimony of General Groves and having read in transcript the testimony of Dr. Bush, I have attempted to compose my statement so as to supplement the evidence which has so far been presented.

With your permission, I should like to begin by quoting some facts and figures and by presenting some simple considerations which may serve as a starting point. In this way, it will be easier to draw a picture of the role which peace time application of atomic energy might play in the next ten or fifteen years in our power economy.

We are at present producing in factories which were built during the war two substances which are in many respects rather similar. One of them is uranium 235, or light uranium. This substance is not so much manufactured as it is merely extracted by means of a rather laborious process from natural uranium. Light uranium accounts for less than 1% of natural uranium and accordingly its quantity is essentially limited by the quantity of natural uranium which can be made available.

In one of the pre-war years we imported, for instance, 400 tons of uranium. If we worked every year such a quantity of uranium and if we managed to extract all the light uranium contained in it, we would obtain every year 3 tons of light uranium. We would do pretty well, however, in extracting two-thirds of this quantity and obtaining 2 tons of light uranium every year.

If we wanted to use up 2 tons of light uranium per year by allowing it to disintegrate, or let us simply say by "burning" it, and if we used the heat generated for the production of steam and steam for the production of electrical power, how much electrical power could we generate? ("Burning" about 1 pound a day would produce heat at the rate of about 500,000 K.W. or electrical power at the rate of about 125,000 K.W.) If we "burn" 2 tons of light uranium per year, we can produce electrical power at the rate of 1.25 million K.W. or about as much as the average production rate of the T.V.A. in 1944.

If this amount represented the limit of electrical power which atomic energy could be expected to provide for us, I would not take your time by discussing this question.

You obtain a very different picture, however, if you think of a fissionable substance, like for instance plutonium, which ~~can~~ could be manufactured in large quantities. Plutonium can be manufactured from a component of natural uranium which accounts not for 1%, but for more than 99%, of natural uranium. If plutonium is allowed to disintegrate, or let us again say if it is "burned", heat is produced in just the same way as in the case of light uranium.

difference
~~A significant circumstance is, however, that~~ ~~h~~Heat is also produced in the manufacture of such a fissionable substance, and when you make one pound of plutonium, you produce as much or more heat than when you "burn" one pound of plutonium. So you see that heat is produced twice, once as a by-product of the manufacture of the fissionable substance and once when you "burn" the fissionable substance. (This does not hold, of course, for uranium 235, which is not manufactured, but merely extracted.) I will assume that

With your permission ~~T~~the quantity of the fissionable substances which can be produced ~~may~~ might be expected to increase from year to year in geometrical progression. For instance, if you start with 1 ton production per year, say in 1946 you might produce 2 tons in 1947, 4 tons in 1948, 8 tons in 1949, and 16 tons in 1950. It ~~may~~ might be, however, that the geometrical progression will be slower, and that the quantity which you can produce will double only every 3 years. This would mean that if you produce 1 ton in 1946, you produce 2 tons in 1949, 4 tons in 1952, 8 tons in 1955, and 16 tons in 1958.

Just how fast the geometrical progression ~~will~~ might proceed will depend almost entirely on the inventive ingenuity of those who will collaborate in our research and development program. The time in which the production would double might be less than one year and might be more than three years.

The years from 1946 to 1949 or from 1946 to 1958 ought to be considered as "the building up period". During such a period, it might not be advisable to divert any substantial quantities of the fissionable substances for the purpose of being "burned" in order to produce electrical power. After such a "building up period", however, there is no reason why we should not "burn" up some 20 tons of fissionable material per year and produce electrical power at the rate of about 15,000,000 K.W. Before the war the average rate of electrical power production by utilities amounted to just about this much in the United States.

The 20 tons per year mentioned above represent by no means an upper limit and we ~~can~~ might produce very much larger quantities if we can find customers for the electrical power produced.

The uranium deposits of which we know at present will not represent a limiting factor for a long time to come and the quantity of uranium contained in as yet undiscovered very low grade ores might be very large. The rate of growth ~~in-~~crease of the atomic energy industry will be essentially controlled by two factors: the rate at which the production of fissionable substances will increase and by the rate at which we are willing to expand our electrical power installations.

During the "building up" period, or say in the next ten years, it might be desirable to throw away the heat which is generated as a by-product. By doing this ~~Such a procedure might~~ we would reduce the amount of the necessary investment because the cost of a steam plant and the cost of the electrical distribution system could be saved. Moreover the fastest ways of producing fissionable material might not necessarily be those which permit the utilization of heat for steam production.

If the output of fissionable substances will increase ~~as expected~~ (as I have assumed it will) in a geometrical progression, atomic power will not be an important factor in our power economy for (perhaps ten years) ~~a number of years~~. Then, rather suddenly, that is, within a few years, it might become a very important factor affecting our economic and monetary policy.

We might then make use of the building of atomic power installations for stabilizing our system of economy. In times when a depression threatens, electrification of our railways, based on atomic power plants, may be pushed with the support of the Federal Government, whereas in boom periods an expansion of atomic energy power projects might be discouraged by the Federal Government.

~~The development, which I have described to you, is one which I know is feasible. I am not able to tell you at the moment what the cost of fissionable substances will be - assuming, say, the rate of production of 10 or 20 tons per year, nor can I tell you for certain whether or not at that rate of production, fissionable substances will be able to compete commercially with coal. We have a very good idea, however, what kind of production methods might be used and if some of us were requested and authorized to make a thorough study of the question of cost, we could probably produce within a few months a fairly reliable estimate.~~

Dr. Urey and Dr. Langmuir have pointed out to you that inspection, as it might be set up under some international arrangement, might be more difficult if atomic power plants ~~are~~ were built on the territory of various sovereign nations. ~~While it~~ I believe it may be possible to overcome such objections, there is however a more serious objection which will have to be scrutinized. It relates to the situation that the United States and other nations would face if, after a number of years (during which inspection may have been successfully practiced), one of the major powers suddenly abrogated the arrangement under which the inspection system had been operating.

Considerations of this sort induce me to raise the question whether we shouldn't contemplate the concentration of all manufacture of fissionable materials during the next ten or fifteen years on some internationalized territory. Since there would presumably be no market in such territory for the vast amounts of electrical power that would be generated, the heat that appears as a by-product of the manufacture would have to be thrown away. I wish to point out, however, that this might not be such a very great sacrifice and perhaps it would be no sacrifice at all in the light of remarks made earlier in my statement.

In erecting such factories in an internationalized territory, we would look towards the time when the fissionable substances accumulated in the next ten or fifteen years could be made available in ten or fifteen years, if the international situation permits, ~~and~~ they might safely be distributed to be burned in electrical power plants located in the United States and in other countries.

STATEMENT PREPARED FOR THE SPECIAL COMMITTEE ON
ATOMIC ENERGY OF THE SENATE
December 8, 1945.
Leo Szilard

SECTION III.

Remarks on "Preparedness"

A satisfactory solution of the problem which faces the United States as a consequence of the existence of atomic bombs can be arrived at only on an international scale. On the one hand there are those who believe that a solution on the international scale has some chance of success, that it should be tried at once and that if we fail, we ought to try again and again. On the other hand, there are those who believe that we have practically no chance of arriving at an international solution and ~~they~~ are naturally led to think of a solution either in terms of "preparedness" or else in terms of a preventive war.

As far as "preparedness" is concerned, just what is it that we have to be prepared for? If preparedness is necessary, it is necessary because we consider Russia as a potential enemy and for no other reason. If we assume that Russia will be building up a stock pile of atomic bombs just as we are at present building up a stock pile of atomic bombs, we assume an arms race. It might perhaps be possible for us to have at any time ten times as many bombs as Russia and possibly also to have larger bombs than Russia, but in spite of this we would lose ground steadily in such an arms race on account of the fact that we have very large concentrations of population located as easy targets for attack by atomic bombs. Moreover, Russia could, and I believe she would, if such an arms race got seriously under way, relocate within a few years the population of her large industrial centers.

Let us, therefore, be quite clear as to what the term "preparedness" means. It means a stock pile of atomic bombs. It also means a large Navy and a strong Army. These are important because a war that starts with attacks on our cities by means of atomic bombs would have to be ended, assuming that we are going to win it, by invading the territory of the enemy. But if atomic bombs must be expected to be available in quantity in the hands of the enemy at the outbreak of the war (and no country is going to attack us unless she has such a stock pile of atomic bombs), getting prepared means also the relocation, in time of peace, of 30 to 60 million people, together with the industries which they serve and which serve them.

I, for one, do not contemplate with equanimity the death of possibly 40,000,000 people in the United States at the outbreak of war. Senator Tydings asked Dr. Bush, ~~one of your other witnesses~~, to comment upon the possibility of such a contingency and was told that this sounded like a story by

Buck Rogers or Jules Verne. Maybe this is a Jules Verne story. But by the same token you might call the story of Hiroshima an H. G. Wells story, (and as a matter of fact ~~since~~ Wells ~~was the first~~ ~~to write~~ wrote a story about atomic bombs and their use in 1914) (H. G. Wells, The World Set Free, 1914).

There is one significant difference, however, between these two stories. It took man's ingenuity and imagination to translate the story of H. G. Wells into reality, whereas it will take only man's lack of imagination to make this Jules Verne story come true.

However distasteful ~~it~~ it may be to us to contemplate such a large scale relocation of population, we have to face the fact that without it there can be no policy of "preparedness" which makes any sense at all.

I quoted a figure of 30 to 60 million because 30 million people live in cities of over 250,000 and because 63 million people lived in metropolitan areas in 1940.

If we had enough time, say 10 years, to bring about this relocation, it would be a very expensive proposition, but at least it would be a feasible one. Dr. J. Marschak, formerly director of the Rockefeller Institute for Statistics at Oxford, England, and now the Director of the Cowles Commission at the University of Chicago, jointly with Dr.Klein, also of the Cowles Commission, estimate that with a yearly expenditure of 20 billion dollars we could relocated 60 million people and make this country considerably less vulnerable. According to their computation, our economy could stand this expenditure without an appreciable reduction in the standard of living during the transition period and the volume of the construction industry would have to be expanded only slightly above its peak volume in the year 1942.

~~The longer time we can take for this relocation, the less formidable the task would appear to be and if we could take, say, 15 years to achieve it, our city planners might be in favor of it, quite apart from any considerations of defense. They might point out that it would immensely improve living conditions and would have a beneficial effect on the life of the country as a whole.~~

~~(Atomic bombs are, unfortunately, not the only weapon that threatens to destroy our population in case of war. There might be other methods of attack against which the dispersal of the population might offer no protection.)~~

Drop

~~Relocation of 60 million people, if it has to be carried out in a time shorter than 10 years,~~ ~~may~~ would be however an exceedingly severe shock to our urban civilization. ~~Just how fast would we have to disperse in order to be prepared?~~

Those who think ~~and talk~~ in terms of preparedness and talk in terms of preparedness to the American people ought to talk in terms of a peace time expenditure for preparedness of more than 20. billion per year

STATEMENT PREPARED FOR THE SPECIAL COMMITTEE ON
ATOMIC ENERGY OF THE SENATE
December 8, 1945
Leo Szilard

SECTION II.

Organization of Future Development and Manufacture.

The development indicated above will come to pass quickly only if the Government is put into the position to carry out research and development, under the sponsorship of some Government agency, and preferably within the framework of a Government-owned corporation.

Research and development in this field cannot be separated without jeopardizing the chances of this development. For this reason, I believe it is exceedingly important to have research and development carried out by the Government, rather than trying to solve the problem by farming out separately research and development problems on the basis of contracts to universities and industrial corporations. If that were done, the Universities would probably fall short on the development side, and industrial corporations would fall short on the research side.

On the other hand, it is important that the staff which works directly for the Government should not have the field entirely to itself and should be constantly prodded by advances made at universities and industrial corporations. Such work carried out by private corporations ought to be encouraged by the Government by means of grants in aid and experimental orders.

Grants in Aid to Private Corporations

Such grants in aid would create competition with the work carried out directly under the Government. ~~and it is exceedingly important that~~ But those who are in charge of the Government corporations taking care of the Government's own research and development program should not be allowed to be the judges of how large these grants are to be, nor should they be entrusted with the allocation of the grants.

Manufacture of Fissionable Substances.

It appears desirable to have a building-up period of perhaps ten years in order to build up a stock of fissionable substances which do not exist in nature. Therefore, it may be necessary to have the manufacture of fissionable substances carried out in factories which are owned and operated by the Government of the United States (or possibly owned and operated by some international agency which might be set up under the United Nations Organization). If they are owned and operated by a Government-owned corporation this corporation ought to be different in its general set-up and separate in its management from the Government-owned corporation which will be entrusted with the research and development program.

The corporation in charge of manufacture ought not to be prevented, however, from carrying out such research and development work as their management considers desirable within a fixed budgetary limitation. This might represent a certain amount of duplication and overlapping of developmental activities, but in this new field duplication and over-lapping is desirable and necessary.

When several industrial companies do development work in the same field, this is usually regarded as very desirable competition. Duplication and over-lapping in the Government's own work ought to be regarded in precisely the same light.

STATEMENT PREPARED FOR THE SPECIAL COMMITTEE ON
ATOMIC ENERGY OF THE SENATE
December 8, 1945.
Leo Szilard

SECTION IV.

The Time Factor

In order to answer this question let us examine how long it would take for another country, for instance Russia, to have atomic bombs available in substantial quantity. ~~and~~ What are the essential factors which enter into the consideration of this question?

As far as production of plutonium is concerned, which is described in the Smyth Report, any competent mechanical or chemical engineer who spends some time thinking about the problem can see that no precision work is involved in the manufacture of plutonium. The design which we actually used ~~does~~ did require rather narrow tolerances and high-class workmanship.

This we could afford because we have this kind of workmanship in abundance.

~~But even so, the design was severely criticized for this unnecessary feature by such eminent men as E. P. Wignar and E. Fermi, at the time when it was submitted to us by the Du Pont Company.~~

Naturally, a country like Russia need not choose just this kind of design, but might prefer a design which does not require high precision work.

The statement has ~~(made by another witness)~~ ~~As far as the manufacture of plutonium is concerned, the statement of General Groves made before~~ been made before this date by another witness

~~this committee to the effect~~ that it requires high precision work manship such as can be provided only by a few countries, including Switzerland, to make atomic bombs / as far as the production of Pu is concerned such a statement would have no basis in fact. ~~has no basis in fact.~~

skip 2.

There is, of course, beyond the mere "production" of plutonium in the narrow sense of the word another process involved in its manufacture. Plutonium has to be chemically separated from the uranium in which it is produced. Knowledge of the chemical properties of plutonium is basic scientific information which I believe has so far not been released by the War Department, and you might think, therefore, that it would take a long time before another country can discover how to effect a good separation of the plutonium.

The Manhattan District was apparently of this opinion because we were under orders not to discuss with the joint British-Canadian project set up in Canada, the chemical separation of plutonium. We had a good method of which we were very proud and we were not allowed to tell the Canadian project about it.

This annoyed our British friends because it compelled them to duplicate our work which they thought was an unnecessary waste of their time. The result, however, was that they have worked out a method for separating plutonium which is superior to the one which we are using. It is both much simpler and more complete.

As far as the production of plutonium is concerned, I see no reason why any country that is capable of industrial development should rot be able to build plutonium factories. Nor do I see any reason why the building of such factories, say for instance for a capacity of 100 bombs per year, should tax the economy of a country like Russia and affect in the least the standard of living of the Russians. It is true though that a certain amount of uranium is required for such factories and the question therefore arises whether or not Russia has available uranium ores.

This question has been discussed at a previous hearing. The deposits in Czechoslovakia which might supply ore to Russia I would not class as important deposits, nor do I believe that any of the deposits of which there is public knowledge in this country can be considered as important. However, it would be exceedingly foolhardy to assume that in the vast territory which is accessible to Russia no adequate deposits of low grade ores could be found if prospecting for such ores is carried out in earnest.

How long would it take the Russians to produce plutonium in substantial quantities? ~~As far as the industrial develop-~~ ment is concerned, which goes beyond the Smyth Report, we started it pretty much from scratch at the end of 1942, and it took us from then 2½ years until plutonium came from the factories in quantities sufficient to manufacture bombs.

~~How long would it take Russia to duplicate what we have~~

~~done~~? When Germany attacked Russia I thought that Russian resistance would collapse within three months. With such a past record as a prophet with respect to Russia, I think I ought to disqualify myself from answering this question. If any of your other witnesses have a better record in this respect -- let them disclose their record together with their forecast.

It is a natural tendency to overestimate our own achievement both as individuals and as a nation but it would be ~~very~~ unfortunate ~~indeed~~ if by underestimating what others can do, the people of this country were lulled into a false sense of security.

STATEMENT PREPARED FOR THE SPECIAL COMMITTEE ON
ATOMIC ENERGY OF THE SENATE
December 8, 1945
Leo Szilard

SECTION V.

Solution on an International Scale

In thinking about an international solution of our problem, we may take encouragement from the fact that at least as far as the United States is concerned, this question has not become a political question in the ordinary sense of the word. It seems to me that the essential difference is not between Democrats and Republicans, or Progressives and Conservatives, but rather between two schools of thought.

According to one school of thought, two powerful countries, like for instance Russia and the United States, could both have a large stockpile of atomic bombs and have the means to deliver these bombs to their distant targets and yet a durable peace could exist on the basis of fear of retaliation.

According to the other school of thought such a situation would inevitably lead to war and war would break out even if neither of the two countries wanted it, more or less automatically as a result of the arms race. I, myself, believe this to be true. Perhaps if through some freak accident both countries were exactly equally strongly armed with bombs and equally vulnerable to bombs, peace could be maintained since (in that case) the bombs which would fall on the cities of both nations at the outbreak of the war would not materially shift the balance of power of two such countries. Such conditions can hardly be expected actually to arise. In most cases which we can envisage, the balance of power will be considerably shifted during the first days of the war either because one of the countries has a much larger number of bombs or, more likely, because one of the two countries is much more vulnerable to attack than the other.

In the conditions which actually exist, the greatest danger which faces us is a war arising out of such a situation between the United States and Russia. What can we do to avert this danger?

It seems to me that if the United States and Russia would set up an arrangement in which there would be no stockpiles of atomic bombs in ~~the territory under the jurisdiction of~~ either country and no manufacture of atomic bombs on the territory of either country, such an arrangement could be extended without much difficulty to all major powers, as a matter of fact to all nations whose voluntary collaboration is necessary.

Let me be quite specific in the assumptions which I am going to make in the following. Let us assume that there is no essential change in the present set up of the United Nations Organization, that the veto right of the great powers has not been abolished, but that Russia, the United States and other nations have concluded ~~the~~ an arrangement~~s~~ of the type outlined above and that they have reserved the right to abrogate that arrangement at any time.

Under these specific assumptions, we may now scrutinize ~~the~~ the following question could ~~whether~~ Russia and the United States ~~could~~ within the framework of such an arrangement create conditions by means of which ~~Russia and the United States~~ they would convince each other that secret violations ~~of the arrangements~~ in the in territory ~~of either country~~ would be detected and would become instantly known to the world.

Clearly, the arrangement would have to include certain ~~the~~ rights of inspection on the part of some international agency which might be set up under the UNO. I do not propose to discuss, however, the more or less mechanical aspect of inspection which ~~is, of course, important and has~~ have been mentioned by some of the previous witnesses. Clearly there are a number of ways in which inspection could be made effective. None of the methods are perhaps infallible, but all the methods taken together might be exceedingly effective.

You could for instance decide to inspect ~~Let me point out, for instance, that~~ even if there were as one of the rarest commodities, the scientists and engineers of a country many as 100,000 engineers in the United States ~~who could usefully be~~ usable ~~employed on an atomic power project~~, it would take only 3,000 college graduates ~~who have acquired a general knowledge of science during their studies, to~~ in the U.S. acting as agents of an international agency ~~set up, for instance, under the UNO, who would have to reside in the United States~~ in order to keep track of these 100,000 men. Each college graduate ~~could easily keep in~~ would then have to keep in constant touch with about 30 men in his area and know at all times what they are doing, and this he could do easily.

Another approach to the same problem, ~~for instance~~, might be perhaps~~, even preferable and could be~~ used to supplement ~~all~~ this and other methods of inspection. And with your permission, I want to elaborate somewhat on this particular approach as follows:

Russia and the United States might ~~clearly~~ reassure each other concerning secret violations by going about it in the following way. ~~If the~~ after the agreement providing for ~~an~~ "inspection" were ratified and became the law of the land, the President of the United States could call on all American engineers and scientists and ask them to pledge themselves to report to an international agency all violations committed on the territory of the United States.

The Espionage Act would have to be modified so that it should no longer cover information of a scientific or technical nature, whether or not it may relate to the national defense.

All men classed as scientists or engineers could be invited to spend each year four weeks' vacation, abroad and with their families as guests of the United Nations Organiation.

These vacations abroad would give an opportunity to all those who wish to report secret violations to secure immunity for themselves by staying abroad rather than returning home, after having delivered their report.

All this presupposes, of course, that Russia takes similar action and that a number of other countries would do likewise.

In this type of inspection (like in every other type of inspection) we will have to take into consideration that Russia is in a rather special position and therefore certain arrangements which we could accept very easily will not be easily accepted by Russia. But with some good will, a way out of such difficulty can always be found. It might, for instance, be that Russia might be reluctant to accept the arrangement which is being discussed here because she might feel that a certain number of her scientists might prefer to settle in the United States where facilities for scientific work are very much better than in Russia. In the next 4 years the loss of 10 or 20 of her best physicists would indeed be a blow to Russia from which her scientific life could recover only with difficulty. While I personally believe that the vast majority of Russian scientists would disregard any personal advantage which they might obtain by settling in the United States, I believe that Russia ought to be given on this point every assurance that she might feel she ought to have, always provided that such assurances do not infringe the principle of extending immunity to all those who report actual secret violations of the arrangement.

There is no doubt in my mind that a very high percentage of American scientists and engineers would obey the call of the President, would live up to their oath and would not hesitate to report any illicit activity of which they learn. My acquaintance with Russian scientists is far less extensive than my acquaintance with American scientists. But the difference between Russian and American scientists can only be qualitative; it cannot be quantitative. And even if only a small percentage of the Russian scientists would respond the way most of the American scientists would respond, that small percentage of the native scientists might still represent a more potent source of information than the agents of the international agency who might reside in Russia.

Secret violations of the arrangement would in these circumstances be risky undertakings indeed, and if various methods of "inspection" are used simultaneously, secret violations on any appreciable scale may become virtually impossible.

Clearly, in the absence of a machinery for enforcement, an arrangement providing for adequate inspection cannot rule out the possibility of war. Clearly in the case of war, sooner or later atomic bombs can be expected to drop from the sky.

Yet such an arrangement, assuming that the inspection system functions satisfactorily as long as it lasts, would be a long step forward, because under such an arrangement war need break out only if one of the parties to the arrangement actually decided to risk a war by ~~starting an arms race in~~ abrogating the arrangement.

There are two questions which have not been touched yet which will require further examination: First (a) What incentives would, under such an arrangement, Russia and the United States have for abrogating the arrangement after it had been in operation for a number of years (by invoking their legal right to abrogate which we have postulated they have retained)? How could we diminish those incentives, if they existed? Second (b) What would be the situation facing the United States if worst came to worst and such an abrogation occurred?

At the time of abrogation, always assuming that inspection was reliable as long as it lasted, there will be, of course, no bombs available, but the question is how long would it take until bombs would be manufactured, and at what rate they would come out of the factories. The answer to this question depends to a large extent on whether or not electrical power installations based on atomic energy have in the meantime been erected on the territory of the United States, and on the territory of Russia. And if they have been erected, whether or not certain specific limitations have been imposed upon them which will make their conversion more difficult.

I am raising these questions without attempting to answer them within the limited space of this statement. This much may be said, however: If the inspection system, after it has been in operation for a number of years to everyone's satisfaction, were abrogated by one of the major powers other than the United States, ~~I have little doubt that~~ the attitude of the scientists in this country would undergo fundamental change.

At the present they are all focusing their attention on trying to find an international solution which is based on collaboration and collaboration would be inconsistent with any kind of secret, whether it related to atomic bombs or any other method of warfare or any other kind of scientific and technical information. If such an abrogation occurred, my guess would be that the scientists would stream back from their universities to new laboratories set up by the Government and would work as hard as they did during the war.

I do not believe, however, that the scientists could ever be converted to the idea of "preparedness". In the case of an abrogation, I believe they would more likely become proponents of preventive war. "Preparedness" means that we build up a stock pile of atomic bombs and then wait until some other country builds up a stock pile of atomic bombs and when they catch up with us or when they overtake us, we destroy each other's cities within the first few hours of the war. This kind of procedure does not make sense to scientists.

Returning to the present
I think we must all realize that we can make progress only step by step but we cannot acquiesce to moving so slowly that it becomes difficult to judge whether we are moving forward or backward. Who can tell whether, for instance, we moved forward or backward in the three months that followed Hiroshima? I believe that we can go a long way without waiting for any machinery for enforcement, but it seems to me that the first step must be an arrangement to rule out the manufacture of atomic bombs, coupled with such methods of inspection as give us a reasonable assurance that secret violations will become known to the world. Short of this, I believe there is no step that can be taken and it is regrettable that ~~in~~ 4 the statement issued by the President and the Prime Ministers of the United Kingdom and Canada, listed inspection as the last rather than the first step.

What is the use of exchanging scientific information and scientists, if the scientists who go to Russia are forbidden to speak of ~~certain things in the field of~~ important questions connected with atomic energy? How can we expect to have discussion with our Russian colleagues if they are working feverishly, their minds set on duplicating what we have done, trying to catch up with us in the production of atomic bombs? On our first visit to Russia we might have a friendly reception, but when we return the State Department might want to know from us what we have learned on our visit, whether the Russians are working on atomic bombs and how intensely. The second time we visit Russia we will then be considered as spies and not as friends. Putting exchange of scientific information and scientists as the first step, rather than the last one, would be putting the cart before the horse.

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STATEMENT PREPARED FOR THE SPECIAL COMMITTEE ON
ATOMIC ENERGY OF THE SENATE
December 8, 1945.
Leo Szilard

SECTION VI.

Remarks on Secrecy

In the past, secrecy fulfilled an exceedingly important function and we might have lost the war if it hadn't been for the secrecy which the scientists imposed upon themselves in the early stages of the war. If the Germans had known in 1940 that a chain reaction can be maintained in a mass composed of graphite and uranium and if they had known that the plutonium produced in such a chain reaction is likely to be a fissionable substance similar to light uranium, they might very well have started an atomic bomb project in 1940 and with their eyes on the ball, they might very well have brought it to a successful conclusion by the spring of 1944. They might have won the war before we had a chance to invade Europe.

The first of these two pertinent facts which I mentioned was contained in a paper which I sent to the Physical Review in February 1940, with the request that its publication be withheld. The second fact was emphasized in a paper which Prof. L. A. Turner of Princeton University sent to the Physical Review a few months later, and which he decided to withhold from publication.

Neither of these facts was known to the Germans at the time when the war ended, though they are public knowledge at present through the Smyth Report.

The point I am trying to bring out is that secrecy has been maintained by the voluntary cooperation of the scientists in 1940 when it was most important that secrecy should be maintained, and that if secrecy should again become important in the future, it can again be maintained by the voluntary cooperation of the scientists. To my mind willing cooperation on the part of the scientists is the only satisfactory and really effective way of maintaining secrecy both in the field of fundamental scientific information and basic engineering principles which are involved in the manufacture of fissionable substances.

Compartmentalization of Information:

Compartmentalization of information to which the scientists were and are still subjected was mentioned in Dr. Urey'stestimony. It is a special technique which is used in the Services for keeping secret military operations, and applied in its proper sphere it is an effective method for keeping secrets. Both its meaning and its effectiveness undergo a profound change when it is attempted to apply this special tenhnique to research and development work.

As applied to scientific work, you may justify compartmentalization of information by pointing out that if a scientist knows not only how to extract light uranium, but also knows how to manufacture plutonium and if such a scientist is a traitor, then he can teach the enemy how to make both kinds of bombs instead of teaching him only how to make one kind of bomb. Or even better, if he knows only part of the story of how to make light uranium and nothing about how to make plutonium, he can give the enemy information, but that information alone is not sufficient to enable the enemy to make any kind of bombs.

Compartmentalization of information was practiced in the atomic energy project from the very first day on, that is, from November 1940, or before the Army was in the picture, ~~and~~ the situation was not better when we had to deal with the N.D.R.C., which had "to play ball" with the Army and Navy than later on, when we had to deal with the Army direct. If anything, dealing with the Army direct appears to be preferable, since the Army is afraid only of Congress, while agencies like the N.D.R.C. are afraid of both Congress and the Army.

I shall be glad to demonstrate, if required, that compartmentalization of information was the cause for our failure to realize that light uranium might be produced in quantities sufficient to make atomic bombs. We should have known that in the fall of 1940. We might have failed to realize this altogether just like the Germans failed to realize it if we hadn't had the good fortune that the British scientists were not compartmentalized. They were able to put two and two together and communicated their conclusions to the United States Government in the middle of 1941. Had we in the United States reached these conclusions in the fall of 1940, we most likely would have had bombs ready before the invasion of Europe.

Looking back we know now that full secrecy would have been maintained if compartmentalization had not been imposed upon us because we know that there was not a single scientist through whom information of any kind reached the enemy. There were many compartments, but there was no traitor in any of them, and the Germans had no information whatsoever about us. This was told to ~~you~~ in his testimony by Dr. Goudsmit, who headed the official War Department Intelligence Mission to study the atomic energy work in Germany.

At first we all observed rules on compartmentalization because we did not ourselves realize how damaging it was. Later on, the rules were purposely violated because we would rather violate rules than slow down our work. Men coming from different sites would drop into my office, ~~and we would go out for a walk, assuming that there might be a~~

microphone in the wall, and they would tell me things which I was not supposed to know, but which they felt that I ought to know. They usually told me that they did not expect me to conceal the fact that I was in possession of this information, but they asked me not to reveal to the Army that they had given me the information.

Some of you saw at Oakridge a certain installation and were told by a representative of the Army that it shortened the war by one week. That installation was ~~installed~~ based on a pilot plant which was built by the Navy. The installation was erected at the recommendation of Dr. Oppenheimer made in an interview with Dr. Bush. But if you investigated how Dr. Oppenheimer got the idea of recommending this to Dr. Bush, you would find that at least two patriotic scientists deliberately violated the rules and broke through compartments. Afterwards, everything was covered up nicely. Dr. Oppenheimer's projects officially asked for the information which was already unofficially in their possession, and made an official study of what they already knew, and then finally Dr. Oppenheimer approached Dr. Bush.

The installation of which I speak did not quite fulfill the hopes of these men who broke through compartments. Somehow the performance of the installation which was built by the Army did not approximate the performance of the pilot plant which had been built by the Navy, perhaps because the installation was built in great haste, and without the expert advice which in the absence of compartmentalization might have been available.

Compartmentalization of information was very irritating to scientists and as a result of this many of them go much further in their opposition to all secrecy than they otherwise might do. Clearly compartmentalization is only a special technique and in my opinion an inadequate technique for maintaining secrecy. The question of secrecy is in reality an entirely different issue and ought to be judged on its merits in the light of the international situation to which we shall have to adjust ourselves.

THE SENATE OF THE UNITED STATES

SPECIAL COMMITTEE ON ATOMIC ENERGY

Dec. 10, 1945
(Date)

THE CITY OF WASHINGTON,

THE DISTRICT OF COLUMBIA

To Leo Szilard, GREETING:

You are hereby commanded to appear before the Senate Special Committee on Atomic Energy, laying all other matters aside and notwithstanding any excuse, at the offices of the Committee in the West Terrace of the Capitol, Room 4-B, on the 11th day of Dec., 1945, at 200 o'clock A.M., to testify with respect to problems relating to the development, use, and control of atomic energy, before the said committee, and to be available in the City of Washington at the call of the Chairman and/or a duly authorized Staff Officer of the Committee, pending further notice.

Under authority of Senate Resolution 179, 79th Congress, First Session, October 22, 1945, given under my hand this 10th day of Dec., 1945

Brien McMahon
Brien McMahon, Chairman

I, ______________________, being first duly sworn, depose and say that on the _____ day of ___________, 194__, I served the above subpoena upon ______________________ by delivering to him personally a true copy thereof and leaving the same with him.

____

Sworn before me this _____ day of ___________, 194__.

____

My commission expires the _____ day of ___________, 194__.

HEARINGS
BEFORE THE
SPECIAL COMMITTEE ON ATOMIC ENERGY
UNITED STATES SENATE
79th Congress
1st session
Pursuant to

S. Res. 179

A resolution creating a special committee to investigate problems relating to the development, use, and control of atomic energy.

- - - - - - - - - - - -

Monday, December 10, 1945.

"Dr. Szilard. In answer to the question of how long it would take other countries to make bombs, perhaps I can read a short section, section 4 (referring to prepared statement).

What are the essential factors which enter into the consideration of this question?

As far as the production of plutonium is concerned, which is described in the Smyth report, any competent mechanical or chemical engineer who spends some time thinking about the problem can see that no precision work is involved in the manufacture of plutonium."

"The design which we actually used did require rather narrow tolerances and high-class workmanship. This we could afford because we have this kind of workmanship in abundance.

Naturally, a country like Russia need not choose just this kind of design, but might prefer a design which does not require high precision work. The statement has been made before this committee by another witness that it requires high precision workmanship, such as can be provided only by a few countries, including Switzerland, to make atomic bombs. As far as the production of plutonium is concerned such a statement would have no basis in fact."

"I am not making any statement about the separation of light uranium, but only about the making of plutonium, and I am not making any statement about the construction of the bomb; but it was indicated here in earlier testimony that it was not the bomb but the production of the fissionable material which is difficult. I flatly contradict that statement as far as plutonium is concerned."

"As far as the production of plutonium is concerned, I see no reason why any country that is capable of industrial development should not be able to build plutonium factories. It is true, though, that a certain amount of uranium is required for such factories, and the question therefore arises whether or not Russia has available uranium ores.

This question has been discussed at a previous hearing. The deposits in Czechoslovakia which might supply ore to Russia I would not class as important deposits, nor do I believe that any of the Russian deposits of which there is public knowledge in this country can be considered as important. However, it would be exceedingly foolhardy to assume that in the vast territory which is accessible to Russia no adequate deposits of low grade ores could be found if prospecting for such ores is carried out in earnest.

How long would it take the Russians to produce plutonium in substantial quantities?

When Germany attacked Russia I thought that Russian resistance would collapse within 3 months. With such a past record as a prophet with respect to Russia, I think I ought to disqualify myself from answering this question."

"If any of your other witnesses have a better record in this respect, let them disclose their record together with their forecast."

"It is a natural tendency to overestimate our own achievement, both as individuals and as a nation, but it would be very unfortunate, indeed, if by underestimating what others can do the people of this country were lulled into a false sense of security.

I may give you, perhaps, an example of the ease with which we can underestimate others.

In the production of plutonium there is another process involved beyond mere manufacture. Plutonium has to be chemically separated from the uranium in which it is produced. You might think that it is very difficult chemically to separate an element if you do not know well the chemistry of that element, and plutonium is a new element. The Manhattan district was apparently of this opinion.

Interpreting very narrowly the directive of the President, the Manhattan district gave us orders not to discuss with the joint British and Canadian project set up in Canada the chemical separation of plutonium. We had a good method, of which we were very proud, and we were not supposed to explain this method to the Canadian project.

This annoyed our British friends, because it compelled them to duplicate our work, which they thought was an unnecessary waste of their time.

The result, however, was, as I have been told by two reliable scientists, that they have worked out a method for separating plutonium which is superior to the one which we are using. It is both much simpler and more complete.

You see, there is an example of how easy it is to believe that what we have done and what seems so difficult to us is something that others cannot do or cannot improve upon.

Senator MILLIKIN. Mr. Chairman, I may say that the witness' testimony so far has reversed a number of tentative conclusions that I had reached, and I hope if there is any rebuttal to what he said it will be brought before us promptly, because it seems to me that he has struck right at the heart of a number of our problems.

The CHAIRMAN. That is right.

Senator TYDINGS. There is no doubt about it.

Senator MILLIKIN. Don't you think we ought to get somebody in here and get an answer, if there is one?

The CHAIRMAN. I suggest to the War Department representative who is present that he get a transcript of this testimony as quickly as he can and submit it to General Groves for such observations as General Groves cares to make on it."

December 21, 1945

Speaking about the future use of atomic energy for the production of electrical power, Szilard distinguished between the building-up period of ten two fifteen years during which there will be a gradual accumulation of fissionable substances and the period which will follow, during which we might "burn up" twenty tons of such substances per year. "After such a building-up period however, there is no reason why we should not burn up some twenty tons of fissionable material per year and produce electrical power at the rate of about 15,000 Kw. Before the war the average rate of electrical power production by utilities amounted to just about this much in the United States."

"The uranium deposits of which we know at present will not represent a limited factor for a long time to come and the quantity of uranium contained in as yet undiscovered very low grade ores might be very large. The rate of growth of the atomic energy industry will be essentially controlled by two factors. The rate at which the production of fissionable substances will increase and the rate at which we are willing to expand our electrical power installations".

"We might make use of the building of atomic power installations for stabilizing our system of economy. In times when a depression threatens, electrification of our railways based on atomic power plants may be pushed with the support of the federal government arrangements in boom periods an expansion of atomic energy power projects might be discouraged by the federal government.

Dr. Urey and Dr. Langmuir had pointed out to you that inspection, as it might be set up under some international arrangement, might be more difficult if atomic power plants were built on the territory of various sovereign nations. I believe it may be possible to overcome such objections. There is however a more serious objection which will have to be scrutinized. It relates to the situation that the United States and other nations would face if after a number of years (during which inspection may have been successfully practiced) one of the major powers suddenly abrogated the arrangement under which the inspection system had been operating."

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Szilard described how compartmentalization of information endangered the success of the project, particularly in the early phase of this work. "Compartmentalization of information was practiced in the atomic energy project from the very first day on, that is, from November 1940, or before the Army was in the picture. The situation was not better when we had to deal with the N.D.R.C., which had "to play ball" with the Army and Navy than later on, when we had to deal with the Army direct. If anything, dealing with the Army direct appears to be preferable, since the Army is afraid only of Congress, while agencies like the N.D.R.C are afraid of both Congress and the Army."

"Compartmentalization of information was very irritating to scientists and as a result of this many of them go much further in their opposition to all secrecy than they otherwise might do. Clearly compartmentalization is only a special technique and in my opinion an inadequate technique for maintaining secrecy. The question of secrecy is in reality an entirely different issue and ought to be judged on its merits in the light of the international situation to which we shall have to adjust ourselves."

Speaking about Russia,Szilard said, " How long would it take the Russians to produce plutonium in substantial quantities? When Germany attacked Russia I thought that Russian resistance would collapse within three months. With such a past record as a prophet with respect to Russia, I think I ought to disqualify myself from answering this question. If any of your other witnesses have a better record in this respect, let them disclose their record together with their forecast.

It is a natural tendency to overestimate our own achievement both as individuals and as a nation but it would be unfortunate if by under-estimating what others can do, the people of this country were lulled into a false sense of security.

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Szilard warned against thinking of the problem that confronts us in terms of "preparedness". He said, "if atomic bombs must be expected to be available in quantity in the hands of the enemy at the outbreak of the war (and no country is going to attack us unless she has such a stock pile of atomic bombs), getting prepared means also the relocation, in time of peace, of 30 to 60 million people, together with the industries which they serve and which serve them.

I, for one, do not contemplate with equanimity the death of possibly 40,000,000 people in the United States at the outbreak of war. Senator Tydings asked Dr. Bush, to comment upon the possibility of such a contingency and was told that this sounded like a story by Buck Rogers or Jules Verne. Maybe this is a Jules Verne story. But by the same token you might call the story of Hiroshima an H. G. Wells story, and as a matter of fact Wells wrote a story about atomic bombs and their use in 1914. (H.G. Wells, The World Set Free, 1914).

There is one significant difference, however, between these two stories. It took man's ingenuity and imagination to translate the story of H. G. Wells into reality, whereas it will take only man's lack of imagination to make <u>this</u> Jules Verne story come true.

However distasteful it may be to us to contemplate such a large scale relocation of population, we have to face the fact that without it there can be no policy of "preparedness" which makes any sense at all.

ATOMIC ENERGY

HEARINGS

BEFORE THE

SPECIAL COMMITTEE ON ATOMIC ENERGY
UNITED STATES SENATE

SEVENTY-NINTH CONGRESS

FIRST SESSION

PURSUANT TO

S. Res. 179

A RESOLUTION CREATING A SPECIAL COMMITTEE
TO INVESTIGATE PROBLEMS RELATING TO
THE DEVELOPMENT, USE, AND CONTROL OF ATOMIC ENERGY

PART 1

NOVEMBER 27, 28, 29 AND 30, 1945

DECEMBER 3, 1945

Printed for the use of the Special Committee on Atomic Energy

p. 62

p 180

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CONTENTS

ATOMIC ENERGY

TUESDAY, NOVEMBER 27, 1945

UNITED STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to call, at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Russell, Johnson, Connally, Byrd, Tydings, Vandenberg, Austin, Millikin, Hickenlooper, and Hart.

Also present: Edward U. Condon, scientific adviser, and James R. Newman, special assistant to the special committee.

The CHAIRMAN. The committee will come to order.

The Special Committee on Atomic Energy of the United States Senate is beginning this morning its public hearings on the entire question of the atomic bomb and atomic energy. Senate Resolution 179, by which the committee was created, stated that it shall be the duty of the committee "to make a full, complete, and continuing study and investigation with respect to problems relating to the development, use, and control of atomic energy."

(S. Res. 179 is as follows:)

Resolved, That a special committee on atomic energy to be composed of eleven Members of the Senate appointed by the President pro tempore of the Senate, of whom one shall be designated as chairman by the President pro tempore, is authorized and directed to make a full, complete, and continuing study and investigation with respect to problems relating to the development, use, and control of atomic energy. All bills and resolutions introduced in the Senate, and all bills and resolutions from the House of Representatives proposing legislation relating to the development, use, and control of atomic energy shall be referred to the special committee. The special committee is authorized to report to the Senate at the earliest practicable date by bill or otherwise with recommendations upon any matters covered by this resolution. The existence of this committee shall terminate at the end of the Seventy-ninth Congress.

For the purposes of this resolution the committee, or any duly authorized subcommitee thereof, is authorized to hold such hearings, to sit and act at such times and places during the sessions, recesses, and adjourned periods of the Senate in the Seventy-ninth Congress, to employ such experts, and such clerical, stenographic, and other assistants, to require by subpena or otherwise the attendance of such witnesses and the production of such correspondence, books, papers, and documents, to administer such oaths, to take such testimony, and to make such expenditures, as it deems advisable. The cost of stenographic services to report such hearings shall not be in excess of 25 cents per hundred words. The expenses of the committee, which shall not exceed $25,000, shall be paid from the contingent fund of the Senate upon vouchers approved by the chairman.

The CHAIRMAN. These hearings are going to be full, complete, and extensive. We want all the pertinent facts submitted to the committee so that our decisions may be based upon all the evidence which we can secure.

The release of atomic energy is certain to affect every phase of our life. Like the discovery of steam and of electricity, this may well hold the promise of tremendous benefits to mankind. It is essential that we exercise the best judgment of which we are capable in order to insure that atomic energy becomes a blessing to mankind and not a scourge.

All of us, I am sure, are anxious that the atomic bomb may never be used again in warfare. All of us want atomic energy used for peaceful purposes, to make life better and fuller.

We are conscious of the fact that no time is to be lost in dealing with this problem and I confidently hope that our hearings and deliberations will proceed expeditiously. However, we members of the committee feel impelled to bring out the relevant facts in the democratic manner. When those facts have been developed, then, and not until then, we will turn to specific legislation. We must have the basic data of scientific, industrial, economic, and social significance relating to the development of atomic energy, so that in weighing any proposed bill for its control and in making recommendations we will be in the position to contribute to the safety and welfare of our own country and the peace of the world.

The first witness before the committee, I believe, is Dr. Alexander Sachs, an early figure in this matter.

Dr. Sachs, will you identify yourself?

STATEMENT OF DR. ALEXANDER SACHS

Dr. SACHS. I am by profession, gentlemen, a practical economist, economic adviser, and consultant. I was previously economist and vice president of the Lehman Corp., of which I am still a director and a special economic adviser in my new capacity. Throughout the decade prior to the war I was associated with them.

I have also been interested in problems of national welfare and related problems, and from the very beginning of the great depression I had taken a much greater concern over its nature and development than other people were doing, and came to be known or nicknamed as the "Economic Jeremiah."

In the course of that, I had gone to Europe, and from the great crisis of 1931 my advice was sought by leading figures.

I was particularly a special adviser in an informal capacity to Lord Reading and Lord Lothian, who were concerned with the impact of the world depression on England.

I came back from that trip with a sense of foreboding as to the evolution of that great depression and a sense that its nature, as the collapse of the postwar reconstruction, was bound to affect us and was bound to undermine the political order of the world. I had so distinctly felt that that it became communicated in 1932 to Mr. Roosevelt, and so I began an association in which I continued through the years as an informal adviser without any special label. I tried to live up to a concept that he had formulated in connection with his reorganization message of January 1937 about certain assistants, that these should be men in whom the President has personal confidence and whose character and attitude are such that they would not attempt to exercise power on their own account. They should be possessed of high confidence, physical vitality, and a passion for anonymity. I tried to live up to the last one, a passion of anonymity, and I have not myself participated in any self-reverentialness, feeling that my job was to be a person who was on tap and not to be one who was in the news or in any way trying to influence the course of events beyond that of trying to point out their implications and their consequences.

It was from the very beginning of 1933 that I sensed that the economic crisis was going to have political consequences. I had in 1932 written what I had passed on to the President-elect. The statesmen of the world continued to be overtaken by a sort of high-tension paralysis, like the trivial oscillations of the trench war battle fronts up to America's entrance in the great war, only to find that the imperious and menacing march of events swept aside the half-willed and half-thought schemes, and even attacked improvised defenses that were resorted to too late, as in the case of Germany to save Germany for democracy.

The outstanding feature of this great depression is that the economic concept developed since the Reformation and the great society developed since the fall of the Roman Empire have come to be threatened not by the destructive impact of external or natural forces, but by a disintegration from within because of an incipient failure of will and political wisdom.

Thus imbued in 1933, in connection with the National Recovery Act where I had been called in in my capacity as an economist, I had suggested that the best use for public-works money was to apply it to the reconditioning of the Navy and to the improvement of national defense.

Gen. Hugh Johnson, who was at the time an assistant in an economic capacity to Mr. Baruch, and who had gotten to know me from echoes heard of what he thought were always correct forecasts, had called me in; and I had urged upon him the inclusion of these provisions.

Senator Austin. What year was that?

Dr. Sachs. That was 1933, in the legislation of April and May.

Hugh Johnson was a little bit too humorous about it in thinking that I had put anything over, but the fact was that it was a very patent argument with the President that the advent of Hitler to power boded ill for all democracies, and that it was necessary that we take time by the forelock.

Hugh Johnson in the Blue Eagle, pages 197–198, credits me with having suggested that this provision about the availability of funds for naval construction be written into the NRA bill.

I have always been of the view that the real warmongering is done by the pacifists combined with a defeatism, and that one who is concerned about the protection of national interests without aggressive aids is the real practical pursuer of peace.

Later on—and I had been in the habit of reporting to the President regarding the progress of international developments—in 1936 he called me in to help in working out a solution on the problem of public utilities and power. I had proposed the idea of a power pool, and even then we discussed that in the event of danger we would want to have a mechanism for the coordination of private and public power.

The distinguished figures representing the public were Mr. Owen D. Young and Mr. Lamont, and I had been another one that was selected alongside those representing the public-utility interests and the governmental authorities concerned with power.

After Munich I had begun to send the President a series of memoranda, and it was at the turn of the year, in January 1939, that I had sent in a very long study on the international situation. In the preface to it, in the foreword, I described that memorandum and its predecessors. I had been discussing these things with him in 1936, and also in 1937 prior to the "quarantine" speech.

My role was, if you will, to be a reasonator for ideas that he had and also as a humble submitter of ideas. In this preface I wrote:

> The orientation toward the crisis that has been developed in prior reports and needs to be borne in mind continually is that we are already in what Thomas Hobbes, who lived through the British civil war 300 years ago, justly called "war time-tract" and "war-weather": "For war consisteth not in battle only but in a tract of time wherein the will to contend by battle is sufficiently known * * *. For as the nature of foul weather lieth not in a shower of rain but in an inclination thereto of many days together; so the nature of war consisteth not in actual fighting but in the known disposition thereto during all the time there is no assurance to the contrary."

The thesis then was that the aggressor powers, the Nazis and the Fascists and their other allies—since Japan had already started this in 1931—were passing from the state of "white" war and limited war to totalitarian war.

On March 10, 1939, when I was asked by St. John's College to deliver a talk on the world situation, I prepared certain notes, a copy of which I sent the President. Those were "Notes on Imminent World War in Prospective Accrued Errors and Cultural Crisis of the Interwar Decades." That was a memorandum dated March 10, 1939, and the opening sentence was:

> This interwar generation has been living on the edge of a smoldering volcano; and the predominant attitudes among both what is called "Right" and what is called "Left" have been variants of escapism, very much like peasants situated on the edge of a volcano who go on cultivating the slopes in the hope that the eruptions will not take place in their lifetime.

Then I reviewed the errors of the interwar period, and said:

> The present period is too late for that reversal of error which prevents the consequences of error. The real "Munich" took place in 1936, in connection with the Rhineland. Then was the last opportunity missed for preventing that cumulative German aggression that was bound to culminate in a new and more terrible war by Germany. But what can and must be done for our salvation and safety is self-clarification and self-reorientation towards the onrushing dangers.

Then in the concluding sentence—and you must pardon the length—I thought it was my business to try to think these out, not try to be popular, I said:

> There is still time for western civilization, and especially for the exceptionally and fortunately situated United States, to use the time drafts that can still be made on the Bank of History for the preparedness that has and will become more and more urgent and inevitable for all members of western civilization as a result of the past errors committed and in the course of the prospective unfolding aggressions of Nazi Germany.

That was in March, and the address was delivered in April before St. John's College on war imminence and the cumulative crisis of the interwar period.

It was in the following month, on April 15, 1939, that there was published in the Physical Review a note by Dr. Leo Szilard entitled "Instantaneous Emission of Fast Neutrons in the Interaction of Slow Neutrons with Uranium."

In keeping with the custom in scientific research, the date of its original sending was included, dated March 16, 1939; so it coincides with the time when Hitler seized Prague and by seizing Prague became the controller of the crossways of the continent.

The background of that was that at the turn of the year 1937 certain experiments had been concluded in Germany, and they were made available and made known. Dr. Niels Bohr of Denmark came to this country and spoke to his colleagues. Scientists are an international community. I think the word "international" is not as precise as it ought to be; it really is "transnational," across the boundaries of nations. They function in terms of common ideas because, after all, our heritage of common moral ideas and intellectual ideas dates for our world from the Reformation or the Renaissance, and it is a crystallization of the very Christian ideas and the pursuit of science irrespective of national boundaries, but as a human activity. These scientists depend upon the free flow of knowledge, the free flow of ideas. They had learned that there were completed in Germany experiments by Drs. Hahn and Strassmann regarding the fission of uranium.

What was done in this country represented a distinct advance because of the work of Dr. Szilard and the independent confirmatory work of another scientist, Dr. Fermi, a Nobel Prize man in physics of Italian descent who, under the conditions of fascism, found it inadvisable to return to Italy. The Nazi contamination had advanced so far that it became difficult for those who did not conform to the tribalistic notions of their sect.

The confirmatory work of Dr. Szilard and Dr. Fermi amounted to the suggestion that a chain reaction could be established in the process of atomic fission, and that chain reaction had implications for the type of energy for the kind of power that would be telescoped and concentrated in the process of disintegration.

Because I had been imbued with those ideas upon the nature of the world crisis, I was concerned with what was happening to the victims of nazism and fascism, and I tried in my own small way to be helpful during the period when the scientists had to leave.

I gave you at first some highlights of the "book of genesis" of my concern, and that is, if you will, the "book of exodus," the exodus of scientists who came to this country as a haven.

Prior to that, Dr. Szilard had worked in England at Oxford and Cambridge, at Oxford with F. A. Lindemann, who afterward became Lord Cherwell and played toward Mr. Churchill a role analogous to the one, in respect to this project, that I played toward Mr. Roosevelt.

In this phase of the exodus, the scientists were concerned not only with the progression of a technical problem, but with its political and moral implications.

There was another great physicist, who was a friend of Dr. Szilard and part of that group, Professor Wigner, of Princeton. There were a great many of them in Princeton, which became one of the great centers. There was Professor Wigner, Professor of Theoretical Physics, and then there was Professor Einstein, whose theoretical work antedated the First World War, whose practical confirmation in the astronomical tests interestingly enough came just in the closing phase of World War I, as Prof. A. S. Eddington, of Cambridge, shows in his book on "Space, Time and Gravitation"—he was the head of that expedition.

Einstein, Wigner and Szilard discussed the problem; and I want to impress upon you gentlemen that, if I may refer to the Gospel of St. John—I happen to regard these testaments as equally significant in relation to basic ideas—"in the beginning was the Word." In the beginning was a moral idea and a political concern on the part of the physical scientists and this social scientist whom they brought in. They brought me in because they had heard that I was in a position to talk to the President and talk to him in terms of broad and fundamental concepts; and the ideas was, how can this be brought to the attention of the President?

The Germans were organized to carry on experimentation without limit. The Nazis were not at all concerned about money expenditures. Ironically, despite all the beblinkered concern on the part of experts in my own field, economics, as to the terrible problem of reparations, the fact was Germany was spending on armament in any and every year, once it got going, more than was involved in the total amount of its remittances on reparations. Money was no object. They had these institutions. Many of the scientists were themselves refugees from work that they had been doing at these same institutions, the Kaiser Wilhelm Institutes of Physics and Chemistry.

The idea was that if they should be able to discover a concentrated power that could be used as an explosive, then the real safety of the United States and the rest of civilization would be gravely imperiled, because bear in mind that the essence of this period of foul weather internationally, to use Thomas Hobbes' expression of this wartime weather, was that the Nazis were rushing and not permitting the time for the organization of defense.

Therefore, these scientists, these physical scientists and myself, who was brought into the picture in the summer of 1939—and I had been introduced to Dr. Szilard by Mr. Stober, who was an economist; but I had known in a general way what was taking place because I had long been interested in theoretical physics and had followed publications in a general way—then felt that it was important to bring these matters to the attention of the President. We felt that it was essential that an opinion should be written by the one man whom the world recognized as the preeminent scientist of our day, and not only the preeminent scientist but, as the Senator this morning remarked, one of the greatest humanitarians, because he had left nazism before expulsion orders were given to him He had anticipated the trend of events. He did have political foresight, and did see what it implied.

Dr. Einstein wrote a letter regarding this, dated August 2, 1939. I had also asked Dr. Szilard to write a memorandum describing the significance of the current and evolving scientific research, and that was a memorandum of August 15, 1939.

Then I sought for an opportunity to see the President. I had been in touch with him, but I felt at the time that the mere delivery of memoranda was insufficient. Our social system is such that any public figure—you gentlemen in your work as statesmen, and the administrators in Government—are punch-drunk with printer's ink. You have to read so much that I felt there was no point to transmit material which would be passed on to someone else. This was a matter that the Commander in Chief and the head of the Nation must know. I could only do it if I could see him for a long stretch and read the material so it came in by way of the ear, and not as a soft mascara on the eye.

Then, of course, with the outbreak of the war it was not possible for the President. He had the problem of the existing neutrality legislation, as you recall, and only when that was solved did I accept an appointment, because it meant that then I could see him at leisure and read the material. I brought over the material to him, and met with him on October 11, 1939. I wrote the letter in anticipation of my seeing him so that I would be able to read it, and the opening sentence was:

With the approaching fulfillment of your plans in connection with revision of the Neutrality Act, I trust that you may now be able to accord me the opportunity to present a communication from Dr. Albert Einstein to you, and other relevant material bearing on experimental work by physicists with far-reaching significance for national defense.

Briefly, the experimentation that has been going on for half a dozen years on atomic disintegration has culminated this year (*a*) in the discovery by Dr. Leo Szilard and Professor Fermi that the element uranium could be split by neutrons and (b) in the opening up of the probability of chain reactions—that is that in this nuclear process uranium itself may emit neutrons. This new development in physics holds out the following prospects:

1. The creation of a new course of energy which might be utilized for purposes of power production—

naturally featuring first peacetime production.

2. The liberation from such chain reaction of new radio-active elements, so that tons rather than grams of radium could be made available in the medical field.

3. The construction, as an eventual probability, of bombs of hitherto unenvisaged potency and scope. As Dr. Einstein observes, in the letter which I will leave with you, "a single bomb of this type carried by boat and exploded in a port might well destroy the whole port, together with some of the surrounding territory."

In connection, then, with the practical importance of this work—for power, healing, and national defense purposes—it needs to be borne in mind that our supplies of uranium are limited and poor in quality as compared with the large sources of excellent uranium in the Belgian Congo and, next in line, Canada and former Czechoslovakia.

I also informed him that we had learned that in the wake of successful experiments by Drs. Hahn and Strassmann, one of whom afterward also joined the exodus, that the Germans, upon capturing Czechoslovakia, the seizing of Prague, had embargoed the export of uranium from Czechoslovakia.

I also mentioned the people who had been at work on this and who had been consulted:

Mindful of the implications of all this for democracy and civilization in the historic struggle against the totalitarianism that has exploited the inventions of the free human spirit, Dr. Szilard, in consultation with Prof. E. P. Wigner, head of the physics department at Princeton, and Prof. E. Teller of George Washington University, sought to aid this work in the United States through the formation of an association for scientific collaboration, to intensify the cooperation of physicists in the democratic countries—such as Professor Joliot in Paris, Professor Lindemann of Oxford, and Dr. Dirac of Cambridge—and to withhold publication of the progress in the work on chain reactions.

The CHAIRMAN. Doctor, what was the date of the embargo on uranium?

Dr. SACHS. Right in April, right after the seizure of Prague on March 15, 1939.

Bear in mind that this world community was already functioning and included Professor Joliot, married to a daughter of Madam Curie; Professor Lindemann of Oxford, who afterward became Lord Cherwell and played this corresponding role toward Winston Churchill

As the international crisis developed this summer, these refugee scholars and the rest of us in consultation with them unanimously agreed that it was their duty as well as desire, to apprise you at the earliest opportunity of their work and to enlist your cooperation. * * *

In the light of the foregoing, I desire to be able to convey in person, in behalf of these refugee scholars, a sense of their eagerness to serve the Nation that has afforded them hospitality, and to present Dr. Einstein's letter, together with a memorandum which Dr. Szilard prepared after some discussion with me and copies of some of the articles that have appeared in scientific journals. In addition, I would request in their behalf a conference with you in order to lay down the lines of policy with respect to the Belgian source of supply and to arrange for a continuous liaison with the administration and the Army and Navy Departments, as well as to solve the immediate problems of necessary materials and funds.

There is one more document that is pertinent. One of the things that I brought together and submitted to the President, in addition to the scientific material, was, of course, this review of mine of the whole world situation on the imminence of war and the nature of this war, which is really a 30-year war, from 1914 on, for a world dominated by Germany with aggravations, of which there was one brief interlude, a brief armistice.

From 1931 on there was a resumption of war first in Japan in the seizure of Manchuria, and then came the succession of wars, the Italian war against Abyssinia, the interventionism by the Axis powers in Spain, the war against Austria, and finally the seizure of Czechoslovakia.

In 1936 there were lectures delivered on the history of science, reviewing the progress in sciences for the preceding approximately 40 years. The book was published by Cambridge University Press after Munich. It was published in 1938. Due to the work that I had done in England and my relationship to figures who consulted me—in addition to Lord Reading and Lord Lothian, there was Sir Josiah Stamp, a great economist, who had gotten in touch with me—I used to get these publications, as my interests included scientific work.

This book published in 1938 contained two lectures on the history of recent developments in physics, and the development of the theory of atomic structure by Lord Rutherford, whose work initiated the technical side of the physical research begun about the turn of the century.

Some of the greatest work of Lord Rutherford was done right nearby when he was professor of physics at McGill University, and it was for this work that he got the Nobel prize.

There were these two lectures prepared by Lord Rutherford, which after his death, were revised by an assistant of his, and then there was a separate lecture, in addition, on Forty Years of Atomic Theory, by F. W. Aston of Cambridge, who died only a few years ago. You may have seen the notice.

F. W. Aston, reviewing the work that had been done in 1936 and describing what was being done in England and elsewhere, ended up his lecture as follows, and I showed it to the President with a view to high-lighting the fact that, like all things, there is an ambivalence in it, there are two poles of good and evil. The concluding paragraph is as follows:

> There are those about us who say that such research should be stopped by law, alleging that man's destructive powers are already large enough. So, no doubt, the more elderly and ape-like of our prehistoric ancestors objected to the innovation of cooked food and pointed out the grave dangers attending the use of the newly discovered agency, fire. Personally, I think there is no doubt that subatomic energy is available all around us, and that one day man will release and control its almost infinite power. We cannot prevent him from doing so and can only hope that he will not use it exclusively in blowing up his next-door neighbor.

The President remarked, "Alex, what you are after is to see that the Nazis don't blow us up."

I said, "Precisely," and he then called in General Watson, lovable "Pa" Watson, another one of that period who has gone from us, and he said, "This requires action."

General Watson then went out with me, and the informal group was established.

Senator VANDENBERG. What was the date of this?

Dr. SACHS. October 11, 1939, sir.

He selected, with the approval of the President, one man representing the Army concerned with science, and one representing the Navy; Colonel Adamson for the Army and Commander—since Admiral—Hoover for the Navy.

Holding that as an expert I ought not to be injecting political views, I have throughout my work remained an associate regardless of party and other affiliations. As I have the honor to know ex-President Hoover, I was very pleased to find a namesake of his concerned with these scientific problems, as President Hoover during his incumbency as Secretary of Commerce did a great deal for the advancement of science and scientific research.

As the central figure, the President named a Government individual who was concerned with problems of science, the Director of the Bureau of Standards, Dr. Lyman Briggs, who rendered very great work during the critical period.

I got in touch with Dr. Briggs that very night, before having to go again to the White House to have some words with the President to report progress, because the potentialities of this were very much in the mind of the President, and he had communicated, "Don't let Alex go without seeing me again."

I saw him later that night, and the idea was to hold a meeting. A meeting was scheduled after this October 11 conference at the White House; a meeting was scheduled for October 21.

I reported to Professor Wigner, who throughout this period occupied a pivotal role because he is highly esteemed and was perceptive on what you might call the political problems. I reported to him in a letter of October 17 and I sought throughout the interval to broaden the group of scientists who were to attend that conference

Senator VANDENBERG. How about the Einstein letter you referred to?

Dr. SACHS. The Einstein letter of August 2, from which I quoted in part in my own letter, was left with the President, along with my letter.

The CHAIRMAN. Have you a copy of it?

Dr. SACHS. That is part of a record which I will leave with you gentlemen, which was a report I prepared immediately after the announcement about the use of the atomic bomb in August, which I prepared for the White House, the Department of Commerce—Mr. Wallace as the successor in charge of the Department that had such an important role—the Bureau of Standards, and the War Department.

The CHAIRMAN. Does that contain your letter?

Dr. SACHS. It contains all the documents, sir. It contains Einstein's letter, and it contains other memoranda.

I had throughout this period sought to be a historian, because the President said to me, "Pa Watson is going to be too busy to be a historian; you had better do that."

I made contemporaneous reviews, and would submit them as galvanizers of action.

I have a copy of Einstein's letter, a duplicate, which has his signature, and I will leave that copy with you.

Senator VANDENBERG. Could you state in a sentence or two the import of Einstein's letter?

Dr. SACHS. Yes, sir. [Reading:]

> Some recent work by E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendation.

He then describes the new phenomenon, and describes that the sources of supply are outside the United States; that the United States has only very poor ores of uranium in moderate quantities, and that there is some good ore in Canada and the former Czechoslovakia. As to that, he reports:

> I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under Secretary of State, von Weizsaecker, is attached to the Kaiser Wilhelm Institute in Berlin, where some of the American work on uranium is now being repeated.

In other words, there was political interest being taken in the work. So Dr. Einstein said that one of the ways in which the administration could be helpful was to entrust this task to a person—

> * * * who has your confidence and who could perhaps serve in an unofficial capacity. His task might comprise the following:
>
> (a) To approach Government departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States;
>
> (b) To speed up the experimental work, which is at present being carried on within the limits of the budgets of university laboratories, by providing funds, if such funds be required, through his contacts with private persons who are

willing to make contributions for this cause, and perhaps also by obtaining the cooperation of industrial laboratories which have the necessary equipment.

These scientists, as you see, gentlemen, were no doctrinaires, but indicated only a practical perceptiveness—using whatever means were available so that the Government and the Nation had a supply and had funds for going ahead with this thing

The next meeting that was held was on October 21 in Washington under the chairmanship of Dr. Briggs of the Bureau of Standards, and there was a survey made of the whole situation. Many scientists were there, scientists who were not as much concerned as these refugee scientists, because, as I tried to explain, gentlemen, they just were not only interested in advancing science; they were interested in the imperiled position of the United States and civilization. They were imbued with a concern in the Quaker sense of the word, devoted interest and responsibility.

Many other scientists said: "This is very remote; we have got to wait and see; there are other lines of progress rather than the chain reaction that may be more attactive," and the discussion wandered all over the attractive side issues

The job on the part of one who occupied this intermediary and catalytic role in behalf of the President, was to ask these gentlemen of science and Government officials, including the Army and Navy, to indulge—and I remember using a phrase by the Irish poet Yeats, echoing Coleridge—in a "willing suspension of disbelief."

The issue was too important to wait, and the important thing was to be helpful because if there was something to it there was danger of our being blown up. We had to take time by the forelock, and we had to be ahead.

One great advantage that we had was that these refugees, these scientists, themselves responded to that very spirit of freedom that brought the Pilgrim fathers over here, a freedom of speech in religion, if you will, free science and free thought, and were saturated by the idea that that motive which the regimented scientist would not have would itself lead them to make advances much faster.

In the wake of that conference, a subcommittee was appointed, notwithstanding these expressions of doubt. The subcommittee was presided over by Dr. Briggs, and on behalf of Keith F. Adamson, lieutenant colonel, United States Army, and Gilbert C. Hoover, commander, United States Navy, a report was written to the President on November 1, 1939, on the stationery of the National Bureau of Standards of the Department of Commerce, which reviewed the situation technically and culminated with this observation:

3. The energy released by the splitting of a mass of uranium atoms would develop a great amount of heat. If the chain reaction could be controlled so as to proceed gradually, it might conceivably be used as a continuous source of power in submarines—

I would not have wanted to limit it to this form, but a continuous source of power was the fundamental idea—

thus avoiding the use of large storage batteries for underwater power.

4. If the reaction turned out to be explosive in character it would provide a possible source of bombs with a destructiveness vastly greater than anything now known.

The military and naval applications suggested in paragraphs 3 and 4—

in this case he was expressing the not-quite-suspended disbelief of the representatives of the services. Voicing their greater skepticism, Dr. Briggs said that the military and naval applications—

must at present be regarded only as possibilities because it has not yet been demonstrated that a chain reaction in a mass of uranium is possible. Nevertheless—

and in this respect those representatives were willing to go ahead—

in view of the fundamental importance of these uranium reactions and their potential military value, we believe that adequate support for a thorough investigation of the subject should be provided.

There had been a previous adverse report that I had known about, which was given by a technical adviser of one of the services in the summer, and it was because of that adverse report—they didn't see any reason for being interested, although they wanted to be kept informed—that I was brought in to go directly to the Commander in Chief.

So they concluded:

We believe that this investigation is worthy of direct financial support by the Government.

But, alas, we had no money.

The Lea bill now before Congress, if enacted, would provide for carrying out important investigations of this kind in cooperation with the universities.

We recommend the enlargement of the committee to provide for the support and coordination of these investigations in different universities. We suggest the following be invited:

President Karl Compton, Massachusetts Institute of Technology.
Dr. Alexander Sachs, 1 William Street, New York—

that was my address at Lehman Bros., who were very kind to let me devote time, and did not ask me to tell them what it was about. Mr. Robert Lehman is particularly to be thanked for this, and a man who afterward became an adviser of the War Production Board, and later Deputy Chairman, Mr. Arthur Bunker, who was then executive vice president of the Lehman Corp.

The people who were asked to be added were Prof. Karl Compton, myself, Prof. Albert Einstein—I am reading this in order; I belong very much at the foot of any such list—Prof. Albert Einstein, of the Institute for Advanced Study, and Dean George B. Pegram, Columbia University.

As a sequel to the major finding and recommendation, the committee proposed that initial support take the form of:

(*a*) Supplying for immediate and experimental work four metric tons of pure-grade graphite, and

(*b*) If later justified, supplying 50 tons of uranium oxide.

Later on there were all kinds of difficulties about getting the supply, to which I referred, and in the following year there was another refugee, an industrial engineer by the name of Pregel, who made available very valuable supplies to Columbia University for the experiments of Dr. Szilard and Professor Fermi, for which he was thanked by Dean Pegram.

The first phase was to coordinate the group of physical scientists for the purpose of presenting the idea to the President. The second phase was the securing of action by the Government, and that was climaxed by a report, which was a go-ahead signal, that Dr. Briggs wrote on November 1, 1939.

If you bear in mind how narrow has been the time, how correct was the concept of the memorandum from which I read of mine of March 10, 1939, that the job was "time borrowing, the issuance of drafts on the Bank of History," if the work had not been thought through before the advent of the war, if the President had not taken action immediately after, if the report of the Bureau of Standards and its technical head had not come forth on November 1—the bomb came toward the end of the war; it abbreviated the war, but it came in 1945—you will realize that the time borrowing was very essential, and the organization and the finding of proper medium was the great task of the year 1939 and the year 1940.

While I was an adviser of the President, also, on problems of strategy, I was also a special consultant to General Donovan, of the Office of Strategic Services, and had written the first report on the work that was being done outside on problems of totalitarian economics and war economics, as well as strategy, before the organization of the Office of Coordinator of Information, which afterward became the Office of Strategic Services.

Through these connections I was able to keep in touch, and I was kept in touch on the basis of great confidence, with the White House on what was going on, so I knew what was happening, even to the very last. I discussed the problem of the form of the use of the bomb with the President early in November 1944, when I submitted a memorandum on the final phase of the European war. That memorandum contained a forecast that the war would end in April or May, and that there would be no lasting stand, that the whole German system would collapse.

Though I have kept in touch, my official role as the representative of the President continued up to the time when, as you will see, I submitted to him the idea that it must be given over to an organization in charge of all scientific development, and suggested Dr. Bush, of whose keen interest and ready aid I had learned in the course of the difficult months of 1940.

Many of the pivotal figures are not now alive; the President is dead; General Watson, who rendered very great service, is dead. I remember that to military and naval men who said, "Well, this is still so remote; what is this thing; let's wait and see," "Pa" Watson would answer, "But the Boss wants it, boys." That was the one theme song of "Pa" Watson.

He is dead, and the secretary who used to call me up and pass on my messages is dead.

These documents which fortunately were written, represent the only available record of the flock of events, apart from scraps; and the scraps that are available in the files are insufficient to give a correct picture. One gets a picture by reading some of the things that have been published, but there was a linear progression.

Like all things, it was full of set-backs, difficulties, and perceptiveness and willingness, doubts, and hesitations, and it required continuous prodding. Such work as I was able to do, I was able to perform because everyone knew I was not concerned about anything but the progress of the work, and had made myself anonymous.

If I may again quote the New Testament, there is a verse in 1st Peter, "Be ready always to give answer to anyone that asketh of you the reason of the hope that is within you," and yet with meekness and fear I felt that I had to go on with this work, that I had this vision and it must go on; and so I sacrificed my time and concentrated on that. Later on, as a matter of fact, when the war broke out I resigned from my administrative post and became a private economic adviser so as to be able to devote myself to war work to a very large extent.

In the summer of 1941 I had given to the Navy a plan that was worked out with the aid of a great engineer, radiosonic buoys for the establishment of the Atlantic security lane for the lend-lease shipments. This was afterward adopted by the Navy through the technical work by Professor Huntsacker of M. I. T.

I want to convey this impression, that in the beginning there was a political concept and a moral concern, and that it was necessary to provide proper vehicles for action and also to get acceleration of action.

The third stage was the coordination phase of the university researches with limited governmental aid and pressure—these were words that I used at that time—as I was saying, limited governmental aid and pressure by Einstein and the writer for a new framework and an accelerated tempo for the project.

While a number of the university representatives were encouraged by the governmental interest, the fundamental tenor and the tempo of the work remained, on the whole, continuous with the past—that is, they were regarded as mere laboratory researches.

The time of this phase was approximately coincidental with what was called at that time the "phony" war. This was the time of the war which embraced the period between the fall of Poland and the Nazi invasion of the Lowlands.

You can well believe that the President during this period was pressed by, and preoccupied with, numerous internal and international problems.

Our liaison officer for the project, General Watson, orally conveyed to the President the general tenor of Dr. Briggs' report. While he had done that, he thought, when he transmitted it to the writer on February 8, 1940, that a more pointed conclusion was necessary. He added that he had asked for a special recommendation from Dr. Briggs.

Meanwhile, some progress was made in the coordination of the university researches by the coordinating committee mentioned in the concluding point of Dr. Briggs' report. The appointment of Dean Pegram served to focalize activities in Columbia on this project, and frequent conferences were held thereby with the speaker and Doctors Pegram, Fermi, and Szilard. This group used to meet often at the Columbia University Faculty Club.

In mid-November, this group projected an octet of experimental projects in the hope that the subsidiary questions could be cleared within a period of 6 months.

Based on notes that were made at the time, I find that the nature and scope of these subsidiary problems and the recommended personnel, all of them from nearby educational institutions, were as follows—I will not read that, but it included the leading figures in this country, people working on these problems.

However, I will say that the most important of the men who were brought in was Prof. Harold C. Urey, who won the Nobel Prize for his work on heavy water, and who later on became very important.

At the same time, the Columbia project became the recipient of governmental aid in the form of limited funds intended for the purchase of materials, as is borne out by the reply that Dr. Briggs made on February 20, 1940, to General Watson's note of February 8, 1940.

On the other hand, Dr. Einstein and myself were dissatisfied with the scope and the pace of the work and its progress. The writer conferred with Dr. Einstein at Princeton in February. I went out to see him there and there developed an inquiry as to the importance of the work that was being carried on at the time in Paris, work that had been described in a contemporaneous issue of Science.

We felt that it was very important that this free trade in ideas—to use Justice Holmes' words, one of his expressions given in one of his great and discerning decisions—that this exchange of ideas should be carried on because these things that were being reported served as links and as stimuli to future work.

I had asked him, Dr. Einstein, about the work of the French, and he reported about that, and he said that he thought that the work at Columbia was more important.

As I say, I evoked from him the statement that the work being done at Columbia was more important. He further said that conditions should be created for its extension and acceleration.

Accordingly, the writer sent, on February 15, 1940, to General Watson a plea for larger aid and an intimation that presently Dr. Einstein would give a favorable evaluation of the work which had been completed at Columbia.

(The letter referred to is as follows:)

FEBRUARY 15, 1940.

Gen. EDWIN M. WATSON,
Secretary to the President,
The White House, Washington, D. C.

DEAR GENERAL WATSON: Thank you very much for your letter of the 8th and the accompanying report of Dr. Briggs to the President, both of which will be treated as confidential. Had the recommendations from the second part of point 5 through points 6 and 8 been placed ahead of the more technical points 1–4, the practical meaning of the letter would have been clearer and more forceful—namely, that in the opinion of Dr. Briggs and his colleagues it was distinctly worth while to go ahead. Due to too academic a presentation, I feel that that practical point was lost.

As the last issue of Science contained a quotation from Science Letters bearing on work in Paris, and as, since our meeting, there has been even more searching and significant work in this country, I shall take the occasion to submit within the next month an up-to-date appraisal of the situation which, according to Dr. Einstein in a recent conversation, holds forth even greater promise than we had thought.

With kind regards and appreciation,
Yours sincerely,

ALEXANDER SACHS.

Dr. SACHS. Ensuing conferences which I had with Dr. Einstein prompted the suggestion that he prepare another review of the situation for submission to the President. I had felt that Dr. Einstein's authority was such that, combined with his insight and concern, it could affect the tempo of the work which then, to use a musical term, too slow, troppo lento.

His review, which was dated March 7, was written as a letter to me. I will read the opening and closing paragraphs of this letter dated March 7, 1940. It was addressed to me at my office at the Lehman Corp.

In view of our common concern in the bearings of certain experimental work in problems connected with national defense, I wish to draw your attention to the development which has taken place since the conference that was arranged through your good offices in October last year between scientists engaged in this work and governmental representatives.

He also reported that he had learned of the further work that was going on in Germany since the outbreak of the war, the work on uranium.

He pointed out that this work was being intensified in Germany. I shall quote a portion here:

I have now learned the research there is being carried out in great secrecy and that it has been extended to another of the Kaiser Wilhelm Institutes, the Institute of Physics.

However, when it comes to secrets—even under the totalitarian system, secrets come out. Under our freer system, things also come out. They come out even while we are taking terrific measures, and very rightly, they still come out. I refer specifically to the Minerals Yearbook of 1943.

On page 828, that book contains something which was very significant. In a very technical statement about uranium, it spoke about uranium production in 1943——

Senator TYDINGS. Was that our book, or was it a German book?

Dr. SACHS. It was our book, the Minerals Yearbook for 1943, on page 828.

At the very time that newspapers and editors were not even to breathe the word "atom," the Minerals Yearbook of 1943, page 828, said, with reference to uranium:

Uranium production in 1943 was greatly stimulated by a Government program having materials priority over all other mineral procurements, but most of the facts were buried in War Department secrecy.

Then, it goes on to say:

Most of the 1943 uranium supply was used by physics laboratories for research on uranium isotopes as a source of energy.

These technical books went everywhere, they were available, by the ordinary routine, to the technicians, who would not have to read between the lines.

Our secrets leaked out. However, the same thing applied in the hermetically sealed German system. It is inherent in the situation.

The only way in which secrets do not get out is if no one knows anything about them. Once it is known, it is out. The only reason they got no secrets from me was that no one knew that I had anything to do with it. The newspapers, which are always eager in trying to get stories, got nothing from me because they did not know I had anything to do with it, so they did not seek me out and they did not get the kind of denial that would mean an affirmation.

As I said, Dr. Einstein wrote me on March 7, 1940. He said that in view of our common concern in the matter, he wanted to make a report on the developments, what the developments were, since the outbreak of the war. He stated that research on uranium had intensified in Germany.

Since the outbreak of the war, interest in uranium has intensified in Germany. I have now learned that research there is being carried out in great secrecy and that it has been extended to another of the Kaiser Wilhelm institutes, the Institute of Physics. The latter has been taken over by the Government and a group of physicists, under the leadership of C. F. von Weizsaecker, who is now working there on uranium in collaboration with the Institute of Chemistry. The former director was sent away on a leave of absence apparently for the duration of the war.

Should you think it advisable to relay this information to the President, please consider yourself free to do so. Will you be kind enough to let me know if you are taking any action in this direction?

I shall skip the next paragraph. Then he wrote:

I have discussed with Professor Wigner of Princeton University and Dr. Szilard the situation in the light of the information that is available. Dr. Szilard will let you have a memorandum informing you of the progress made since October last year so that you will be able to take such action as you think in the circumstances advisable. You will see that the line he has pursued is different and apparently more promising than the line pursued by M. Joliot in France about whose work you may have seen reports in the papers.

And I have, throughout, followed the policy not only of having an expert on tap but of going to other people's experts to see what they were doing. When it came to scientific work, I was going to leave that to the scientists, I did not presume to act as a scientist. These memoranda written by Dr. Einstein, Dr. Szilard and the others, I did not presume, when I forwarded them, to act as a synthesizer for them.

I passed on Dr. Einstein's review of the situation to the President on March 15, 1940, asking for an opportunity to confer with him on the latest phases of the experimental work. That letter I have here.

(The letter referred to was entered in the record of the committee and appears below:)

MARCH 15, 1940.

The PRESIDENT,
The White House, Washington, D. C.

DEAR MR. PRESIDENT: As a sequel to the communication which I had the honor to submit to you on October 12, Prof. Albert Einstein sent me another regarding the latest developments touching on the significance of research on uranium for problems of national defense. In that letter he suggests that I convey to you the information that has reached me that since the outbreak of the war, research at the Berlin Institute of Physics, which has been taken over by the Government, was placed under the leadership of C. F. von Weizsaecker, son of the German Secretary of State.

In the realization that these further views of Dr. Einstein have a definite bearing on the favorable report submitted to you by Dr. Briggs as chairman of the committee which conferred with experimental scientists concerned and myself, I am enclosing his communication for your kind perusal. May I also ask whether and when it would be convenient for you to confer on certain practical issues brought to a focus by the very progress of the experimental work, as indicated in the concluding paragraph of Dr. Einstein's letter?

In view of your original designation of General Watson in this matter, I am transmitting it through his good offices.

Yours sincerely,

ALEXANDER SACHS.

Dr. SACHS. The reply of General Watson on March 27, 1940, was to the effect that the governmental committee was awaiting "a report of the investigations being conducted at Columbia University" and hence "the matter should rest in abeyance."

I did not feel that I could rest.

Senator TYDINGS. In abeyance?

Dr. SACHS. Yes. However, the sense of foreboding about Nazi aggression that had been voiced before the outbreak of the war—as

I disclosed previously—impelled the writer to relate the expectations of new invasions in the wake of spring to the instant project.

At the beginning of April, opportunity was afforded the speaker in the course of a visit to the White House to unfold views on the probable course of German aggression as encompassing in this war—as distinguished from the last war—the elimination of neutrals so as to secure complete control of the coast from Norway to France.

It had this bearing on the uranium project: It was suggested to require diplomatic arrangement for the shipment of uranium supplies in Belgium to the United States, instead of shipment on the eve of invasion to France, to avoid their probable capture by the Germans in their military onrush through France.

Taking the project as a whole, it was urged that instead of delimited aid in the form of specific material purchases or reimbursements for expenditures by universities, a fund be made available from governmental sources or by persuading foundations to allocate a fund in order that research could be planned on an adequate scale and on a long-term basis.

You see, I had also another thought in mind in making that provision or assertion that the late spring months were not too early for the planning of the enlargement of the research personnel.

This was because around April and May the scientists were being booked up for the next year's work in the universities, and if we did not take them then, we were not going to have them later on. So, our job was this, to divert academic talent from teaching to research, public research. Otherwise, the right kind of people, the people we wanted, would have completed their negotiations with faculties for the next academic year.

The tenor of these considerations and recommendations was embodied in an aide-memoire which was prepared in Washington and left at the White House. That was another memorandum that was left with the President to review the situation.

The fourth phase was the phase which I have called in this report, written immediately after the events, in the role which the President assigned to me, among other things, as one of the originators—what I mean was that I had had assigned to me, among other things, the job of acting as the contemporaneous historian—"efforts by the originators of the project to gain the adherence of the governmental and advisory group to organizational changes needed to attune the research to the urgencies of unfolding World War events."

The representations made to the President at the turn of the month, by me at the turn of the month, that is, in March and early April, as just summarized, led him within a few days to revert to and act upon the preceding correspondence that had been pitched in the same key.

Accordingly, on April 5, 1940, he acknowledged what had been conveyed to him by Dr. Einstein and proposed that a new conference be held in Washington between Dr. Einstein and the speaker on the one hand, and Dr. Briggs and the special representatives of the Army and Navy on the other hand.

The closing paragraph of that letter implied that the President wanted the research continued. That is, the preliminary questions about which a few in the coordinating group still retained tints of doubt were in his mind disposed of.

To General Watson was delegated the making of arrangements for the conference, but he, the President, wanted to be advised directly of the results of that conference.

Under even date, General Watson asked the speaker for a list of scientists to be invited, inclusive of suggestions by Dr. Einstein. The inquiries made by the writer of Dr. Einstein and other members of the coordinating group led to the submission by the speaker to General Watson of the requested list.

Throughout my work I was in touch with Dr. Szilard and Dr. Wigner of Princeton and Dean Pegram of Columbia and, later on, also Urey.

Following the receipt on April 13 of the two letters from the White House of April 5, Dr. Einstein was written to on April 15. The letter opened up with a statement regarding the transmission to the President of Dr. Einstein's communication of March 7 to me.

It noted a contemporaneous impression that the efforts subsequent to the President's return from the Canal Zone trip—he had been on vacation—had contributed to the decision by the President—I had gotten in touch with him in the course of that trip and he had given me certain priorities so that this anonymous representative could go through and convey messages.

The message to the President so conveyed had contributed to the decision by the President "to adopt the procedure suggested" in the speaker's original communication.

Cognizant of the resistances in the group to the proposed enlargement of the organizational framework, the speaker urged Dr. Einstein to participate in person in the forthcoming conference. However, after a conference which the speaker had with Dr. Einstein at Princeton, it became clear that indisposition on account of a cold and also the great shyness and humility of that really saintly scientist would make him, Dr. Einstein, recoil from participating in large groups and would prevent his attendance.

So, he delegated me to report for him, too.

As a substitute, I had asked him to enable me to record the consensus of views in the form of a written communication to Dr. Briggs.

That communication, dated April 25, 1940, to Dr. Briggs, which Dr. Einstein signed, referred to the discussions he had had with Dr. Wigner and myself on the progress of the work of Dr. Fermi and Dr. Szilard.

The purpose of the letter was to impart a new impetus and to suggest an appropriate adjustment of the organization side of the research to the interlinked necessities of the emergent phase of the research and of the international situations.

I should like to quote from his letter, that letter.

I am convinced as to the wisdom——

The CHAIRMAN. Whose letter was that?

Dr. SACHS. This is Dr. Einstein's letter which I brought with me to Dr. Briggs.

I am convinced as to the wisdom and urgency of creating the conditions under which that and related work can be carried out with greater speed and on a larger scale than hitherto.

I was interested in a suggestion made by Dr. Sachs that the special advisory committee supply names of persons to serve as a board of trustees for a nonprofit organization which, with the approval of the governmental committee, could secure from governmental or private sources, or both, the necessary funds for carrying out the work.

Given such a framework and the necessary funds, it (the large-scale experiments and exploration of practical applications) could be carried out much faster than through a loose cooperation of university laboratories and Government departments.

You must bear in mind that this was before the fall of France and the Government executives had no money.

We were trying to take this thing out of where it was. This was the viewpoint of those who had shown an exercise of faith, of those who hoped for assistance, those scientists, as distinguished from other scientists who were more interested in what I called, in the memorandum to the President, a "bit-by-bit procedure."

Since they realized the import and pressure of international events, they wanted the thing lifted out of the somewhat monastic type of research that goes on in universities, a slow process, on a very limited scale. They wanted, we wanted, a greater scale and a much faster tempo.

Originally, the April meeting was scheduled by Dr. Briggs for April 22, and so far as nongovernmental people were concerned was to be limited to Dr. Einstein, Dean Pegram of Columbia, and myself.

Then, by telegram of April 20, the meeting was postponed to the 27th. In the interim I begged to enlarge the group and I requested that an invitation be sent to scientists and executives in universities involved in the current uranium research.

That request was granted, as appears from my letter of May 11, 1940, to the President.

(The letter referred to was entered in the record of the committee and appears below:)

MAY 11, 1940.

The PRESIDENT,
The White House, Washington, D. C.

DEAR MR. PRESIDENT: In furtherance of your kind letter to me of April 5, the conference suggested by you was arranged and held under Dr. Briggs' chairmanship on April 27 between the governmental and nongovernmental groups concerned with the bearing of uranium experiments on national defense. With the conclusion of the first experiment, which was conducted at Columbia University by Drs. Szilard and Fermi, with governmental aid, the whole project is now entering upon a new stage. Assuming that the governmental committee will now, upon your inquiry, report in favor of further and larger governmental action, may I, in accordance with your own gracious expression of a desire to be advised of developments, submit the following considerations and suggestions:

1. With the invasion of Belgium by the very power which has organized the residue of its scientists for uranium work, the danger—alluded to in my original letter to you of October 11, 1939—that America may be cut off from uranium supplies of the Belgian Congo has increased. In addition, the successful completion of the above-mentioned preliminary experiment renders it practicable and advisable that the action to be taken shall be adequate and comprehensive.

2. Such action inherently involves not only larger financial support to be accorded by the Government but also the formation of an organizational framework under which the work can proceed with the flexibility required for a going enterprise. Interestingly enough, the latter practical aspect has been emphasized by Dr. Einstein in conversations with myself and was communicated by him in a letter to Dr. Briggs, of which I am enclosing a copy for your kind perusal and attention. In this communication you might find of interest the enclosed copies of two communications which I have received from Dr. Szilard, the first of which contains a synoptic statement of the implication of the work for national defense that was made orally at the above-mentioned conference of April 27, and the second an outline of the next tasks to be undertaken.

3. The resultant requirement for forming an organization for directing the work outside of governmental institutions and for assuring that work by scientists in the universities is carried out with due secrecy has to be dovetailed with the designation of persons to serve as trustees of a nonprofit organization that is to supervise the allocation of funds and to coordinate the various branches of the work.

4. These interlinked needs suggest to me that it would be desirable to bring one of your legal aides into the circle of discussion, along with General Watson, who is now serving so efficiently as a liaison for the representatives of the service departments and the Bureau of Standards.

In view of the urgency of a decision on these points, I should greatly appreciate conferring with you in the course of next week, at your convenience.

Yours sincerely,

ALEXANDER SACHS.

Dr. SACHS. That, then, is the background against which the conference was held, a background which was lit up by portentous international events. The second week of the month opened with the German invasion of Norway and Denmark on April 9; the third week witnessed counteroperations by the British, the landings in Norway on April 16 and April 18.

Since the concern for national defense and the survival of civilization motivated my mediation of the project between the scattered scientists and the President, it is understandable in the flux of erupting international forces that I should seek to transpose the laboratory questions to the larger theater of international policy and military operations.

Two contemporaneous crystallizations of that preoccupation are available. The first is a memorandum-letter prepared at my request by Dr. Szilard under date of April 22. The second is a self-addressed memorandum dated April 20, 1940, and bearing the title "Import of War Developments for and Application to National Defense of Uranium Atomic Disintegration."

Skipping the technical memorandum, I want to mention the——

The CHAIRMAN. Doctor, I am sorry, but we have to recess at 12 o'clock. So, if you will, we would like to have you bear that in mind.

Dr. SACHS. All right, sir; I will pick an appropriate place.

The memorandum-letter by Dr. Szilard aimed to describe the next phase of the research and its dual alternatives and their respective applications to national defense.

The first case deals with chain reactions in which the neutrons are slowed down so only a small fraction of uranium can be utilized.

In the second case, the neutrons are not slowed down and so the bulk of the ordinary uranium can be utilized. It is the latter case which has the greatest significance for national defense and particularly for the production of atomic bombs. The former significance would appear to lie in power production and would also present the complication that personnel handling such built and powered atomic engines would be exposed to the radiations.

The second alternative also presented a dual utility for concentrated power and concentrated explosives.

As to the second use, the concluding paragraph of that memorandum constitutes a most illuminating formulation:

> A chain reaction of the second type would make it possible to bring about explosions of extraordinary intensity. If, for purposes of aggression, a bomb based on such a chain reaction were set off at sea near the coast, tidal waves brought about by the explosions might lead to the destruction of coastal cities.

The coincident memorandum of the writer was concerned with highlighting the bearing of the war developments on the organizational aspects of the uranium research, and evoking applications for naval warfare with a view to throwing into sharper relief the urgencies of providing more central direction and greater adequacy of scope and speed in the prosecution of the project.

I had previously been called in to discuss what would follow, what would be the results, if control of the Mediterranean was achieved by the aggressor.

In that connection there was an idea, a coincident idea advanced by a person who had been in the Army and who was concerned about this problem, a great friend of mine, Colonel Donovan.

Colonel Donovan and myself had independently perceived this fact, which was that the Mediterranean would be significant north-south, as distinguished from east-west. We saw that the democracies would be pushed out from the continent, that the next war would push France out as a power.

This conclusion did not require great foresight, neither did it require the memory with which I had been blessed.

The French military people engaged in the last peace conference had seen that.

Furthermore, in a book to which Clemenceau wrote the introduction—Clemenceau was a layman who had his own views about military strategy—you will remember he was the man who even wrote, "War is too serious a thing to leave it solely to the military."

Clemenceau had seen that this situation was fraught with difficulty and he expressed himself on it as a layman, with complete respect to the performance of the military—the layman having the advantage that he can synthesize the military considerations with the political considerations.

Clemenceau insisted, at the Peace Conference, "If you do not give the French the protection of the Rhineland, then the democracies will have no base of operations, no base of support."

You will remember the phrase "point d' appui," which means, you might say, jumping-off place—we agreed we would not even have a support on the continent. Therefore, the significance of the Mediterranean was going to be north-south and not east-west.

Following those discussions, I broached the problem of the supply of uranium for the United States.

I pointed out that the biggest supply of uranium was in the hands of the Belgians. I pointed out that even if they sent it to France it would not come to us, that we had to open diplomatic negotiations.

Incidentally, that industrialist I mentioned, Pregel, who at that time was in France and was a French citizen, had asked his own government to make arrangements with the Belgians and he had asked it in 1939.

That prescience on the part of these refugees, gentlemen, is not any special quality in time but rather it was because they were united by a political sensitivity with their specific expertness as scientists and technologists.

Now, the memorandum which I submitted to the President opened with a description of the meetings and the work that was being done by other scientists; by the scientists in England, men like Dirac and Dr. Charwick and Lindemann, and so on. That work would be available for collaboration with research in America. In other words, there was suggested at that time the idea of Anglo-American collaboration.

In a lecture in 1936 it was foreseen that there would be developed a new source of energy; we were aware, profoundly and humanly aware, of the dualism, the good and evil in it.

The memorandum then dealt with the tendency to reservations and understatement of the results of research and their implications, the effect of which on governmental representatives was to cause them to recoil from the very suggestions that were being pressed by Dr. Einstein and me for providing a larger and more resourceful organizational framework for adequate and faster prosecution of the task.

In the effort to overcome the tempo dampening and scale dampening that that very attitude entails, and that is the attitude of conservative hesitation, proper enough in an ordinary task but not for this kind of thing, which called for what I have described as "the willing suspension of disbelief"—the speaker submitted the following observations and considerations which in a later presentation to the President appeared to be contributive toward a resolution of the organizational difficulties.

I pointed out in effect that the action was forthcoming—I did not presume to give these as my results but as my observations from reading all these memoranda. As was my habit, I did not look at it as a scientist.

> The present writer, as a nonphysicist—

this is a quotation from my memorandum—

> would not of course venture an opinion alongside those cited. But as an economic historian and as a practical economist versed in the conduct of technological research, he has ventured to convey to the scientists mentioned and to the governmental authorities his hypothesis that the difficulties which loom so large now might well arise from the characteristic physical limitations of the pre-pilot plant operations that are carried on in the typical university laboratories. If the project is fraught with promise and importance for national defense, then it seems to him worth while to approximate very soon the conditions of industrial-pilot-plant operations. This might entail the building of equipment, machinery, and even the construction of adequately scaled and adequately protected physical plant.
>
> Once we relate the uranium research to national defense, it should be regeared in type and tempo to the most advanced technological research that has been carried out by the American chemical and electrical companies.

I need hardly insert parenthetically that it was this scale of operation which was carried out with such distinction later on by General Groves. Returning to the memorandum:

> What has taken place in Poland, Denmark, and Norway, and will doubtless go on through other European countries that will be invaded, is that the pacific-minded countries have not brought their national defense up to the quantity and quality required for technological warfare. When the import of the European war is assimilated by the American people and national defense is undertaken as a national enterprise, then we may be confident that we will match in war the progressiveness of our civilan technology and come to surpass it, which means surpassing the German military technology.

In the conviction then that "an adequate organizational framework is itself the precondition for the ascertainment and effectuation of the value of nuclear research for national defense," the speaker proceeded to sharpen the possible applications of that research for naval operation——

Senator RUSSELL. What was the date of that?

Dr. SACHS. April 20, 1940, before the invasion of France.

As I say, I proceeded to point out the possible applications for naval operations, on the assumption that the war would in time become global on the part of the Axis, inclusive of Japan, against the democracies, inclusive of the United States.

In that event, the applications in the dual form of telescoped power drive and magnified explosions should aid the United States to overcome "the disadvantage under which we labor due to the enormous distances between continental United States and our possessions, and between our possessions and the Japanese homeland."

This was not war-mongering; this was adjustment to the import of events as I saw them, as I followed this phenomenal development of mass effort.

If I may quote again from the Bible, from Jeremiah: "Take the wine cup of this fury at my hand and—drink it."

I could see that we would all be engulfed; that on the Continent, only Great Britain would be left; and that we would be the only continental insular power left in the universe and that then we would have to take action.

I saw that we must not let Germany go ahead with research on the kind of weapon they were working on, a weapon whose essence is the elimination of time for the defense, the elimination of that borrowed time we all needed so badly in this war.

Inasmuch as the attempt to relate the applications to strategic and logistic configurations presupposed naval data, Dr. Briggs' good offices with Admiral Bowen and Commander Hoover brought answers to questions submitted in a letter. This letter I do not have.

Now, the sequel to this was a new stage in this progress. You must bear in mind that this is not the the linear progress that people have written about. You will remember that story in Alice in Wonderland, about the queen: You start with the end, you start with the sentence, and then you work back.

So it is when it comes to writing history. People might say, "We have got the bomb and we used it; therefore, it must have been present throughout."

There was no such straight line. It was a very zigzag line, and every bit of time and every urgency that was applied turned out to be indispensable. Every infinitesimal effort, even, became infinitely important in the course of the eventuation of what gave us the timely use of a weapon that did serve to shorten the war.

It did shorten the war, although it must be recognized that, strategically and otherwise, Japan had been completely beaten by naval and other action. They had been beaten by the Navy, by the air power. We must not, in our concern with these things, tend to eliminate the problem of the whole organization of our national defense. We needed those bases protected by the Navy to use for the bombing and that was the result of war operations by other war technologists.

However, it presents a new factor, a most vital factor—but I will not go into those questions. I will return to the history.

The conference of April 27, 1940, on organizational framework, the inadequacy we had then, resulted in new submissions to the President for a resolution of the difficulties.

The conference that was held on April 27 at the Bureau of Standards under Dr. Briggs' able and conciliatory chairmanship did serve to dispel doubts that had been entertained by some members. It also marked further progress in evoking a willingness to entertain consideration of large-scale expenditures that might run up to six figures. That was fantastic alongside the cost heretofore, the thousands that were being spent and the money that was being furnished by those who were on the margin, who were spending out of their own pockets in connection with this work in corresponding amounts.

It had begun to run into six figures. Yet the majority, accustomed to the small scale of physical laboratories at the universities and the correspondingly reduced scales of the budgets of governmental scientific laboratories, did not appear ready to design a large scale and comprehensive program, and instead insisted on "bit-by-bit" procedures with ranked preferences and time deferments.

By the beginning of May the uranium research at Columbia, which was the pathfinding research, had reached the point where expansion was deemed advisable and desirable by the whole quartet of scientists concerned—that is, the direct experimenters, Drs. Fermi and Szilard and Dean George Pegram and Prof. Harold Urey.

After a number of conferences of the speaker with the Columbia group, a sort of minute was drafted as of May 10 embodying the consensus as to the successive stages. In this case, I myself did the secretarial work. I did not hesitate to be a glorified office boy.

The first point in this minute was:

> The first large-scale experiment would have as its aim to demonstrate beyond any doubt whatever that a nuclear chain reaction could be maintained in a system composed of carbon and uranium. This would require about 100 tons of graphite and some 10 to 20 tons of uranium metal. It would also be necessary to design a rather elaborate mechanism to stabilize the chain reaction and to safeguard against overheating as well as the possibility of an explosion.

The second point was:

> The next stage is to carry out a general survey of all nuclear constants in order to confirm the values previously obtained and to narrow down the limits of experimental error beyond observed values of the constants. This would strengthen the assurance of the group in the ultimate success of the experiment.
>
> Then as preparatory ground for that experiment would come the advancing of structural details and the carrying out of techonological tests on samples of materials which have to be used in large quantities in the ultimate experiment. This in turn would require getting bids for the manufacturing of the material in needed quality and quantity.

As to quality, the problem of refinement was throughout a very grave one; it was the industrial know-how which had to be acquired, as well as the fundamental scientific research.

In financial terms, the first stage would require expenditures of \$30,000 to \$50,000; the second stage would require from \$250,000 to upwards of \$500,000.

It was the speaker's view that in the interest of time, speed, and even of economy, the second could be prepared for while the first was going on, providing that adequate funds were made available to begin with. The proposal which had been submitted for a nonprofit organization directed by a mixed board of trustees seemed particularly suited to methodical and economical direction of the work.

The lack of resolution of the organizational difficulties led the speaker to submit an analysis of the situation and resultant recommendations in a communication to the President dated May 11, 1940, together with a note of transmittal to General Watson of even date.

The point of departure was—I am coming to the end of this section, that may serve as a terminal point.

The CHAIRMAN. Very well, Doctor.

Dr. SACHS. The point of departure was that, according to the advices given to the speaker by Dean Pegram, the graphite experiment, which had been partly financed by the Government, was a success. As the communication was coincident with the German march through Belgium, the invasion having begun on May 10, the situation adumbrated in the initial presentation of October 11, 1939, had come to pass.

I mean, the situation I had presented when I stated that we should acquire uranium supplies from Belgium had come to pass.

A problem of access of uranium supplies that would be needed on a larger and larger scale had been thrust forward.

This, in turn threw into sharper relief the need for a change of the organizational framework "under which the work would proceed with the flexibility required for a going enterprise."

The President was therefore requested to designate a legal aide to facilitate the establishment of a nonprofit body which would secure the resources for carrying on the work under conditions where the tenure of the research posts would be secure and their equipment and material be amply provided for. I have in mind here that large group of scientists that would have to be brought in at that period when they were looking for other university posts.

Along with that there should be provision for the necessary secrecy as distinguished from the normal eagerness and competitiveness in early publication of indicated results.

You must see that we had a job there. Even in getting the scientists, you had to take that into account, the fact that we were preventing them from having what is the biggest asset to the scientist—the knowledge that the results of his research will get published to all when he does an important job. He would not have that satisfaction—and you have to give them an adjustment in salaries.

This was no time to delay; if we delayed, then we would be losing the scientists.

Also, at that time—this was before the invasion of France—you would have to see to it that, so far as our publications go, the scientific magazines, such as Science, and the Physical Review, and related publications, that this work, in view of the potential value and the potential danger, was not made known to the potential enemy.

Is this a good stopping point, Mr. Chairman? I could go on. What do you say, sir?

The CHAIRMAN. Doctor, the Senate meets at 12 o'clock.

Dr. SACHS. All right, let me go on, then; this is a very short part.

The CHAIRMAN. All right.

Mr. SACHS. This is part 6 of this contemporaneous history, assembled at the end, in August. This is on the basis of what had been done with these reviews that were made, it is contemporaneous with what I have developed.

The heading is:

Resolution of the difficulties and resetting of the uranium research project into the new organization established by the President on June 15, 1940 for the direction of all scientific developments related to national defense.

The CHAIRMAN. What was the date that the small-scale stage ended and that you were to go forward on the large scale?

Dr. SACHS. Between May and June it was decided that we needed to go forward on the larger scale. The appointment of a new organization, the Office of Scientific Research and Development, came, I think on June 15, having been preceded by suggestions of such a scheme as I transmitted to General Watson.

Senator AUSTIN. This was 1940?

Dr. SACHS. This was in 1940.

In keeping with the practice of full confidence and cooperativeness with the Presidential representatives from the Government services to direct the joint committee on the uranium project, the letter to the President of May 11 was given a counterpart in the communication to Dr. Briggs of May 13, 1940. That is, I did not do anything with the President without sending a copy of it or speaking about it to Dr. Briggs, as the administrator-scientist, and to General Watson, as aide to the President.

My letter to Dr. Briggs drew attention to Dean Pegram's favorable report on the graphite experiment and inferred that the governmental committee would report favorably to the President on the project. That would be reported directly to the President and I was convinced enough and could discern that it would be certain to be recommended.

Recognizing that university research is inherently characterized by a "traditional discursive attitude and leisurely tempo," the contemporaneous facts of the invasion of Belgium threw into sharper relief the requirements of national defense. Applied to this project, those requirements were for a resourcefulness of operation and an acceleration of pace and also a secrecy that could not be had in the university projects, generally carried on with limited means and in an atmosphere of mutual interchange.

And I want to say here that the scientists, Dr. Szilard, Dr. Wigner, and Dr. Einstein, were all of the same view, that there had to be secrecy against leaks to the enemy.

In furtherance of the foregoing, another letter was written to General Watson on May 15, the second and revised version of which is included here.

[The letter referred to was entered in the committee's record and appears below:]

(Revised version)

MAY 15, 1940.

DEAR GENERAL WATSON: Confirming the intimation that I had the honor to convey in my letter to the President and in my covering note to you, I have just received a letter from Dean Pegram, of the department of physics of Columbia University, stating that the initial experiment "has now been concluded with satisfactory result," and that "the absorption cross-section of carbon was found to be encouragingly small * * * only about one-third of the upper limit previously reported in the literature." The detailed meaning of that has been set forth in the letters of Dr. Szilard of May 10 and of April 22, which I forwarded to the President; a copy of the latter was also sent to you. Please advise me before any conference on this is arranged.

In connection with an independent matter having to do with economic and fiscal policies for effectuating national reconstruction and defense, I should appreciate your expressing to the President my readiness to submit certain social-minded economic ideas that had interested him in 1936 and 1934, as to incentive devices for evoking large-scale plant investment for national defense and the training and reconditioning of the requisite skilled labor. To the original proposals drafted in 1932, there was added in early 1933—when submitted for the National Recovery Act—a provision authorizing public works' expenditures for national defense, in view of the altered international situation. The ideas and proposals in connection with the original FHA plan submitted in 1933 were later expanded in the second FHA plan that, at the President's behest, was worked out for Governor Eccles' advisors. In keeping with the pattern of these earlier plans, the role of Government can be adjusted to specific requirements.

For the instant purpose, the organizational instrumentality proposed is the establishment of a Scientific Council of National Defense, composed of executives, engineers, and economists, acting in behalf of the Government, who should be invested with administrative powers for the testing and execution of technical projects of utility for national defense.

Yours sincerely,

ALEXANDER SACHS.

Gen. EDWIN M. WATSON,
Secretary to the President,
The White House, Washington, D. C.

Dr. SACHS. There was a telegram in between that letter and the revised version of it.

The letter starts out with a reference to a letter from Dean Pegram, of Columbia University, which I do not have. The substance of that letter from Dean Pegram as given to General Watson was as follows: "The initial experiment has now been concluded with satisfactory result; the absorption cross-section of carbon was found to be encouragingly small, only about one-third of the upper limit previously reported in the literature."

The main communication of the speaker contains the first adumbration of a plan similar to that later developed by the President for the direction of the scientific work related to national defense. The new suggestion was made in the setting of proposals which the speaker was evolving for submission to the President with respect to amortization and other incentive-tax devices for national defense plant construction.

It was my belief that industry had to be regulated and integrated for national defense and I had been asked to submit some suggestions and I made many suggestions in my professional capacity as an economist with reference to these problems, besides my interest in this uranium research.

For instance, in connection with the economic aspects of national defense, I make allusion here to the suggestion contributed by me under the National Recovery Act in 1933, for the inclusion in that Act of a provision authorizing public expenditures for national defense and naval construction.

In respect to the specific problem of an organizational framework that would carry forward uranium research on a bigger scale and at a faster tempo, the new recommendation of the speaker was as follows, against the background that the Government was then thinking of going to the Congress with a request for bigger appropriations.

> For the instant purpose, the organizational instrumentality proposed is the establishment of a Scientific Council of National Defense, composed of executives, engineers, and economists, acting in behalf of the Government, who should be invested with administrative powers for the testing and execution of technical projects of utility for national defense.

In acknowledging that letter, General Watson on May 16 added an observation regarding the broader suggestion for a mixed executive and administrative group for scientific phases of national defense.

The CHAIRMAN. Was that group formed?

Dr. SACHS. That group was formed on June 15; there was an intervening communication and I had received an authorization after an O. K. and an encouraging word from the President to represent the Government in negotiations with the Belgian company representatives here for the acquisition of uranium.

The CHAIRMAN. Doctor, there has just been a quorum call from the Senate and I think we will have to stop at this point:

Dr. SACHS. May I read the last stage and that will complete the whole story?

The culmination of the foregoing phases of the uranium project came on the day following the German Army's entry into Paris. On June 15 the President established a new committee for the correlation of the scientific efforts of the country concerned with the problems of national defense and placed that committee under the chairmanship of Dr. Vannevar Bush, president of the Carnegie Institution of Washington, whose name I have mentioned in the course of my discussion here. This committee included representatives of the Army and Navy and distinguished scientists and, initially, was to be attached to the Council of National Defense, in keeping with the suggestions I had made.

Accordingly, the President advised Dr. Briggs on June 15 that "since the problem on which you are engaged is part of this larger picture," Dr. Bush was requested by him to take over the uranium project and to reconstitute the committee.

Now, I make my summary. Thus was found a larger framework in accordance with the tenor of the speaker's recommendations. Dr. Bush's committee after our entry into the war became the Office of Scientific Research and Development. Associated with him and Dr. James B. Conant, of Harvard, was the General Policy Committee, which included the then Vice President, Henry A. Wallace; Secretary of War Stimson; Gen. George C. Marshall; and Army and Navy representatives. The other group of the Army came in 1942.

The uranium project as initially presented by Dr. Einstein and the speaker in October 1939, having by the Spring of the next year been reported on favorably by the testing and coordinating committee that the President had appointed under Dr. Briggs' chairmanship, was thus launched on a permanent and progressive career in the wake of our decision after the fall of France to embark on expanding defense.

From then on it became invested with the importance, the resources, and the secrecy available to the Government of the United States in defense and later in war for the translation of an idea into a reality and into an instrument of national policy in war and peace.

The CHAIRMAN. Thank you very much, Doctor.

The committee will adjourn until 10 o'clock tomorrow morning.

(Whereupon, at 12:05 p. m., the committee adjourned until 10 a. m., Wednesday, November 28, 1945.)

ATOMIC ENERGY

WEDNESDAY, NOVEMBER 28, 1945

UNITED STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to notice, at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Russell, Johnson, Connally, Byrd, Tydings, Vandenberg, Austin, Millikin, and Hickenlooper.

Also present: Edward U. Condon, scientific adviser, and James R. Newman, special assistant to the special committee.

The CHAIRMAN. We have with us today Major General Groves, who took such a prominent and leading part in this project.

We are pleased to have you with us, General. Will you go right ahead.

STATEMENT OF MAJ. GEN. L. R. GROVES, UNITED STATES ARMY

General GROVES. I have a short opening statement which I would like to read to the committee.

It is essential, in the highest national interest, that further development in the field of atomic energy be pursued under controls which will preclude the utilization of atomic energy in a way which would imperil the national safety or endanger world peace. Future activity in this field is so important to the national welfare, and potentially to the enrichment of our living, that control should be exercised by a special commission independent of any existing Government agency with the sole duty of supervising and controlling the development of atomic energy. The commission should have complete authority over all activities in the field, subject only to the approval of Congress and the President. The commission should be composed of persons of recognized ability whose actions would be unquestionably in the publi interest. Broad discretionary powers and adequate funds are essential to its success.

The War Department will always have a vital interest in the use of atomic energy for military purposes. In the field of practical administration and operation, the Army can furnish invaluable assistance. Civilian and military personnel who have acquired knowledge and experience on the project should continue to serve to the extent that their services are useful. The commission should be in complete control of policy and should exercise general direction and supervision of all activities.

Because of the current uncertainty, we are daily losing key people whose services should be retained. Until that uncertainty is resolved by the establishment of a national policy, we are not in a position to offer acceptable commitments to these key people. Prolonged delay will result in appreciable loss of the present efficiency of the vast combination of plants, scientific talent, and engineering skill.

We must recognize the clear distinction between domestic control and international control. The two can and should logically be separated. Domestic control is necessary no matter what international policy may be eventually worked out for the United States and the world. It is necessary to protect America's tremendous investment in atomic research and development and to insure that this development will go steadily forward.

I would like to discuss for a few minutes what happened when these bombs were dropped over Japan. I don't know how much repetition there is in this, but I do not believe there is very much.

The atomic bomb mission which went overseas, headed by Major General Farrell, made no attempt at Nagasaki and Hiroshima to secure or estimate exact casualties. This was not possible because the mission did not survey the cities until over a month after the dropping of the bombs.

The best over-all estimates—and these come from the Japanese as they were given to General Farrell—of the dead and missing at Hiroshima are somewhere between 70,000 and 120,000; injured, between 75,000 and 200,000.

At Nagasaki, the dead and missing were between 40,000 and 45,000, and the injured about 40,000.

The figures at Nagasaki are much better than they are at Hiroshima because the authorities were able to act after Nagasaki because it hit one section of the city, the industrial section, and did not destroy all of the city and military governments. At Hiroshima there were a number of military targets, including army divisional headquarters, an army ordnance depot, an army transport base, an army clothing depot, all the public utilities, an oil storage depot, various textile and rayon plants, and Japanese Army headquarters, the commander of which was charged with the defense of that section of Japan against American attack.

Practically everything at Hiroshima for a radius of about a mile and a quarter from the point of detonation was burned as well as blasted. Up to a radius of 2 miles from the point of detonation everything was blasted, with some damage from burning. Between a radius of 2 and 3 miles, everything was about half destroyed. Beyond a radius of 3 miles, damage was fairly slight, with roof damage up to 5 miles. Glass was broken up to a radius of 12 miles.

There were about 20 masonry and steel structures left standing in the central portion of the city. However, the interiors of all buildings were gutted and all windows were out. Few bridges were destoyed; most were left intact except for handrails and sidewalks.

In the pier area—Hiroshima was a great military port—individual warehouses were collapsed. Intervening hills protected some nearby areas from the blast. Automobiles had roofs caved in, shelters were caved, and street cars were derailed and burned. About 4 miles away a fire was started in a forest on the mountainsides.

There were approximately 20,000 army personnel in Hiroshima at the time of the bombing, of which 80 percent were casualties. The Army headquarters, which I spoke about, had 9,000 men in the headquarters; of those, 7,000 were casualties.

At Nagasaki the blow was struck in a largely industrial area, which left a large part of the residential area more or less standing. The effects of the explosion in the industrial area were probably more spectacular and startling than Hiroshima; for example, the complete destruction of the huge steel works by blast and fire, and the destruction of the torpedo works by blast alone. Within a radius of 2,000 feet from the point of detonation, heavy industrial buildings, gas storage tanks, and many reinforced concrete structures were destroyed. The steel frames in all buildings in all cases were pushed away from the point of detonation. For a radius of 8,000 feet, Japanese workers' homes were completely demolished. Up to a radius of 2 miles, workers' homes had collapsed; roofs and walls were smashed, but were left partly standing except in isolated cases where exceptional shielding was given by local topography. Up to a radius of 3 miles there was some roof damage to tiles of heavy type. Glass and plaster damage was evident up to much greater distances.

Up to 2,000 feet, 9-inch concrete walls were destroyed. Up to a radius of 4,000 feet, brick smokestacks with 8-inch walls were displaced, cracked, and overturned.

The northern ordnance plant, at a distance of 4.000 feet from the point of detonation, had corrugated iron stripped from walls and roofs, window sash pushed out and framework overturned and destroyed. These were of light-steel-frame construction.

Fire damage was heavy throughout the area. The length of the burning area was 3 miles, with a 6,000-foot width in the northern part of the city.

The Japanese listed no destruction to shipping in the harbor, which was a considerable distance away, except minor damage to superstructures, which included broken glass. There were about 100 ships and small boats in the harbor, of which about a third were 100 tons in size.

Senator AUSTIN. May I ask a question at this time, Mr. Chairman?

The CHAIRMAN. Of course, Senator.

Senator AUSTIN. Have you any record of the examination of these two areas made since the time that you are now testifying about that would indicate whether there is a residue there of radioactivity in those areas?

General GROVES. Yes, sir; and there is none. That is a very positive "none."

I would like to read a statement from an eyewitness, which goes into that phase of it.

The CHAIRMAN. General, was that because of the way that the bomb was exploded?

General GROVES. Yes. The bomb was exploded at considerable height, and for that reason there were no after-effects from radiation. There were some radiation effects at the time of the explosion; they were instantaneous. No one suffered who was not exposed at that moment, and the casualties, as far as we can determine, resulting from that were relatively small.

The CHAIRMAN. If it is a permissible question, at Alamogordo, where you exploded from the top of a steel column, there was some radioactivity, was there not?

General GROVES. At Alamogordo we exploded it at a height of 100 feet on top of a tower, and there was residual radioactivity on the ground right below the point of explosion. That was of such a nature that you could walk through it, you could spend hours in there, but I would not have wanted to sit down and make my home in that area.

The CHAIRMAN. Would you want to own some of those cows, General, that they say changed their color?

General GROVES. They changed their color, but an examination of the animals shows they were not injured in any way other than having temporary gray hairs. They were streaked with gray.

This account was written at our request by a Jesuit Father, who was on a mission to Japan. He had formerly been in Tokyo, and his school was moved from Tokyo to Hiroshima.

As you know, the Jesuit Fathers, for a number of years—and I should say centuries—have been some of our most accurate reporters of world events. He prepared this at our request. I imagine he would have prepared it anyway and sent it back to the headquarters of the society.

He is a German named Father Siemes. This is his eyewitness account:

> Thousands of wounded who died later could doubtless have been rescued had they received proper treatment and care, but rescue work in a catastrophe of this magnitude had not been envisaged. Since the whole city had been knocked out at a blow, everything prepared for emergency work was lost, and no preparation had been made for rescue work in the outlying districts.
>
> Many of the wounded also died because they had been weakened by undernourishment, and consequently lacked the strength to recover. Those who had their normal strength and who received good care slowly healed the burns which had been occasioned by the bomb.
>
> It was also noised about that the ruins of the city emitted deadly rays and that many workers who went there to aid in the clearing died, and that the central district would be uninhabitable for some time to come. I have my doubts as to whether such talk is true, and myself and others who worked in the ruined areas for some hours shortly after the explosion suffered no such ill effects.

He and a number of his fellow priests went from this outlying novitiate where they were living down into the center of the city to rescue their Father Superior who had been injured. I think they were in the ruins for about 12 hours, and from that time on they devoted most of their attention in assisting in the alleviation of the suffering, and certainly were exposed to anything anyone would be exposed to.

Senator RUSSELL. That was immediately after the explosion?

General GROVES. Within a few hours they got the word. It took about 12 hours going in and out of the city.

There has been something said of relief workers who were injured in the relief work. Those relief workers were in the city before the bomb went off, and they were just like any other inhabitants. They were in there because the Japanese had decided to evacuate all unnecessary population from Hiroshima. I think they felt that the city had been spared from bombing up to then. They did not know why, but they expected it to be bombed. They did not know it was being reserved, as it were, for this.

Senator MILLIKIN. May I ask, General, was Hiroshima on the list of cities to be bombed that were scattered over Japan?

General GROVES. No. sir; it was not on that list. That list was put out by General LeMay, and did not include Hiroshima. I don't recall whether it included any other cities that we were interested in or not.

This is again from Father Siemes' account, and is his concluding paragraph.

Senator AUSTIN. May I ask a question before you pass forward?

General GROVES. Yes, sir.

Senator AUSTIN. There was one phrase in your testimony that causes this question, and that was "as soon as he heard about it," or words to that effect. Is it true that this priest did not know of the explosion until someone told him?

General GROVES. Oh, no, sir. He was, as I recall, about 4 to 5 miles from the explosion—or maybe 3—well into the suburbs. He was standing in front of the window when this bomb went off, apparently just looking out and seeing what a beautiful day it was. It was good weather, and there had been an air-raid alert, because of these three planes that had come over, but the Japanese had decided the three planes were photographic planes, and had apparently recalled the alert.

He was standing there looking out the window when the bomb went off and he saw this terrific light effect, and was scratched around his face and hands, I suppose by flying pieces of glass.

He did not realize at the time—for he thought it went off right over his head, and to him it was just a single bomb—he did not realize what had happened to the city until the refugees started streaming by. He did not know even then, and couldn't imagine that his Father Superior who was so far removed from him could possibly have been injured.

This is the final conclusion by Father Siemes:

> We have discussed among ourselves the effects of the use of the bomb. Some consider it in the same category as poison gas and were against its use on the civilian population. Others were of the view that in total war as carried on in Japan there was no difference between civilians and soldiers, and that the bomb itself was an effective force tending to end the bloodshed, warning Japan to surrender, and thousands to avoid total destruction.
>
> It seems logical to me that he who supports total war in principle cannot complain of a war against civilians. The crux of the matter is whether total war in its present form is justifiable even when it serves a just purpose. Does it not have material and spiritual evil as its consequences which far exceed whatever good might result? When will our moralists give us a clear answer to this question?

Senator RUSSELL. Before we get away from the question Senator Austin asked, do you intend to touch any further on the radioactivity?

General GROVES. I would be glad to right now.

Senator RUSSELL. I suppose the War Department has conducted an independent investigation other than that statement submitted by the priest?

General GROVES. Oh, yes, sir.

Senator RUSSELL. The first reports coming out of Japan were naturally highly colored and stated, as you have just related, that there were thousands of people who sickened and died several days after the explosion, and went so far as to say it killed all the fish in the rivers and created havoc generally.

What did the commission find?

General GROVES. I would like to explain first what the mission consisted of.

I have forgotten now whether it was after the Nagasaki bomb or after the Hiroshima bomb that I realized that this war was not going to last very much longer. I had always thought such would be the case once we dropped one. So I assembled in this country a special group to go over to investigate what had happened in Hiroshima and Nagasaki. Some of the group came from the Marianas where General Farrell was, and the whole group went over under his personal guidance. We sent essential medical scientists of the highest repute in the United States, headed primarily by Col. Stafford Warren, who is, in normal times, one of the leading authorities, a professor at the University of Rochester.

We had the full support of General MacArthur's headquarters over there and assistance in going into these cities once we were landed in Japan.

They made very careful studies. They talked to the Japanese doctors and the military, all of whom had order and who faithfully carried out those orders to cooperate in giving us all possible information.

We are still studying those facts and figures, and I think I can make some positive statements. First, there was no radioactivity damage done to any human being excepting at the time that the bomb actually went off, and that is an instantaneous damage.

The CHAIRMAN. General, you don't make any point of congratulation on that result, the fact that that didn't happen, do you? If there was radioactivity, there wouldn't be anything morally wrong with that?

General GROVES. No; we hoped to avoid that, and we did avoid that; but I think that is something that if it was a choice between radioactivity on a few Japanese or even a number of thousands of Japanese or a case of saving 10 times as many American lives, I would go the American way on that question without any hesitation.

The CHAIRMAN. It seemed to me that the War Department had made a great deal of the fact and sought to emphasize it time after time, that there was no harm from radioactivity.

Of course, if you are simply telling the fact, that is one thing, but its very reiteration seemed to me to indicate that there was some feeling on the part of the War Department that there was something morally wrong if it had. I just wanted to get your view on that.

General GROVES. There would be no feeling, as I say, on my part, on anything that would have shortened this war by a single day.

Senator RUSSELL. My question was not intended to indicate that I thought there was anything morally wrong if the radioactivity had been very disastrous; but thousands of people all over this country are living in tremendous fear of this atomic energy and its use. I thought it would be well to develop just how far the effect of the radioactivity would go.

General GROVES. I would like to go into that, if it is agreeable to you gentlemen, now.

As I say, our facts disclosed that nothing happened of that character excepting at the time the bomb went off, and that the number of casualties from that were relatively small. Nobody knows what the casualties were or how they were made up; but all the investigations by men who were in there to investigate and get the facts, not to come out with an answer, indicated very clearly that that was the case.

Now, at the time the bomb went off, a person who was within a certain range could be affected by radioactivity; but in the normal case, he would already have been killed by the effects of the explosion or by the tremendous heat, and that is the real thing to think of. If he was right on top of the bomb, he could be killed in a dozen ways, all of them equally fatal; and as he removes himself from that exact point, certain of these possibilities are removed.

It really would take an accident for a man, the average person, within the range of the bomb to be killed by radioactive effects.

Senator MILLIKIN. Mr. Chairman, may I ask a question, please?

The CHAIRMAN. Yes, Senator.

Senator MILLIKIN. General, is there any medical antidote to excessive radiation?

General GROVES. I am not a doctor, but I will answer it anyway. The radioactive casualty can be of several classes. He can have enough so that he will be killed instantly. He can have a smaller amount which will cause him to die rather soon, and as I understand it from the doctors, without undue suffering. In fact, they say it is a very pleasant way to die. Then, we get down below that to the man who is injured slightly, and he may take some time to be healed, but he can be healed.

Senator MILLIKIN. Does that come about through treatment or through time?

General GROVES. Through time. Radioactive effects are like X-rays. They depend upon the intensity and the time. Anyone who is working with such materials, who accidently becomes overexposed, just takes a vacation away from the material and in due course of time he is perfectly all right again.

Senator MILLIKIN. Let me ask you, would the effect be different had the bomb exploded in the ground?

General GROVES. If the bomb had exploded on or near the ground, that is, within a hundred feet or so, the effect would have been the same as at New Mexico, I believe; there you would have had lasting effects for a considerable period of months. You would have had a considerable number of radioactive casualties, and I think that you would have had an area which should have been banned from traffic.

The first mission given to our organization that went over there was to determine that the cities of Hiroshima and Nagasaki were 100 percent safe for American troops, and to know absolutely that that was a fact so that the men themselves would know that everything was all right.

Senator MILLIKIN. General, can you tell me the largest size regular bomb that was used in the Pacific area at the time of Hiroshima and Nagasaki?

General GROVES. No; I really do not know, Senator.

Senator MILLIKIN. Can you give us a reference point, some sort of bomb that was in use, and tell us how many of those bombs it would have taken to produce the same result in those cities?

General GROVES. I am sorry, I cannot tell you exactly. I believe that at that time they were using against Japan a bomb which must have had about 1,000 pounds of explosives in it; against Okinawa, possibly up to 10,000 or 15,000 pounds of explosives. I may be in error on these figures, but I can tell you that taking the heaviest type of bomb they had that a rail of a thousand planes would not have been as effective as this one bomb in actual damage done to the cities—no comparison.

Senator MILLIKIN. One thousand bombs of the type they were using would not have produced a similar effect?

General GROVES. That is correct. At Tokyo, which had been bombed repeatedly, and I don't know how many times or how many bombs were dropped there, there were a great many burned-out sections, but it also had a great many usable sections. The casualties at Tokyo I understand are greater than they were at Hiroshima or probably as great as in both of these bombings, but the effect was not the same.

Senator MILLIKIN. Are the cities comparable, so that you could draw a comparison?

General GROVES. In physical damage, I would say that it would take maybe as many as 2,000 planes to equal the effect of 1 of the bombs; but in the effect on the people, there is a much greater effect. I think the Japanese officer who was assigned to aid General Farrell at Hiroshima presented that thought in the best possible way. He stated that when it cames to the fire bombing of Tokyo and the high-explosive bombing, there was something you could do about it—that the bomb fell and you took your chances; a small number of people were killed with each bomb, and you could get out and save some of your property. In general, it was something that you could stand up against. But he said when it came to the Hiroshima bomb it was unendurable, and I think that is the real statement; that it is an unendurable bomb to anyone, and particularly to someone who did not know it was coming. How much the surprise element had to do with our success I don't know, but I am a great believer in military surprise, as is everyone; and this was the greatest surprise since the Trojan horse, and it ended a war just as suddenly.

Senator MILLIKIN. May I ask you, what was the percentage of loss on our plane flights in that area?

General GROVES. I do not know, Senator. Due to the cooperation of various services, such as the Navy Special Rescue Service, and the supreme care that was exercised, I think that our loss rates were getting better all the time. After all, these planes were flying a tremendous distance, and just in the normal time of flight they were bound to have accidents. How many men were lost there, I do not know.

Senator MILLIKIN. Passing the question of time in shortening the war, I was trying to determine the lives that we saved just in point of the air missions that would be required to produce the same amount of damage.

General GROVES. In that, I don't know that you could get a real figure, but I think we could get that from the War Department for the record if you would like to have it. I think that the real saving in life came in regard to the attack on the beaches. The Japanese, from all that we can find out, had no intention of quitting this war even if we had bombed by normal means and destroyed every city in Japan. The people on the beaches of Kyushu, in the caves there, were perfectly prepared and expected to stand there and die—men, women, and children—and take as many Americans with them as they could.

Senator MILLIKIN. Your point is that the pyschological effect created by this bomb served to pull them out of the war, whereas the same amount of damage, the same number of casualties produced in other ways might not have pulled them out of the war?

General GROVES. That is absolutely correct.

Officers I have talked to, who have toured Japan under the conditions as they are now, state that this bomb created a fear throughout all of Japan that was just indescribable, and that that was the first real propaganda that they could understand; maybe they had gotten a lot of leaflets, but this was something they could understand, and it went all over the Japanese press, and they knew that it was the end. Of course, it was a tremendous point for the Japanese Government and the ruling classes to lean on as a face saver to get out of the war.

Senator MILLIKIN. Thank you very much.

The CHAIRMAN. You and I have talked about Churchill's estimate of what he thinks was saved this country and England.

Do you agree with his estimate, and will you state it for the record?

General GROVES. As I recall, it was 1,000,000 Americans and 250,000 British. I don't know what the basis of his estimate is. I think probably that it is a little high.

All that I can say definitely is that probably, if you figure on the number of divisions that had been announced as making that landing, and think of the number that were on Okinawa and that this was the homeland, you can estimate quite properly that the casualties that would have been suffered—and I am speaking of the serious casualties, not the ones that are just for a day or two and not the ones who are disabled for life due to illness of various kinds—could well have numbered into the hundreds of thousands, possibly up to Churchill's figures, and certainly enough so that everyone who had a boy over in that theater, or expected to have one, was dreading the day of that landing on Japan. I don't think that that dread was unjustified at all.

Certainly, the military authorities in their plans and in their estimate of the situation never felt that the landing on Japan would be a push-over in any sense of the word. They felt that they were going to fight to the last cave.

Senator VANDENBERG. What was the Hiroshima date, General?

General GROVES. August 5.

Senator VANDENBERG. And what was the date of the test in New Mexico?

General GROVES. July 16.

Senator VANDENBERG. So that as soon as this bomb had been developed to your satisfaction as a success, there was no delay in its use in the war itself?

General GROVES. There was no delay. I would be glad to tell you of the delays that we had from the time that we could have done it. The whole bomb depended on when we could get the material. The mission that I gave to the scientific laboratory at Los Alamos, N. Mex., under Dr. Oppenheimer, was that I wanted a test of that bomb as soon after we got sufficient material to them for the test and it could be processed and put into the bomb. My recollection is that they were 3 days late. In other words, they had a few things that they had not solved ahead of time. That mission had been given to them over 2 years before. I felt it was a master performance on their part.

Part of the bomb for Japan was sent over there, as you know on the *Indianapolis*, and part of it followed by air. The bomb was ready to be dropped, or could have been ready to be dropped on the 31st of July. It had to be assembled overseas in part. We had to wait for weather, so that it was really from the 16th of July until the 31st, and in that time we had to assemble enough material and ship it.

Our production of material was going up on a very sharp curve, and we had enough for the first time. The delay in the use of this bomb was 5 days, and that was due to weather.

Senator VANDENBERG. Up to July 16, you had not been prepared to proceed?

General GROVES. Oh, no, sir. We did not have enough. We couldn't. In other words, we could have fired our first bomb on July 16, and the second on July 31 in the Marianas. If we had had a second test in this country, which we would not have had under any circumstances, that could have saved the time of travel from the United States over there of about a week. So that the second test could have been on July 24.

Senator VANDENBERG. So that completely dissipates the stories that were general in this country, that there was a long and substantial delay in the use of the bomb for international political reasons?

General GROVES. Those stories are completely without basis in fact.

Senator HICKENLOOPER. General, coming out of the Los Alamos test were the stories of the effect of the flash and the light on the eyes of the observers at great distances.

Did the priest who wrote this report make any statement as to any effect on his eyes at that comparatively close distance?

General GROVES. He did mention that eye effect and talked about a girl who was much closer than he was, and how she was blinded temporarily from the flash just as you are if you happen to look at a welder on a street-car track as you drive down the road. You are temporarily blinded, but your eyes soon recover, and you are all right.

We have had no results that I know of that indicated any real eye effect. There would possibly be some, but if they were minor, just a few, I would not know it. There were certainly not any great number or I would have known it.

Senator HICKENLOOPER. It seems to me I recall from reading some of the stories that have appeared in articles and in the newspapers that the observers at Los Alamos were unable to view the first flash even through darkened glasses.

General GROVES. That is correct. I think the best example of that were the observers who, I believe, were 27 miles away. Those were the observers who had worked with it and were not necessary to the test, and they had a vantage point out there. They were provided with the equivalent of welders' helmets with the glass that is in them, and they could view the explosion through those.

The ones who were looking directly at it at the time of the explosion, which were approximately 90 percent, were just sort of temporarily blinded just as you are when a flashlight bulb goes off, just that same feeling, and the result was that they could follow right along and see what happened. Some of the men in their excitement, having had 3 years to get ready for it, at the last minute forgot those welders' helmets and stumbled out of the cars where they were sitting, and did not have the helmets in front of their eyes. They were distinctly blinded for maybe 2 or 3 seconds, and in that time they lost the view of what they had been waiting over 3 years to see.

Senator HICKENLOOPER. How far away were they?

General GROVES. About 27 miles, as I recall. It may have been 20, but I think 27.

I was at 10 miles and looked at it as soon as I could turn around after it went off. I looked at it through dark glasses. That was probably a fraction of a second, or maybe a little bit more. At that time I could look at it, and it was perfectly all right through a piece of smoked glass.

Senator RUSSELL. What equipment did you give the crew of the plane that carried the bomb?

General GROVES. They had special glasses of the polaroid variety that they could twist to change from almost full light down to no light at all, and they were supposed to be screwed down to the complete no-light basis.

Senator HICKENLOOPER. It seems curious that this priest could be 4 or 5 miles away from the center of this explosion without anticipating it and suffer no particular ill effects from his eyes.

General GROVES. I think the answer to that is that when we saw the thing go off in New Mexico, although we had figured out and told ourselves that we were going to have this tremendous light and should watch our eyes and all of that, we did not really believe it; it was so far beyond the human experience, seeing this tremendous light in the sky, that it just gave you a strength of light many times that of daylight, so we over-emphasized that effect and thought it was more dangerous than it was. In the same way, it was so overpowering that I was not particularly interested in the blast or the noise effects of this explosion. In other words, most of us lost the keenness of observation that we should have had for such a thing because we were so dumbfounded by this light effect, although we had expected it and said, "That is what is going to happen."

Senator MILLIKIN. Can you tell us of the heat reactions, if any, felt by the observers in New Mexico?

General GROVES. The only heat reaction that I recall was just a sort of warm glow. Some people claimed they felt it on the backs of their necks. We were all lying on the ground faced away from the explosion, and they claimed they felt some; but I did not feel any.

Of course, for a considerable distance around all the vegetation was seared off. There wasn't any left.

Senator MILLIKIN. What is the heat generated at the moment of explosion?

General GROVES. I would prefer not to answer that in open hearings, sir.

Senator MILLIKIN. Let me ask you one more question.

In your opinion, had Japan lost the war strategically at the time of the bomb?

General GROVES. I think Japan lost the war—and of course I am not speaking for the War Department here—at the Battle of Midway, but they didn't know it and would not admit it, and their people did not know it. It took something to knock them out of the war. They were still fighting, and they had no expectation of quitting even if they had lost the war.

The CHAIRMAN. General, it occurs to me that some foreign agent might spread this radioactive material around a city, and you would not know it was being spread because you could not see it, and it might kill a whole population.

General GROVES. You would know it, because everybody who used X-ray film would know it was all fogged, and you would have almost immediate warning because they are using X-ray film constantly. Every person with a camera would find it out as soon as he tried to develop a picture. The photographic film would tell you immediately.

The CHAIRMAN. Suppose some enemy were to drop an atomic bomb or atomic rocket on you. Would there be any danger of radioactivity?

General GROVES. If they dropped one on a city and exploded it close to the ground, there would be radioactivity there that would have an effect.

The CHAIRMAN. Do those rockets that the Germans used over London explode near the ground?

General GROVES. I don't know just where, but some exploded, I believe, on landing. I don't know where most of those exploded, but I believe the world knows today that the way to get maximum explosive effects is to get up in the air, depending on the size of the explosion. For that reason, if they want explosive effect, they will certainly set it off up in the air.

If we had set that bomb at Hiroshima off when it hit the ground, the damage would not have been nearly so great. It was designed to be set off so as to give us the maximum possible explosive force.

The CHAIRMAN. I think those rockets that went over London exploded on contact. If they were loaded with atomic material and it spread out, there would have been considerable danger then from radioactivity?

General GROVES. There would have been considerable danger, but the total damage done to London would have been much less than if the rockets had been exploded in the air; so the real fear would have been in the case of a fuse that did not work and did not go off when it should have up in the air, but then would have been a much less favorable result from the explosion. I say "less favorable" from the standpoint of the enemy dropping it.

The CHAIRMAN. General, relating the bomb to approximately the same size that was sent over Hiroshima, suppose one dropped upon Washington. Could you estimate the amount of damage and relate it to Washington?

General GROVES. Related to Washington, if that bomb had been dropped, say, in the center of the Pentagon, there wouldn't be any Pentagon left.

The CHAIRMAN. That is a big result.

General GROVES. That would have far-reaching consequences.

If it were dropped in what would probably be the goal of any enemy dropping it in Washington, so that it hit on the Federal triangle and destroyed the offices of the Government, it would have destroyed an area maybe 2 miles in diameter so there wouldn't be much left there.

Of these big Federal buildings that are well built, many would have their walls standing. All of the limestone and marble on the facing would have been blown off. There is not much question of that, but the concrete and steel structure might still be standing.

All interior partitions would be gone; all the windows and window frames would be gone, and in general you would have a number of buildings standing just as you see them in the picture of Hiroshima, everything flat in between, and maybe 2 feet deep in rubble of all varieties, with these walls standing there but absolutely unusable.

The normal house that most Washingtonians live in would be completely destroyed in that area. It wouldn't be findable.

The area of real damage, where there wouldn't be much left, would have extended from the Capitol to the National Cathedral at Massachusetts and Wisconsin, or something of that general order.

It would have gone over across the river into the Pentagon area, and have blown out all the windows and window frames of the Pentagon, and probably blown out most of the interior partitions. It would not have destroyed the Pentagon, but it would probably have done a tremendous amount of damage.

Senator VANDENBERG. It wouldn't have wiped out our deficits, would it?

General GROVES. I think it would have taken the Treasury out, excepting the lower vaults; but, in general, there just wouldn't be anything left.

You would have found all of your headquarters in municipal government would be gone. At Hiroshima, as a rule there were about 400 firemen in the town, or 450, and about 25 were left fit for duty immediately after the explosion. That is typical of what happens to all your municipal affairs.

In the United States, it would have taken probably about 30 minutes to start organizing relief, and every man that could walk would be helping someone else. The Japanese did not handle it that way, and that built up their casualty lists.

The better disciplined our people are—that is, the fact that they know such a thing might come now automatically gives them a defense against it—and anything that is in the nature of an organized body gives still more power to resist and to lighten the losses that occur in such a catastrophe.

Senator VANDENBERG. General, if you had to start from zero today, with nothing except your experience and knowledge, how long would it take you to produce a bomb?

General GROVES. You mean with the same full authority I have had in the past?

Senator VANDENBERG. Yes.

Senator CONNALLY. Do you mean with the installations?

Senator VANDENBERG. No; I mean all installations are out; he has got to start at zero.

General GROVES. But knowing what we do today?

Senator VANDENBERG. That is right.

General GROVES. I would say if we had complete authority and freedom from interference by suggestions from lots of people, we could do it in probably 2 years' time as compared to the almost 3 that it took us.

If we had that interference I think it might take anywhere from 5 to 10 years, because it is so easy to say, "We have got a better process; you should build the better process and get more efficiency, or you can do it faster," or something else, and by the time you get through settling those matters, the time has gone.

Senator VANDENBERG. Would you be willing to state what our total investment in atomic energy is up to this time?

General GROVES. I would be willing to state, but unfortunately I do not know the figure. I should say, offhand, the figure of $2,000,000,000 that was given in August was very close. I think by this time it is probably about, I should say, a little over $2,000,000,000, maybe $2,100,000,000, something of that order. I would be very glad to supply that figure.

Senator VANDENBERG. Would you state the total employment in the United States on this enterprise?

General GROVES. The maximum direct employment either by us or our contractors who were working directly for us was 120,000 peak.

There were, in addition to that, all the suppliers of goods who were furnishing on a unit-cost basis. These are not included in that; it might make up a total of 200,000 people, maybe 225,000.

With respect to the operational forces, operating our establishment, the peak of those was somewhere in the order of about 55,000—between 50,000 and 55,000.

Senator VANDENBERG. Now, in dealing with the problem we have to consider, among other things, that we have some Federal cities on our hands, have we not?

General GROVES. Yes, sir.

Senator VANDENBERG. Will you state for the record what they are and, very briefly, what has been done there?

General GROVES. At Oak Ridge, Tenn., we have a town, or a city I think would be a better way to put it, which had a maximum population of 78,000. We have discontinued certain work down there, trying to economize where we can, remembering that money is now controlling where time was before. So that I should say that it would compare in size with the normal city, residential city of, maybe, approximately 50,000. That is 100 percent a Government city.

Senator VANDENBERG. That is the city you built right up from the ground?

General GROVES. Yes; right up from the ground in every way, including every facility considered to make up a city—amusements, stores, and everything else.

Senator VANDENBERG. And the Federal Government owns the whole thing?

General GROVES. The whole thing is owned by the Federal Government; yes.

Senator VANDENBERG. What else?

General GROVES. Hanford, Wash., at Hanford Engineering Works, at what was the site of Richland, Wash., a small town.

There we have a city which is designed to house, I believe, about 5,000 workers and their families. Just what the total population is, I cannot say. I imagine it would be about 15,000 to 18,000. The houses there are different from the ones which you saw in Tennessee. They are probably of better construction but they were also cheaper to build because of the locality.

Senator VANDENBERG. Now, is that a Federal city?

General GROVES. That is a Federal city, the same way, on Government property, everything owned by the Government.

At Los Alamos, N. Mex., the town there is more like the normal military reservation. It has housing for married people and it has quarters for bachelors and the unmarried. It has a large military population, mostly enlisted men who were young scientists who came into the Army and whom we picked out by reason of their records and brought into the work. They were people without whom we could not have done this job. We had a total of about 3,500 of these men out there at Los Alamos.

Our problem there is much more serious than at the other two places. We can house the people we need at the other points but we cannot house them at Los Alamos,, the people we should have there right today.

They were brought in there during the war but they will not come in time of peace without some provision for their families and we are faced now with what we are going to do with that establishment.

Due to the uncertainty we are losing the people; we are faced with a very desperate situation.

That laboratory was designed to develop the bomb, all the theory connected with the bomb, the designing and the engineering of it, and to take the pieces that were made elsewhere, as well as some that were made right there, and assemble them into the final bomb; to do some of the final processing of the material as it came from these two plants.

Generally, that laboratory was to develop all the technical details that went into our operations overseas. They furnished the men who were our technical detachment overseas, which was a combination, like everything else in this project, of the American people, made up of Army officers, enlisted men, Navy officers, and civilians, both scientific and highly skilled mechanics of a type that is far beyond what you would normally refer to as a skilled mechanic.

Senator VANDENBERG. Now, is it your contention, General, that in the adequate continuity of developing atomic energy, it is going to be necessary to maintain all these enormous installations?

General GROVES. It is going to be necessary from the standpoint of—but before I answer that, I would like to add that, in addition to those things that you have generally been made aware of, we have certain laboratories that are Government-owned. We have one in Tennessee, which you went into that afternoon. That is a very important laboratory. We have one near Chicago, in the outlying districts of Chicago.

The CHAIRMAN. That is the Argonne?

General GROVES. The Argonne; that, also, is a Government laboratory, although it has been operated for us by the University of Chicago.

Then, we have these various laboratories in universities where, while they are university laboratories, we have been supporting them. We will have to continue to support them if we are going to stay in the lead in this field, because the universities cannot afford to support them, in the first place. In the second place, the universities will not wish to work on certain problems we are vitally interested in, because they are not of particularly scientific interest as a whole.

The CHAIRMAN. Is that not the reason, General, that you have lost some of your personnel?

General GROVES. Oh, yes.

The CHAIRMAN. Some of these scientists who have done a wartime job of making an explosive will want to get back to something that they consider a litle more constructive, will they not?

General GROVES. They wish to get back to the type of life which they chose as young men. They chose to be academic scientists because they like the life. When a man chooses his profession considering all the financial rewards and considering how hard he is going to have to work, and considering the surroundings, and he chooses an academic profession, he would like, in the main, to get back to it. They still feel that the academic profession is more attractive.

The CHAIRMAN. General, going back——

Senator VANDENBERG. Excuse me. Can we have an answer to the question, General?

General GROVES. Did I dodge it? I am sorry.

Senator VANDENBERG. No; you wanted a little more prefix to it. You remember what my question is?

General GROVES. Yes. I would like to amplify a little the situation I am faced with at Los Alamos.

There we are trying to establish this scientific laboratory which will be of a highly secret order. It will have there the heart of the weapon and everything else, as it has in the past.

In order to have scientists of the caliber we are getting—we are getting good men there despite all the handicaps that we have in getting men—we are not getting some of them, we are losing some we would like to keep, but we are getting good men and we hope that we will have an operating laboratory.

To get those men, we are having to encourage them to come and we are encouraging them in two ways.

The first way is that, in addition to working directly on this weapon for us, they are going to be given the equipment and they are going to be given the time to engage in certain fundamental research that they would be doing if they were back in their home universities. That is part, as far as I am concerned, of their salary. We are merely giving them that much time to do the work that will enable them to keep on doing our job with the fullest of interest.

These men have very active minds, they border on the genius type and unless we do that, we just cannot keep these men, we cannot keep them doing it willingly and with pleasure and, I think, with efficiency. In other words, we cannot keep them working toward one goal all the time without ever taking their noses off that particular grindstone. They should have that opportunity of doing their own work, and we are going to furnish that.

We are also going to furnish them with housing that will enable them to have their families there and to have the proper housing for the supporting cast, which is enormous.

These scientists will need the technicians; they will need the technicians to do the wiring for them, so that they can devote their time to what they are being paid for, which is scientific endeavor and not the rigging up of their own experimental equipment. This is the custom in most university laboratories. You see these very high-grade men having to spend time worrying about wiring up things that they could buy if the budget permitted them to buy.

Now, what we have to keep operating, in my opinion, at the present time is this:

We have to keep operating everything from the standpoint of having a sufficient supply of bombs on hand until somebody makes up his mind as to what is to be the future of this work.

If we shut down a plant, there is no telling what the cost of that shutdown will be. It is possible it can be restored in 6 months' time, that the cost there would be five million or ten million dollars.

How long it will take us to get the personnel back even in time of war is a question. We, of course, have our lists of everybody who worked or is working for us and, naturally, we would send out and call them and get them back.

But we do not know about the equipment. We have never shut down a plant like this. We are shutting down certain sections in our plant in Tennessee and we are shutting down the sections that we feel aid the least and the shutting down of which would enable the greatest saving in money.

In other words, if we can save 35 percent of our money, maybe we will only lose 10 percent in production.

However, when it comes to shutting down the remaining works at Tennessee or the Hanford Engineering Works, we are making a decision that cannot be easily corrected—in fact, a decision which may not be possible of correction. I do not know whether certain of these buildings and equipment could be shut down without having to replace certain parts. I know that we would have to replace certain parts; just how many, nobody knows and nobody will know until we shut down and try to start again.

It is not like some other weapons, like a gun which we can cosmoline and put away and say that we can always clean it up in 30 days and we would have that gun in shape. We cannot do that.

We cannot shut down the Los Alamos laboratory and ever assemble a laboratory like it again, except in time of war. We cannot stop our work at the Clinton laboratories and start up again because we would have lost the personnel—there is not much in equipment there.

With regard to the work at the Argonne, we would lose the momentum we now have and it would cost a tremendous lot of money if we had to get that momentum back.

Senator VANDENBERG. How are you operating? Are you still operating under war appropriations?

General GROVES. We are still operating under war appropriations and those appropriations, of course, run out next July 1.

Senator VANDENBERG. Have you made a budget estimate for the next fiscal year?

General GROVES. No, sir; I have not, because I had hoped that that would be done by some other agency.

We are preparing now, in view of the fact that legislation has not been passed, we are starting in now to get together a general idea of what it will cost.

I cannot possibly give you any figures today, because we are still trying to decide what is going to be done on the major decisions, the ones that will affect us for 5 and 10 years. We cannot do that until we have somebody who will make up his mind about it.

Senator VANDENBERG. So, if I understand you, speaking generally, you would anticipate not only the desirability but the basic necessity of substantially maintaining your present establishment in peacetime?

General GROVES. Yes, sir; as it now stands. That is, with the reduction we have already made in Tennessee and with a distinct saving in personnel as time goes on, because we are getting savings. Naturally, we are watching and seeing where we could do with less personnel. As we learn more about the process we are able to do that and as the time factor becomes of less importance, we are also able to do a great deal more.

For instance, we no longer have to rush materials through; we can take our time about it and it does not cost us anything to have material in process, whereas before it was costing us days of war.

Now it merely means we can get it any time; but the pressure of time is gone.

Senator VANDENBERG. Speaking generally, is this going to be a billion dollars a year, half a billion, or do you have some figure in mind?

General GROVES. I would hate to speak because you might remember the figures [laughter] but I should say that it will be less than a half billion.

Senator HICKENLOOPER. I was just wondering, General, with regard to this matter of safety. How long would it be safe for a fellow to walk around with a radioactive dime in his pocket?

General GROVES. I don't know, Senator.

Senator HICKLENLOOPER. Do you think it would be safe?

General GROVES. I wouldn't carry it. [Laughter.]

Senator MILLIKIN. General, am I correct in interpreting your remarks to the effect that you favor the maintenance of the essential parts of your set-up until Congress decides upon its policy?

General GROVES. Yes, sir.

Senator MILLIKIN. You are not advocating a permanent maintenance?

General GROVES. No, sir; I am not advocating its permanent maintenance; the permanent maintenance of the essentials of our present organization.

I am advocating it until such time as Congress passes some legislation. I am advocating it beyond that point to the time when the body that is given the responsibility over this thing has a chance to really understand what problems it is going to be faced with.

Senator VANDENBERG. Regardless of what kind of action Congress takes, is it your view that it is necessary to maintain it? If I understand you, if we are to maintain our momentum in the field of atomic energy, regardless of what Congress does, you say it is going to be necessary substantially to maintain an institution approximately of the present magnitude?

General GROVES. No; I think that it is possible that that can be cut considerably in magnitude, within a period of, say, 2 years.

In other words, our first problem is to get adequate supplies on hand and then we will be in a position where we can say that now we can start cutting down on that establishment.

Senator AUSTIN. May I ask a question?

The CHAIRMAN. Certainly, Senator.

Senator AUSTIN. In your view, does it make any difference, with respect to this minimum amount of facilities, whether the ultimate control of this production is in the hands, you might say, of an institute that is operating as a private enterprise, with its own horde of trustees that are self-perpetuating and thus released from Government; or whether it is to be continued to be operated by Government through some agency set up for that purpose and always under the control of the Government?

Whichever role we should decide to take, whether public ownership or private ownership, there is a minimum below which we cannot afford to drop, in your view. Is that right?

General GROVES. That is correct; but I cannot imagine the Government failing to continue to have a controlling voice in this problem because it involves the whole existence of the Government and of the people that make up that Government.

Senator CONNALLY. General, at that point, I assume that your theory is that it is no more necessary to keep an Army and Navy than it is to keep other essential war or aggressive agencies and weapons in a distant part of our national defense. Would you not say that it is just like maintaining—spending hundreds of millions of dollars—maintaining the Army and the Navy?

I assume that your idea is that so long as this thing has all its potentialities it is pretty well demonstrated to be in the interest of the Government to maintain these plants and control this instrumentality until some new policy is adopted; is that right?

General GROVES. I think that this is an integral part of our national defense.

Senator CONNALLY. That is right.

General GROVES. And it is not only an integral part but it is absolutely essential to our avoiding national suicide.

To me it is not a substitute for the Army and Navy, but it is certainly part of the integrated force—I hope a well-balanced force—of whatever is needed to protect the interests of the United States.

Senator CONNALLY. I would like to ask you this question. Furthermore, would it not be wholly impracticable to turn this over to any private corporation? Do you not think that the Government itself ought to keep the whole of it?

General GROVES. I feel that this is so important that it must be retained under complete governmental control and that private industry should have no rights whatsoever with respect to this, excepting those rights that can be given without interfering with the welfare of the United States.

Senator CONNALLY. Thank you.

Senator TYDINGS. Have you any estimation offhand as to the number of employees that you think would be required to operate permanently the establishment that you describe, beginning 2 years from today?

General GROVES. I should say offhand that it would get down below 35,000.

Senator TYDINGS. For all these plants?

General GROVES. For everything.

Senator TYDINGS. How many do you have now, roughly?

General GROVES. Roughly, we have now, I believe, about 45,000.

Senator TYDINGS. So all you see in the picture is the possible reduction of about 10,000 employees when you reach the 2-year level which you have described?

General GROVES. Yes; but I also see a great reduction in the subsidiary employees who are furnishing materials of one kind or another, so that the impact on the country will be less.

Senator TYDINGS. Are they Government employees or private?

General GROVES. You mean on furnishing those materials?

Senator TYDINGS. Yes.

General GROVES. Private.

Senator TYDINGS. So that the governmental picture as of today is 45,000; and you see it 2 years ahead from now as being about 35,000?

General GROVES. The governmental picture is a lot more than that at the present time. I was speaking of operating only. We are still trying to finish certain things which are almost finished so that we will have a well-planned process.

Senator TYDINGS. What I am trying to get at is: What is the over-all governmental picture—governmental employees as of today and what you think it will be in 2 years?

General GROVES. I should say the over-all governmental employee situation is that we will cut it almost in half within 2 years. It is about 70,000.

Senator TYDINGS. And you think that 2 years from now, if the plan you have in mind is carried out, it will be 35,000?

General GROVES. I think under 35,000. As I said to Senator Vandenberg, I hate to submit my successors to something that will be worrisome in the future.

Senator VANDENBERG. Well, is this figure you are making a figure that would include the operation of the Federal cities?

General GROVES. Yes, sir.

Senator VANDENBERG. And it includes the necessary employees for that purpose?

General GROVES. Yes, sir.

Senator TYDINGS. May I ask you one other question? The expense of operating that plant today, the over-all governmental expense of operation today on the 70,000-employee basis, plus the cost of acquiring materials, and so forth, the operating of all the plants you now have, how will that figure compare with your figure for 2 years from now? Will it be the same cost, will it be half, one-third, or two-thirds, in your opinion, of what it is today?

General GROVES. I think it will go down to probably half or two-thirds.

Senator TYDINGS. You mean it will go down two-thirds?

General GROVES. No, sir; it will be, at the end of that time, between 50 and 60 percent of what it is today.

Senator VANDENBERG. That is, without inflation? [Laughter.]

General GROVES. Of course, if you are going to raise all the civilian salaries we had better make it all military, so that the pay rates won't go up. [Laughter.]

Senator VANDENBERG. General, I would like to ask you one more question—if I may, Mr. Chairman?

The CHAIRMAN. Yes, sir.

Senator VANDENBERG. Assuming an international decision to outlaw the use of atomic energy for miiltary purposes, in your opinion could the world be successfully policed in respect to that objective?

General GROVES. I don't know. It all depends on what the attitude of governments is. I don't think it could be policed as of today unless the United States is ready, on the drop of a hat, to start an offensive, aggressive war against somebody who has taken the first step toward preventing the inspection that will be necessary.

I don't think—you are really getting me out of my field—but personally speaking, as an individual—I don't believe that the people of the United States would ever be willing to enter on an aggressive war to destroy another nation because some agent of the United States Government said that he was not allowed to go and look at a certain city because they said, for example, that the roads were bad or they had an epidemic of smallpox in that area.

Now, that is what we are faced with. We have got to have inspectors who can go everywhere, who can go into every man's house—not quite into every man's house but, in general, nose into everyone's business throughout the world.

Now, we can do a lot and be reasonably certain that things are going on as they should be by other means, maybe, by watching certain trade movements and the like. But it is impossible, unless you have complete and free access to every nation in the world, a willing access of the type that we give any foreign national in traveling in this country in general. It will be necessary also to have that access include every one of our industrial plants. It will be necessary for them to poke into all the rooms where we are developing a new piece of commercial equipment and it will be necessary to have the shrewdest and sharpest people to do that job.

It is awfully hard to think of anyone who is of that caliber who could ever forget his national loyalty. I certainly would not be willing to recommend any man that I thought was capable to be one of these international inspectors who would forget for one minute that he was a United States citizen with all the loyalty that means.

Now, of course, I have been educated and brought up on the United States' first principle.

The CHAIRMAN. Just a minute, General. That implies that the inspector you would recommend, if he found in the making of a joint inspection in this country that, we will say, in the laboratories of one of our big corporations that there were some secret works going on—is it your thought that you would reprimand that man if he reported to an international inspection service what was going on in that laboratory?

General GROVES. You mean—no; I would not reprimand him. I just say that if I were that inspector I would always be thinking about the United States, as well as the international organization.

The CHAIRMAN. You would also think about the obligations that the United States undertook, to open up to an inspection service, under a solemn agreement that they would? You would reprimand this United States inspector who was a member of an inspection panel of, we will say, six members who joined in a report, we will say, to the United Nations Organization that there was some secret atomic-energy work going on, we will say, in Princeton, N. J.?

General GROVES. No; but I would hope not to have anything to do with it, Senator, myself, personally.

If there were secret work going on in the laboratory of one of our big commercial organizations and that secret work involved, say, a new design of an automobile that was being kept secret for trade purposes, I would hate to be a party to encouraging some foreign commercial spy in getting information about that. It is so hard to draw the line as to what is atomic energy and what is something else.

The CHAIRMAN. We are talking about atomic energy, weapons of war, and not automobiles.

General GROVES. But, to me, it means this: As I say, any inspection service has got to be free to go into every crook and nook and cranny of the United States, to be certain that any work being done is not work on atomic energy.

That means that we are all going to have them; if they decide that I am working on atomic energy and they say that I must have some notes at home, it means that they can come up and search my house.

That is the degree to which you have got to go if you are going to depend on that service. That is so because when the scientists developed this thing, the theories on which this was done, practically all of them, were based on theoretical blackboard work and you would have to be able to inspect those blackboards.

I think you have got, maybe, to change the world from feeling loyalty to nations. We had a civil war in this country and it was based on loyalties, and you do not drive those loyalties out of a man's head overnight. You cannot just say that everybody in this country now is going to owe allegiance to some international organization.

Now, we may do it. We may come to it. It may be the solution. But, at the same time, we have to have the feeling—we may be misguided in that feeling—but we have to feel that the other nations of the world will come into this with just the same desires as we have.

Senator VANDENBERG. Now, assuming that we do try to discriminate between the development of atomic energy for war purposes as distinguished from peaceful purposes and suppose we allow a general world-wide development of atomic energy for peace purposes, is it possible to develop atomic energy for peace purposes and stick to that with complete fidelity——

General GROVES. No, sir.

Senator VANDENBERG. And yet be just as ready, the day after tomorrow, to turn it into a war weapon?

General GROVES. We can. The real secret of this development does not lie in the work that was done at Los Alamos, which was the development of the bomb itself; it was in the preparation of the material, that was the hard job.

Now, I am not taking away anything from Los Alamos. They did a magnificent job but it is something that if we had to do over again—supposing I was an outsider and was in some other country and I was told to duplicate that job. My real worry would not be the work at Los Alamos, but the work that led to the development and to the successful operation of the separation plants.

There was involved not only the development. We had to learn how to operate and that took us a long, long time.

We were on the brink of failure; in fact, we were over the edge on the failure side many times and for long periods of time.

It is that that is the real thing which I would like to see kept. Now, in other words, that means that you cannot separate the peace and the war. They are just so closely interlinked that you just cannot separate them.

While you may say that we can use it for peace and if we start out for war we will do something, I say that you have got to be prepared to go into an aggressive war at the drop of a hat, at somebody's say so, and without even waiting to assemble Congress in special session because it would take too long. We would have to change from peace to war pretty fast and get to making enough bombs before they could put our bomb-making capacity out of business.

Senator HICKENLOOPER. In other words, there is no difference between the material and its use for peace and industry and public health and fields of that kind and its use as a weapon? The same material is used for both purposes?

General GROVES. It is the same. It is in a different form, as you know. I think I have shown you all those various steps in these processes, where they take the material and change it from one salt to another and do that all the time and that does not take very long with modern chemistry.

Those things can be studied and they are being studied and these processes can be discerned, they can be learned from very small amounts of the material. It can be done by sneaking out some of the material and they can develop all of our processes and be all ready to go when the time came.

Senator TYDINGS. Right along that same line, suppose that the leading nations started on the production of atomic energy for peacetime purposes and that they had plants which produced it and it was beginning to be utilized to run ships or automobiles or electrical plants or whatever it might be.

They would then have plants that were making the elements that go into a bomb. I imagine that it would not be a very difficult procedure, after assembling all the elements, to build the apparatus that would make the bombs. As I understand it, the problem is to get the elements.

General GROVES. That is right.

Senator TYDINGS. So, if we do have an atomic-energy-operated world, all the inspections will be pretty much dissipated—the value, rather—because once the development of atomic energy is assured to different nations and the means for producing it is set up, it is a very short step from there, both in time and in mechanics and intellect and everything else that enters into it to change that into making a bomb with it?

General GROVES. That is correct. If that came to pass and I had anything to say about the inspections, I would want an inspector of my own in every plant that this material was being used in for the production of energy and I would also want somebody in there watching that man to make certain that he was still my man.

Senator TYDINGS. You would still want another man watching him?

Senator VANDENBERG. In view of all these complications, have you thought this thing through as to a recommendation?

General GROVES. You mean, as to what to do?

Senator VANDENBERG. Yes.

General GROVES. I feel that the step proposed by the President, as announced in the agreement or announcement signed by himself and Mr. Attlee and Mr. King was the correct step to take.

In other words, we have now got a weapon which can destroy an enemy very suddenly and punish him to the point where it would be a long, hard pull if he is going to win out. I don't believe, necessarily, that we will have a push-button war in which somebody will press a line of buttons and then the war will be over. But I do think that whoever is hit by what comes from that line of buttons is going to be at a terrific disadvantage. He is going to have the equivalent of 5 or 10 Bull Runs on the first day of the war.

Senator TYDINGS. With three Pearl Harbors thrown in.

General GROVES. I was not mentioning Pearl Harbors.

Senator VANDENBERG. That is around the corner down there [indicating corridor]. [Laughter.]

General GROVES. That is what is going to happen. I think that the discipline of the people is going to tell whether they quit like various nations quit in this war or whether they are going to go on fighting no matter how dark that day looks to them.

The CHAIRMAN. In that event, maybe there will not be enough people left to compose a coroner's jury if we had that kind of devastation.

General GROVES. I think the thing we are faced with is that this can be a terrific blow in the early stages of a war. It is a terrible temptation to anyone who wishes to start a war, as Japan did with us. It could give them a tremendous advantage in the way of a sudden surprise attack which would come without all the diplomatic palavering that went on in this case.

For example, using Japan as an instance, they would have come in 1935, or something like that time, when supposedly everything was lovely between us, but they would have made up their minds that we were an obstacle to a Greater Asia and therefore they were going to put us out of business.

Senator TYDINGS. General, coming back to this question of inspection, I take it from your remarks that inspection might be feasible and beneficial in the early development of this energy and before atomic energy gets into what might be called civilian use.

I take it that after that point was reached and atomic energy was being used on a wide scale, let us assume, it seems to me that the value of the inspection decreases correspondingly as civilian use of the atomic energy increases, because it would be so widespread, so much of it here, there, and every place. Is that correct?

General GROVES. I would say that perhaps the value would not decrease but the possibility of doing it would become just hopeless.

Senator TYDINGS. Yes.

Senator BYRD. General, the answer you gave to Senator Tydings' question was that you said it was hopeless. I presume you have been doing considerable thinking on the feasibility of inspection?

General GROVES. Yes, sir; I have.

Senator BYRD. Have you called upon the officers for a report on that subject?

General GROVES. Not for a report, but I have discussed it individually with a great many of them.

The CHAIRMAN. It is my information that a great many of them, officers and generals, will discuss that phase and we hope that we will have the best of their thinking on that proposition within a short time. I just wondered as to how deeply the War Department had considered the subject.

General GROVES. We have discussed the subject. On all such matters we have discussed them very closely with a number of scientists. As you know, we have a great many hundreds and even thousands of them and we do not discuss everything with all of them. After all, we still have work to do and so have they.

However, we try to get a cross section of their views and opinions as to how just such a thing can be operated. We also try to get their opinions on a great many other things—when we get into something that involves science as a whole we try to get the views of their representatives.

There is one thing I would like to take this opportunity to correct and that is this: I do not feel that there is any real difference between the War Department and the scientists.

I say that because the War Department does not want to put the scientists in a strait-jacket, they want every possible advance in the country scientifically, as well as in all other fields of knowledge.

The scientists, on the other hand, do not wish to disclose things that should not be disclosed to foreign governments.

I think that that is really their standpoint on that. I had hoped today to be able to read to you an extract from a letter written by one scientist to another of which he sent us a copy.

The CHAIRMAN. Before you go into that, General, I would like to go back to your estimate of 2 years that you made in answer to Senator Vandenberg's question.

Assuming that we were starting from scratch with what we now know about it today and suppose that we wanted to get into production, I want to ask you this.

Have you taken into account the following factors:

First, on the assumption that the safety of operating personnel is to be disregarded, would that period of time be considerably shortened? It would, would it not?

General GROVES. I think, if safety of operating personnel is to be disregarded, it may be.

I would also like to add that when I said 2 years I assumed that we knew what had happened but that we did not have the experimental work done and that we had to repeat that. In other words, that we threw away our notebooks, as it were. If we did not do that, that time, maybe, would be shortened. Well, it would still remain almost 2 years, but it would be a lot easier.

The CHAIRMAN. I would like to go into that because that seems to me to be a very pertinent subject for further inquiry.

I think one of the things you have to determine is the possibility of other nations getting going on this project.

That leads me into another subject I want to inquire into, namely, if certain countries were to announce, tomorrow, that they had it, I wonder if it would change your views any.

Now, you have the assumption that if safety of personnel were disregarded entirely it would cut down the period somewhat?

General GROVES. It would cut it down in this country, if we could do that.

The CHAIRMAN. In other words, if we built those buildings without any regard for safety factors or if we just took an empty factory building, any empty factory building, or put up a great big shed or a great big tent just to cover you from the weather and without any regard to the cities you built around this project which took, of course, a good deal of time, you could then really bring it down to the basic factor of building some complicated machinery, could you not?

General GROVES. No; because you would have a cleanliness affair. Now, if you take the work that you saw at Tennessee, the two big plants, there were no unusual safety factors built into those plants. They were built that way because they had to be in order to start operating.

The CHAIRMAN. But we developed four processes in 3 years, did we not?

General GROVES. Yes, sir.

The CHAIRMAN. Now, assuming that we took the best process and proceeded from scratch on that—that is, when I say "scratch," I mean with the knowledge of how to go about it—without regard to safety and using flimsy buildings without building any city and using one process that will work, that has been found to work before, does that change your 2-year estimate?

General GROVES. Yes; if we built one, the 2 years would probably become 3 years because you could not accomplish what we did if you built one process. It might become 4 years.

The CHAIRMAN. But today you know the best process, do you not?

General GROVES. Yes, I know.

The CHAIRMAN. Knowing the best process and concentrating on that, would it shorten the time?

General GROVES. No, sir; it would increase the time.

The CHAIRMAN. In other words, you have got to use all four processes?

General GROVES. Not all four, but it would increase the time because of the whole over-all picture. I am taking it from the time we started until we have a bomb that would work. I would rather not explain the details of that in an open hearing.

Senator HICKENLOOPER. General, if we disregarded the safety factor of the personnel, would not the morale of the personnel have something to do with the efficiency?

General GROVES. I do not think—knowing what I do know of American citizens—I do not think that we could operate this thing, even with the most highly disciplined troops, without regard to safety.

Senator BYRD. You have had no operating accidents?

General GROVES. We had no operating accidents throughout this project that were directly attributable to the unusual nature of the material that was a fatal accident. We had one after the bomb was exploded. We then had one which we should not have had; there was no reason for having it.

It was like all accidents, industrial or home accidents. If you do not turn on the light when you go down to the cellar, you are going to start having accidents; that is something that's too bad, but that is the way most industrial accidents happen.

Senator HICKENLOOPER. But even in the case—General, let us assume, in order that we may have an extreme assumption—let us assume that we had slave labor or impressed labor of one sort or another. Would not the morale factor of the impressed labor, knowing that their safety was not being taken into consideration, reduce their efficiency almost to the point of zero?

General GROVES. I would say that the best example of that is to read what the American prisoners did in that machine shop in the Japanese prison camp. There the Japs found out that impressed labor ceases to be of value when it is for anything but plain physical labor, like shoveling dirt. Where you get into highly complicated technical processes, where one man can turn a valve and turn it back again and nobody can tell that he did it unless he has a terrific amount of equipment such as we have for registration, it is just too bad.

Senator HICKENLOOPER. And you cannot stand for sabotage in this business.

General GROVES. That is right. Sabotage is a very serious problem. We have had some cases where a man made a mistake and that mistake was extremely costly. I think it would be very difficult to operate without the highest morale on the part of the workers and without the highest degree of intelligence and capacity.

Senator TYDINGS. Going back to the question of inspection again because, after all, sooner or later we have got to determine what to do to protect ourselves and the world, I take it that you are looking ahead 15 or 20 years, to what we might say would be the normal evolution of atomic energy.

With that viewpoint, according to your statement as I understand it, you consider that as of doubtful final value; and that your opinion is that some approach to it, similar to President Truman's statement, is the best thing we have been able to conceive for the future protection of our own country and of the world?

General GROVES. I think so. That will lead to inspection of a certain type. That approach, in my opinion, leads toward the opening of international frontiers and a free interchange of people and essential ideas.

With that free interchange I think that it is impossible for a dictator to exist, except in a very small place, like a city. For example, you may have a city dictator but he cannot become a national dictator with a capacity of waging war and drawing the whole world into it.

To me the important thing is the opening up of all nations to freedom of travel and that, you might say, would be an inspection service, but you would not say that if we had inspection we would be safe.

You would be expanding that. You would have not only scientists, but you would have engineers, you would have nationals of all types traveling back and forth and spreading the doctrine of how the rest of the world lives.

I think that would do more toward obviating wars than anything else because then a man would say, "Why should I starve over here when I can go to another country and be treated decently?" The better men would tend to migrate and the thought of war would be less and less in their minds.

Senator TYDINGS. So that the real hope cannot be pinned too strongly on inspection alone?

General GROVES. No, sir.

Senator TYDING. Inspection simply implements a plan for the control of atomic energy?

General GROVES. I believe depending on inspection alone would be like depending on having most of these bombs alone and saying, "Here, we have got 10 times as many bombs as anyone else has, so we are absolutely safe." We are not absolutely safe. It may have a very strong influencing effect.

I think, in the same way, an inspection service would be a great influence and, as far as we are concerned in our own country, would be quite effective, but I do feel that we cannot depend on it unless we are willing to have every house subject to inspection without warning or without warrant.

Senator MILLIKIN. May I ask a question?

The CHAIRMAN. Yes.

Senator MILLIKIN. General, assuming that there is inspection and assuming that it is reciprocal and assuming that to make it efficient involves a large number of inspectors who would be privileged to go through all our industrial processes and laboratories and that the same privilege would exist in all other countries, what would be the effect on the private enterprise economy of the world?

General GROVES. I don't think there would be anything private anymore because if, for instance, you have got a new type of automobile brake, you would have to explain it to every other nation.

You might say that that possibility might not be included; but as soon as they can pry around and they start finding out things it will be so.

I think the history of the General Motors proving ground, for example, showed that. They had, they found out, to bar the public to keep their competitors from finding out what they were doing.

Senator HICKENLOOPER. As soon as somebody locks a door to an inspector, that places the building immediately under suspicion?

General GROVES. Yes. If I were running that inspection service, I would want to know what was going on in that building.

Senator HICKENLOOPER. Whether it was work on industrial power or atomic power, the inspection would have to be held to find out?

General GROVES. Oh, yes. It may be something that somebody is making; for instance a better microphone. I would say: "I wonder how it fits into this bomb. I want to use it. Maybe they are making a special type of fusing for that bomb."

Senator HICKENLOOPER. May I ask another question?

The CHAIRMAN. Yes.

Senator HICKENLOOPER. General Groves, I would like to ask you, is there any encouragement at this time——

Senator VANDENBERG. I don't think so.

Senator HICKENLOOPER [continuing]. For the development of a reasonably adequate defense against the atomic bomb within the reasonably near future?

General GROVES. I know of none. I think the only defense is to stop the carrying vehicle before it can launch the bomb.

The CHAIRMAN. How about its being planted by sabotage around our cities?

General GROVES. As to its being planted by sabotage, I think that that means that you have to know enough about what is going on if you want to have complete protection.

There again you have got to have a corps of inspectors that will go into every room, you might say, of everybody's house and see if they have got the ingredients for the bomb.

Senator HICKENLOOPER. My point is this: There is no encouraging answer when it comes to defense now to detect a bomb in the air and explode it, for instance, or destroy it before it reaches its target once it is launched?

General GROVES. No way. I see no hope of that and none in the future. You must figure, in this instance, that you have got to stop them 100 percent. It is not sufficient to stop half of them. You have got to stop them all and no one, I think, has yet been ever able to devise a perfect defense line.

Senator HICKENLOOPER. You can detect it with radar, the approach of it if it is coming, just as a metal object; but there is no way of detonating them or reaching them?

General GROVES. You could detonate them with high-powered artillery, but some of them would get through. As you know, the attack by the German buzz bombs—a great many of those were shot down but some of them got through; not enough of them to do enough damage when they got through, so they could stand that. But these bombs, you have to stop them.

Senator VANDENBERG. I would say your answer is, "There is no encouragement—period."

General GROVES. There is no encouragement—period.

The CHAIRMAN. Assuming that 40 of these were planted around 40 of our centers of population and were detonated in some mechanical way, of what value would 10,000 of these bombs be to us, distributed around the country ready to launch at an aggressor?

General GROVES. I would say the value would be that although we had suffered a loss through the damage of 40 such bombs——

The CHAIRMAN. Which might mean 40,000,000 people?

General GROVES. Which might mean 40,000,000 people; but the rest of the people would still win the war.

The CHAIRMAN. How would they know where to launch the 10,000 we had?

General GROVES. It is a little hard for me to conceive of someone just exploding such bombs without at least letting us know who it was.

The CHAIRMAN. Well, let us assume that country A takes over country B, a small country. This small country, for all you can find out, these 40 bombs come from this small country. On that suspicion, are you going to launch the 10,000 bombs at country A?

General GROVES. If I were running the Government I certainly would not hesitate very long on that, because you are faced then with the need of an instant decision which would mean the life or death of the United States and you could not sit down and have a jury trial to determine whether that country did it or not.

The CHAIRMAN. But they might be innocent.

General GROVE:. Well, if they are innocent——

Senator RUSSELL. They are out of luck.

The CHAIRMAN. In other words, it is too bad for us or too bad for them, the innocent country?

General GROVES. Yes, sir. But it is just like anything else. If you are driving an automobile across the street and a child runs across the street and you instinctively turn the wheel and run into another car and kill somebody in that car, it is too bad for that person in the other car.

The CHAIRMAN. I don't think any system of morality I know of would work.

General GROVES. In other words, I feel that it is very difficult when you take a hypothetical question, to know just what all the background is going to be. That is what would determine it, the background. I cannot imagine not knowing who was responsible. I personally feel that if that was done the nation responsible would tell us.

The CHAIRMAN. If we had an inspection force, the feasibility of such an event as I have described would be, you might say, considerably lessened, would it not?

General GROVES. Considerably lessened; yes, sir.

The CHAIRMAN. From that point of view inspection would be zero plus, some factor, anyway?

General GROVES. Yes, sir. That is what I said to Senator Tydings. I hope I made it clear that I do not oppose inspection because I feel that the steps the President is taking will lead eventually to some type of inspection. But I would say that you cannot make inspection 100 percent perfect.

The CHAIRMAN. Don't you think that it would be easier for us to act before other nations got it?

General GROVES. I am very much in favor of rapid action on this and that has been the policy of the War Department straight through, that everything should be done to get this thing settled and on the way as soon as possible.

The CHAIRMAN. Rapid international action as well as domestic?

General GROVES. Oh, yes, sir.

The CHAIRMAN. One more question, General, and then we have got to adjourn.

This stuff we are making now, as you know, has a peacetime use for experimentation, making it serve a use for good instead of for destruction?

General GROVES. Yes; we hope it has. We think it has. We do not know yet, but we think that we will find the way through that problem.

There is no question in my mind that it is going to come.

The CHAIRMAN. So, to consider our production day by day as simply for bomb-making purposes is to throw it a little out of focus, is it not?

General GROVES. Yes, sir; although we do not know yet. In the end, I think that the atomic bomb will be considered as a byproduct of the atomic age.

The CHAIRMAN. Thank you, General Groves.

We will adjourn until 10 o'clock tomorrow morning.

(Whereupon, at 12:05 p. m., the committee adjourned until 10 a. m., Thursday, November 29, 1945.)

ATOMIC ENERGY

THURSDAY, NOVEMBER 29, 1945

UNITED STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to adjournment, at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Russell, Johnson, Connally, Byrd, Tydings, Vandenberg, Austin, Millikin, Hickenlooper, and Hart.

Also present: Edward U. Condon, scientific adviser; and James R. Newman, special assistant to the special committee.

The CHAIRMAN. General, I believe you had finished your formal statement.

General GROVES. Yes, sir.

The CHAIRMAN. Are there any questions which you want to ask, Senator Hart?

Senator HART. No; I was not here during all of his testimony.

The CHAIRMAN. Of course; you had to attend a meeting of the finance subcommittee.

Senator Hickenlooper?

Senator HICKENLOOPER. I would like to ask the general a question or two, if he cares to give an opinion on this matter. If this is a matter that you feel you prefer not to answer, it will be perfectly all right. If you can, I would like to have it answered.

Assuming our present state of advancement in the atomic science, assuming that we kept on within reasonable degrees of scientific progress vigorously advanced, what in your opinion would be our opportunity of keeping reasonably ahead of any other nation for a period of time?

In other words, could other nations catch up to us in spite of all the time and scientific effort that we might put into this thing, based on our accomplishment?

STATEMENT OF MAJ. GEN. L. R. GROVES—Resumed

General GROVES. Other nations can catch up to us on fundamental science within a reasonably short period. They can catch up with us eventually on our present state of technological advance, engineering, and operation, assuming that we remain stationary.

The CHAIRMAN. Pardon me; I did not get that last answer.

General GROVES. I will be glad to repeat it. On the basic fundamental scientific knowledge, other nations can catch up with us within a comparatively short period, say 2 years, and that assumes that other nations will make a really serious effort. They cannot do it by just sitting there with a handful of men and spending a few dollars. They have to spend a lot of money and put their best people on it. There has to be a lot of people, and they have to be supported. They cannot take the time to build their own apparatus. They will have to have it made by mechanics instead of professors.

On the development of that basic information into the information that is necessary to produce a bomb, including the separation of the material, the making of plutonium, and the development of the bomb, they can catch up to where we are at the present time within a period of years.

I testified before the House committee, in response to a direct question on that point, that one nation could catch up and produce a bomb, if they did it in complete secrecy, probably within from 15 to 20 years—more likely the latter. If they did it without secrecy and with a great deal of help from the United States and from England and Switzerland—and I say Switzerland because she is a manufacturer of precision machinery—it could be done in 5 to 7 years, probably seven.

Now, that would be catching up with us to where we stand today.

Senator HICKENLOOPER. Assuming that we go forward from where we are today on advanced research and intensive research into this fission field and the whole field of atomic energy, is it reasonable to assume that we could keep several steps ahead for a long period of time, ahead of the accomplishment of any other nation, if we devoted time to it?

General GROVES. I believe that we can keep ahead of any other nation in the world for all time to come, provided that the rules are the same for the two nations.

Senator HICKENLOOPER. That does not mean, of course, that they cannot build a bomb that would blow up?

General GROVES. That is right, and it also means this: When I say that the rules are the same, if we have secrecy and they have secrecy, we will be ahead. If we have free and open distribution of every bit of knowledge we have, and they have secrecy, they eventually are going ahead because they will finally find out something that we don't know and we won't find it out.

Senator HICKENLOOPER. I have one other question, if you would care to comment.

Do you consider the development of the atomic bomb or the atomic fission in this country, eventually resulting in the making of the bomb, to be entirely a question of scientific calculation plus mechanical development, or are there some other elements that went into that besides those scientific and mechanical things?

General GROVES. There were the scientific developments and there were the decisions as to which route to take to get those developments. Those decisions are probably not so important now as they were at that time, because people know that we were successful.

Then there is the other factor, and that is the operation. These plants do not operate themselves. It took many months before we could make one of our processes work in operation. You could take one element of it and it would work. That was the electromagnetic plant, but it did not work satisfactorily as a complete process until the best management and the best advisers we could get on the problem had worked and worked at that problem for many months.

Senator HICKENLOOPER. Is it a fact that it requires an unusually high degree of fidelity in personnel as well as scientific and mechanical development?

General GROVES. It requires all the qualities that any employer wants in his personnel up to the utmost. It requires skill, ingenuity, faithfulness, and carefulness that is hard to equal elsewhere in the world.

Senator HICKENLOOPER. Thank you.

The CHAIRMAN. General, you say that they can catch up on fundamental science involved within a comparatively short period. I believe you said that period was 2 years. It has been my understanding that the fundamental science has been encompassed in the Smyth Report.[1]

General GROVES. No; I don't believe that is correct, sir. The Smyth Report gives the fundamental science that was known or could be easily deduced. It did not give all the fundamental science.

There is always the question of what is fundamental. Here you have something that stretches over a tremendous field, and the question is: What is fundamental?

It is just like the framework or the bone structure of the body. What is the fundamental framework?

The CHAIRMAN. But the Smyth Report received world-wide distribution, did it not?

General GROVES. Yes, sir.

The CHAIRMAN. That would be my conception of fundamental principle.

General GROVES. If that is your conception of fundamental, if that is the definition you apply to fundamental, then it is already known and was known back in 1939.

The CHAIRMAN. In other words, the problem now is to take the theoretical principles which are known and put them into application?

General GROVES. Yes.

The CHAIRMAN. That is, we have the "know-how" of doing that.

Now, do you think it would take 2 years for them to get to the point where they would start to develop the "know-how"?

General GROVES. I believe it would take them 2 years to get to the point where it would be feasible to get into the actual development of plants, start that phase of it, and to me that is the fundamental knowledge.

The CHAIRMAN. You have two other estimates. You say that if we gave help it would take them 5 to 7 years. What do you mean by giving help, which would reduce it from the estimate of 15 to 20 years?

General GROVES. I mean this: We would give them various engineering developments, how to make certain things, how certain machinery was made, the exact design and exact specifications, the metallurgical processes, as well as the analyses—everything that a man has to know in order to do the job.

[1] A General Account of the Development of Methods of Using Atomic Energy for Military Purposes Under the Auspices of the United States Government, 1940–45, by H. D. Smyth, chairman of the Department of Physics of Princeton University and consultant to Manhattan District, U. S. Corps of Engineers; published by the U. S. Government Printing Office, August 1945.

The CHAIRMAN. Well, it seems to me if we gave that, they would be able to go ahead and do it in a very much shorter time.

General GROVES. No; the only way they could do that would be to have us send over American labor to do the job for them.

The CHAIRMAN. This 15 to 20 years, 5 to 7 years, and 2 years—just so that we will have the record straight—are estimates by you?

General GROVES. Yes, sir.

The CHAIRMAN. That estimate would seem to me to encompass a pretty detailed knowledge about the industrial manufacturing, engineering, and scientific fields in the various nations to which you applied the estimate. What I am getting at, General, is that it is a guess, isn't it?

General GROVES. Yes, sir, it is a guess.

The CHAIRMAN. A pure guess?

General GROVES. It is my guess, based on my knowledge of what it took us, and I certainly had the opportunity to have a better basis for the guess as to what it took us than any other individual.

With respect to other nations, some of them we know something about; others have had a wall around them and it has not been possible to know what is necessary in order to make the guess. But we do know, we have looked into the problem, we have consulted and I have personally discussed the problem in its various phases with everyone with whom I could come in contact who had any basis of knowledge.

The CHAIRMAN. I have some more questions on that, because I think this is a very important point.

As to the countries on which you have not had such full information, the guess would be worth a good deal less than it would in others, would it not?

General GROVES. I think that follows naturally.

The CHAIRMAN. Of course, you know that the scientists who worked on this have a different estimate of the factors involved?

General GROVES. I know that some of them do, and I know that some do not. I believe that the answer to that really falls within how closely they were acquainted with the industrial problems with which we were faced in this country as opposed to how much of their time was devoted to the purely scientific phases.

I would also like to point out that when you say my guess may be in error—which I admit fully, naturally—it may be in error in the other direction. It may be that instead of this being 20 years it should be 40 to 50. A good many people who know and have been in some of these countries tell me they don't think they could ever build it, because they could never get, under their present system, men with courage enough to go in and make the mistakes that are necessary to produce such a thing as this.

The CHAIRMAN. I presume you would agree that no country of any size is holding back on this problem, and, for purposes of prestige and purposes of equalization, if you please, they are not sparing any efforts from here on. You don't think they will go about this lackadaisically, do you?

General GROVES. I have no information which would lead me to believe that they are pursuing it with the vigor that the United States pursued it, or anything approaching that vigor. They are still approaching it from the standpoint, you might say, of the attitude that was taken in Germany from 1939 until the end of the war. It has not reached, as far as I know, the point where anyone has started really to do anything. They are still talking and still working in their laboratories; they are still collecting scientists; they are not putting behind those scientists, or over them, or in front of them, the management and the engineering and the drive that are going to accomplish anything in a hurry. They are going to build up their stocks of fundamental knowledge, their basic science, and the things that build onto that science, so that later they will save some time; but they are not yet, as far as I know, making the determined effort that is necessary in this work to make it a success in a short time.

The CHAIRMAN. Haven't I read something in the papers about England starting a plant?

General GROVES. You have read a good deal of discussion, and it depends on which paper you read; but as far as I can tell and as far as I know, and I think my information is accurate, England has not yet made any step comparable to what we did.

The CHAIRMAN. You stated that we could keep several steps ahead, and I think we ought to make it clear for the record.

As Senator Hickenlooper said, they don't have to go ahead of where we are now to make it somewhat uncomfortable.

General GROVES. I am glad you brought that up, because I meant to comment on that, and that is that in this affair it certainly will not do us any good to be a few steps ahead if they are right up behind us and they have enough; so it is not sufficient just to say, "Well, we can always be ahead of them."

The CHAIRMAN. When you say, "Keep a few steps ahead," I presume you mean a bigger explosive and a bigger detonation?

General GROVES. Yes, one that may be cheaper and may be in greater quantity, particularly cheaper in production.

The CHAIRMAN. Of course, cost has never been a factor in the making of warfare. Isn't that true?

General GROVES. I think costs sometimes have a good deal to do with it. Our country has so much economic power, they have to decide what we will do with that power. In our case, during this last war, despite all of the economic power of the United States there had to be a military decision made by the President on the advice of his military advisers that the effort that would go into this project should be devoted to that rather than to something else. No country is rich enough to embark on such a project as this without realizing that it affects its economic structure.

The CHAIRMAN. Of course that theory does not hold water. There was Hitler. I remember that Mr. Miller, who was the financial attaché at the Embassy, made a speech in this country before the war that there wouldn't be any war because Hitler could not afford it.

The Kaiser was supposed not to have been able to afford it, either.

I don't follow your theory that cost or money has anything to do with the making of war.

General GROVES. Money does not as such, but the economic power does; and when I speak of that, I speak of the factories, the raw materials, and the labor.

The CHAIRMAN. Wherever they are found in abundance, plus a determination to proceed, you have a situation on your hands in which there are unknown factors, of course, but nevertheless you can come to the conclusion they are going through as far as they can.

General GROVES. I have no doubt but that they will go through if they decide that they want to, and then it is just a question of how soon they can. I also understand that most of these nations state that they are unable even to subsist without money from the United States, so it is a little difficult for me to see how they can embark on something of this scale so blithely.

I think they have to consider how they are going to handle this, how much they are going to reduce the rations of their people, and possibly how much money they are going to have to borrow from the United States to build these plants with which to attack us.

Senator HICKENLOOPER. Have you finished, Mr. Chairman?

The CHAIRMAN. For the present, yes.

Senator HICKENLOOPER. May I ask the General a question?

Let's assume that some other nation or other nations, no particular nation, could build pilot models and experimental models in which they could produce small quantities of this fissionable material.

Does it necessarily follow that because they can produce these small models in fairly sizable laboratories, for instance, that they can thereafter easily go on and build quantity production models with any great speed?

General GROVES. Not unless they are a lot smarter than we were.

Senator HICKENLOOPER. In other words, there is a difference between the experimental models that produce very small quantities and the quantity production plants that produce this material in sufficient quantities to be usable as an explosive?

General GROVES. There is a great difference, and I think you saw at Clinton the preliminary pilot model for the Hanford Engineering Works.

Senator HICKENLOOPER. Yes.

General GROVES. Now, the difficulties in the problems that we were faced with there in the Hanford Engineering Works are just not comparable. They merely sort of gave us a little guide as to what might be done.

Senator HICKENLOOPER. In other words, when you built the pilot model you certainly did not know how to advance to production?

General GROVES. It was like having a headline to a newspaper story that was going to run three columns and you had the headline only.

Senator HICKENLOOPER. Reverting to the question of our keeping ahead of other nations, I assume that if they reached a point of production of this material that we have reached today they would be producing bombs that could blow our cities to pieces.

If we went forward from today, on the basis of knowledge that we have, it is reasonable to assume that the main advantage we might get from the scientific development would be, perhaps, an exploration of the field of new and different materials that would be fissionable and possibly, although it may be remote, the discovery of some more adequate defense against the atomic bomb. Is there experimentation and development along those lines?

General GROVES. I think that at the present time we have merely scratched the surface of knowledge, and we are in the same position as some other sciences were a few hundred years ago. For example, in the lifetime of all of us we have seen the tremendous advances in the equipment for medical services. If you go to a doctor's office now, he has everything that is necessary to make a good guess, at least, as to what is wrong with you, whereas formerly, a hundred years ago, he did not have those facilities.

We are now in the same position in this field that medicine and medical treatments were in several hundred years ago. We don't know, but maybe we have gone a lot beyond that point. Maybe we have learned everything, but we have no reason to suspect so, because the more we work the more we learn things. We have not reached any slowing down on learning.

Senator HICKENLOOPER. It is interesting to note that we have not developed any defense, figuratively speaking, against the slingshot except to go farther away or put up a wall; but they can still throw the missile over it.

General GROVES. We can always, of course, if the world should ever get into such a horrible position, disperse. It would be a terrible thing economically to have to live in an armed camp. What we hope, at least I personally hope, will com ewithin a reasonable length of time is a freedom which such wars; but I don't believe that freedom will come by ignoring the tremendous impact of this as a military weapon.

Senator MILLIKIN. Mr. Chairman, may I ask a question, please?

The CHAIRMAN. Senator Millikin.

Senator MILLIKIN. General, roughly how many separate items go into the making of one of these plants? Is it in the order of thousands?

General GROVES. Well, many, many thousands. I think the best answer to that, that really gives you what you want, is that at the Hanford Engineering Works, the Dupont Co. had over 10,000 subcontractors, each of them supplying a different material and not raw materials or basic materials. They were supplying subassemblies, you might say, as if they were in the automobile business.

Senator MILLIKIN. Each one of those items involves a technique that is the result of long experience and oftentimes of exclusive "know how." Is that not true.

General GROVES. I would say not each item, but a great many of them. In fact, of the 10,000 probably 50 percent at least required special "know how." Some of them required "know how" which with all of the power and knowledge of American industry, took us more than 18 months to learn.

Senator MILLIKIN. In many cases you took advanced technology that made them advance still further.

General GROVES. Advance much further, and far beyond what they thought was practicable. I think a good answer to that, in clearing up that point, was a statement made to me by a gentleman I met some months ago who manufactured a certain type of material which is in common use, but in the normal plant you use, say, 100 pounds of it a year, which would seem a large consumption. This gentleman told me he received an order from the Hanford plant which instead of being 100 pounds per year might be said to be 10,000 pounds per year. He replied and said, "You don't need this; you are throwing away, Government money; why do you need it," and the answer came back: "Supply that material."

Without the 10,000 pounds it would not have worked, because you cannot, in this complicated affair, use certain materials when you need a higher grade. They just will not work.

Senator MILLIKIN. Would it be correct to say that thousands of these items represent a reflection of technological skills that have been built up in this country for many, many years, in many cases for many generations back, not only as to the particular firm that is making the item but the workmen and the craft traditions that have been passed on?

General GROVES. I think the answer there would be not only thousands, but probably tens of thousands of items.

Senator MILLIKIN. Leading now to the end point toward which I am driving, anyone that wants to do the same thing has either got to duplicate that same technology in that same way, or possibly in an expedited way as much as it can be expedited, or borrow it or assemble it from around the world. Is that correct?

General GROVES. That is correct.

Senator MILLIKIN. Either way of doing it would be a difficult way of doing it, would it not?

General GROVES. Yes, sir; unless they had world support for doing it.

Senator MILLIKIN. And it would require a long, long time?

General GROVES. I believe so; yes.

Senator MILLIKIN. With a rather technical and highly skilled overall direction which in itself, you suggest, may be lacking?

General GROVES. There is nothing that is harder to get than competent management, I think, as everyone who has tried to operate knows, and not only top management, but down below in what would normally be termed the subsidiary positions.

Senator MILLIKIN. If a country that figured on making this bomb commenced to reach out and pull in scientists that specialized in atomic energy, and if they started buying specialized machinery here, there, and in other places over the world, we would find out about that in the normal course of events, would we not?

General GROVES. We would. That comes back to the point I stated, that if they went out and told the whole world, it would be 5 to 7 years; but if they tried to do it all themselves, it would probably be 20.

I think there is another point there which will clarify it. I have discussed just how a nation would proceed on such a thing. I believe the first thing they would do would be to start educating their workmen and their management so that they could operate such an affair. Now, you cannot pass on the ability and the skill of management, or of scientists, or of any other highly skilled workmen, in, say, 5 years, and then liquidate the men—because you never know what problem is going to come up. You cannot pump a man dry unless it is something that is simple, like a formula.

I believe that certain formulas, for example the one for bitters, have been kept in the family as a trade secret, and no one has achieved the knowledge of that secret. That could probably be told in half an hour, but you cannot tell the secrets and the knowledge that are necessary to operate a thing like this in half an hour or in half a century. You have got to build up your men and build them up so that they have the capacity to do the job.

Senator TYDINGS. General, assuming that in any one of the big nations the funds were available, the material was available under reasonably conceivable conditions, and with a degree of good fortune in discovery, we will say , how long would it take any of the leading nations in your judgment to reach the point that we have reached in this country with reference to the atomic bomb?

General GROVES. Depending upon which country you take, because there is a wide variation between them——

Senator TYDINGS I didn't want to take one particularly, for obvious reasons, but say any of the three or four leading countries.

General GROVES. It would depend on what knowledge they had and what their industry was. In a country in which people were interested in it, if they did it in complete secrecy, it is my opinion it would take from 15 to 20 years; if they did it with the help and assistance of ourselves, England, and Switzerland, they could do it some 5 to 7.

Senator TYDINGS. Your guess would be, as between those two propositions that it looks as if you have a margin of safety in some cases of, say, 12 to 15 years?

General GROVES. Yes; I think that in any case we have a period of at least 5 to 7 years in which the problems of the world can be settled to such an extent that we won't immediately start dropping these bombs on each other.

The CHAIRMAN. Senator Tydings, before you came in, the general testified that was a guess.

Senator TYDINGS. I understand.

General GROVES. There is a more complete discussion, Senator, in the record.

Senator MILLIKIN. Mr. Chairman, I would like to pursue that just a step further.

Aside from Switzerland, Sweden, Belgium, France, what other nations could help a nation?

General GROVES. England.

Senator MILLIKIN. England, I assume, is with us.

General GROVES. Those are the principal nations, and I believe that you can almost limit it to the United States, England, and Switzerland, with possibly Sweden. It is the machine industry that is necessary. Certain things could be done in Switzerland or in the United States that cannot be done easily elsewhere.

Senator MILLIKIN. France used to make a lot of small items of various kinds.

General GROVES. Yes; and Switzerland has also been a center of high-grade machine tools of special design. You find a great many of them in this country, particularly in any plant that has been in operation for a number of years and has accumulated a number of special Swiss machines.

Senator MILLIKIN. Do you think of any other countries? I think we ought to have that pretty clear on the record.

General GROVES. I don't know what was taken out of Belgium and France by the Germans. Those two countries could supply certain assistance, no doubt, and I believe they would if they were paid for the assistance.

Senator MILLIKIN. Did you say France and Germany?

General GROVES. France and Belgium. Germany, of course, could supply technicians, management, engineers, and scientists.

Senator HICKENLOOPER. Doesn't Czechoslovakia have a highly developed machine industry?

General GROVES. It has certain things.

Senator CONNALLY. Mr. Chairman, I want to ask a question. General, it is not your fault, because you have been prodded into it by members. I think it unwise to take up each one of these countries and particularize and estimate how long it would take. It might indicate an intention to have a contest with them, or cause some unfavorable reaction.

I submit that to the chairman as worthy of consideration, at least.

The CHAIRMAN. It might be better, I think, Senator, if we generalize.

General, we have no compact with any country mentioned whereby the country has agreed not to proceed either to do it themselves or help anybody else, have we?

General GROVES. I think anything of that kind I would prefer to discuss in closed session, sir.

Senator HART. May I ask a question, Mr. Chairman?

The CHAIRMAN. Certainly.

Senator HART. Following that same subject of your estimate, you did not mention supplies of raw materials as being in the picture. Is there anything that is not already in the record that you would like to say on that point?

General GROVES. Not in an open hearing, sir; and I would like to make it clear, Mr. Chairman, particularly in view of the presence of newspaper people behind me, that the fact that I would prefer not to discuss certain things in open session does not mean there is anything there, because either affirmation or denial is something that I would prefer to avoid. The fact that I have said I prefer not to answer does not really mean I know the answer. That is important for the benefit of the press, sir.

The CHAIRMAN. We have gotten to this point, General. I think it is safe to say that we have no such agreement with Switzerland, for instance, not to engage in it or experiment. I think it is well for people to know that.

Senator MILLIKIN. I would like to say, for the benefit of Senator Connally, that I opened this subject of nations that might be in a position to contribute material for the making of the bomb without reference to any particular nation, without having as an end purpose an alinement against any nation, and it seemed to me it was very important that we know in our consideration of this problem just who is in a position to give effective help in the construction of an atomic bomb.

There was no reflection on any country; there was no insinuation or implication on my part that it might be used by or against any country.

Senator CONNALLY. My attention was attracted to the fact that you mentioned a whole lot of countries and left out some. I submit that it doesn't require a hand pointing to a sign that this is the so and so country, because by elimination anyone could determine what country you are talking about, and that is what I am objecting to.

Senator MILLIKIN. Senator, I am objecting to the proposition of smothering simple, open facts of what nations are in a position to contribute to the making of an atomic bomb.

Senator CONNALLY. We don't expect them to contribute to us to make an atomic bomb. We are going to have to make them ourselves.

Senator MILLIKIN. I think it is agreed that if anyone else makes them, we will lend the money to make them.

Senator HART. I would like to observe for Senator Connally's benefit that the questions were altogether founded on the state of industry in these various countries.

Senator CONNALLY. The state of industry in manufacturing automobiles or bombs? We are talking about bombs.

Senator HART. No; the general industry.

Senator CONNALLY. Bombs are what we are supposed to be investigating.

Senator HICKENLOOPER. I have a great deal of faith in General Groves' discretion, which I think he has proved, and I don't think General Groves would answer anything he thinks is detrimental to the public interest. Therefore, I felt perfectly free to ask him such questions as he would care to answer, and he has answered them.

Secondly, I believe that the answers elicited about these various countries are probably as well known to every other country in the world as they are to any of our people, and I could see nothing dangerous or inimical to our interests in either the questions asked General Groves or his answers given.

The CHAIRMAN. General, this weapon is not just a new weapon of war, is it?

General GROVES. I don't follow the question, Senator; I am sorry.

The CHAIRMAN. Well, there has been some statement made that this is just a new weapon of war. I know you don't agree with that.

General GROVES. Oh, I think the term usually used is that this is "just another weapon."

The CHAIRMAN. My mistake.

General GROVES. Anyone who says that, with all due respect to whoever he may be, is just ignorant of the power of this weapon; and I think the more people think about it the more they realize the importance of this and that it is not just another weapon. I think they realize that it ended the war with Japan, and sooner than it would have been ended otherwise, and that if we had been able to drop it sooner it would have ended the war just as promptly.

The CHAIRMAN. In other words, it can be a decisive weapon of war.

General GROVES. I don't know that any weapon is decisive, excepting the will of the country to continue to fight, when that is broken. But as a weapon, it is very important.

The CHAIRMAN. In view of that statement, do you not think that your former statement that you can see no desire upon the part of other nations to go ahead with this is perhaps open to some question?

General GROVES. I didn't say that I didn't see any desire, I believe. At least, that was not my intention.

I said, or wanted to say, that I did not know of any nation that was now really going after it hard, but that they were still proceeding along the lines of laboratory research on a limited scale and had not done what we had done, which was to attack this problem with real vigor as if they really meant to get somewhere. They are still wandering around, discussing and arguing as to what is the best method.

They have given wild estimates, such as an estimate that appeared recently from a very distinguished gentleman of one foreign country, to the effect that any nation could have this bomb within 6 months.

Well, I just say that that is an absolute impossibility. It is that kind of discussion that is going on.

The CHAIRMAN. That was Professor Oliphant of England.

General GROVES. That was the press report that came over.

The CHAIRMAN. Well, he wrote an article of recent date in Nature, which is a British scientific magazine.

He is the fellow who discovered the basic tube that made radar possible, is he not?

General GROVES. I don't know much about his career at that time. He is a distinguished physicist and a man of tremendous scientific ability.

The CHAIRMAN. He did; he discovered the basic principle of the radar tube. It was his statement that you referred to.

General, I understand we killed about 500,000 people in areas in Germany, and of course pretty well wrecked her desire to fight, with the air attack.

Reverting to your testimony of yesterday that if we killed 40,000,000 people here you thought the war could still go on, do you think we would be able to wage effective war with 40 of our cities laid waste and 40,000,000 people killed?

General GROVES. I think we would wage war for quite a while on that basis if we still had the will to win, and I think anyone who travels over the United States and knows the strength of American industry and the ability of Americans feels that we would continue to fight for a long time.

I think the war years of 1861 to 1865 show that the American people do not stop fighting, no matter how hard they are pressed or what the conditions or the odds are. I don't think the Americans have changed much since that time.

The CHAIRMAN. Of course the 40 cities would contain the bulk of our industrial industry. Wouldn't that have some effect on the ability of the Nation to wage war?

General GROVES. It would have a tremendous effect, and I did not want to say yesterday that it would not make conditions very hard for us; but I did wish to make the point that we could still go on fighting and that we wouldn't necessarily quit. I don't know just particularly when we would know what we were faced with. If our people have courage we are not going to stop just because of somebody destroying a great deal of our potentialities. We would always be faced with the problem, "Is it worth while to go on?"; but England was faced with that problem and they decided to go on. It was the courage and determination of a few people in England that carried that balance over. Maybe if they had all been willing to quit they could have quit very easily.

The CHAIRMAN. General, do you want to give us some cost figures for the record on these various projects?

General GROVES. I can give you general cost figures, I think. I do not remember those figures exactly, because they are rather large. If you want to give me a little time to hunt, I will try to hunt fast.

The CHAIRMAN. Perhaps you can furnish those for the record. We would like to have those inserted in the record.

General GROVES. All right, sir.

(The following statement was subsequently submitted by General Groves and made part of the record:)

MANHATTAN ENGINEER DISTRICT GENERAL OVER-ALL COSTS

1. Diffusion plant

(*a*) The cost of research and construction of the diffusion plant was approximately \$545,000,000, of which about \$45,000,000 was spent on research by various plants and universities. The one major university working on research was Columbia, and the amount expended there was approximately \$11,500,000.

(*b*) The monthly bare costs of operating this plant under the initial conditions have been approximately \$6,000,000. These costs should increase appreciably as the plant continues in operation. (These costs do not include the cost of Government-supplied materials or the indirect costs of housing and transporting employees.)

2. Electromagnetic plant

(*a*) The cost of research and construction of the electromagnetic plant was approximately \$350,000,000, of which about \$33,000,000 was spent on research with various plants and universities. The one major university working on research was California, and the amount expended there was about \$14,000,000.

(*b*) The monthly bare costs of operating the entire plant have been approximately \$12,000,000. These costs should decrease appreciably in the future. (These costs do not include the cost of materials supplied by the Government or the indirect costs of housing and transporting employees.)

3. Metallurgical, Argonne and Clinton Laboratories, and other institutions

(*a*) The total expenditures on the activities at the Metallurgical and the Argonne Laboratories through June 30, 1945, were about \$17,000,000, of which about \$550,000 was spent on construction at Argonne. (These costs do not include the costs of materials furnished by the Government.)

(*b*) The total expenditures on the activities at the Clinton Laboratories through June 30, 1945, were about \$25,000,000, of which approximately \$12,000,000 was spent on construction. (These costs do not include the cost of materials supplied by the Government or the indirect costs of housing and transporting employees.)

(*c*) The total expenditures on related and closely coordinated activities at other institutions to June 30, 1945, were approximately \$4,000,000.

(*d*) The cost of production of metallic uranium at Iowa State College (where production of uranium ingots continued until the spring of 1945) amounted to about \$2,000,000, not including the cost of raw materials furnished by the Government.

4. Hanford engineer works

(*a*) The total cost of the Hanford engineer works, including housing facilities, is approximately \$350,000,000.

(*b*) The present operating costs are about \$3,500,000 per month. (These costs do not include the costs of certain materials furnished by the Government.)

5. Los Alamos laboratory

The total expenditures on the activiies centering on Los Alamos laboratory have amounted to about \$60,000,000, of which about \$26,000,000 was spent on construction. Military pay is not included in these figures.

6. Housing

(*a*) Oak Ridge: Expenditures on housing facilities, including necessary roads, utilities, schools, and shops, at Oak Ridge total approximately \$110,000,000.

(*b*) Hanford: The total construction cost of all housing facilities at Hanford was approximately \$48,000,000.

(*c*) Los Alamos: The total cost of housing of all types at Los Alamos was approximately \$4,500,000.

7. Industrial accidents

(*a*) The cost to the project of industrial accidents to workers and their subsequent care was about \$4,441,000 up to August 31, 1945. This cost included compensation benefits, medical payments by insurance companies, and that portion of plant medical operating expense assignable to industrial accidents; it is broken down as follows:

(1) Total cost in connection with construction:

(a) Compensation benefits, $1,577,000.

(b) Medical payments, $757,000.

(2) Total cost in connection with operation:

(a) Compensation benefits, $938,000.

(b) Medical payments, $1,169,000.

(*b*) The total accident experience of the Manhattan Engineer District is 62 percent lower than comparable experience of private industry. The National Safety Council's "Award of honor for distinguished service to safety" was presented to the Manhattan Engineer District on December 9, 1945, in recognition of the record made "in achieving and maintaining low accident rates at the Manhattan District facilities throughout the country under the urgent demands for speed in the unique processes attending the development of the atomic bomb."

The CHAIRMAN. General, what are the prospects for the development of bombs of considerably greater destructive power than those produced so far?

General GROVES. I think I can answer that one. It is a little hard to answer in open hearings, but I think it is of sufficient importance so that it should be in the open.

The CHAIRMAN. I asked the question, General, on the basis of the preliminary conference we had in which you said you thought you could answer that question.

General GROVES. I think—and I am speaking now primarily on the basis of the normal course of development, and not on any basis that there is something we know and have not disclosed or anything like that—we have built and fired three bombs. We have done this in a hurry. Our mission was to get a bomb that would go off with power. When we first started, various people talked about enormous sizes. In order to get the thing done, I stated that our goal was to have a bomb that would be the equivalent of at least a thousand tons. That was not the goal; that was the bare minimum.

Senator JOHNSON. Was that a thousand tons of TNT?

General GROVES. The equivalent; yes, sir. As announced by the President, the bombs were of the order of 20,000 tons of TNT.

Initially we all thought we could get something in the order of 10,000 tons of TNT, and I believe that I stated that the various scientists, as they started to work on this and started to wonder about how sure they were of their figures, kept putting in factors of safety, so when we came out at the end some of them even thought it would be below a thousand tons; but it actually had about 20,000, or in that order.

Senator TYDINGS. 20,000 tons equivalent?

General GROVES. Yes, sir; they are always equivalent.

Now, as to the prospects of developing bombs of considerably greater destructive power, I think they are promising; but I would also like to point out that when you go beyond this size of bomb you start to wonder where you are going to get a target that will require the full effect of this bomb. At Hiroshima we had such a target. In other words, it landed and there was space enough so that all of its destructive energy could be used. At Nagasaki we did not have that opportunity. We had a long, narrow target, and the bomb was bigger than it had to be. There was a lot of wasted energy that went off to the sides. If you remember how that river looked, the width of the target varied. I think there were some points where there was actually no development at all.

Senator BYRD. Were the two bombs of the same power?

General GROVES. They were of the same order; yes, sir.

Senator BYRD. You would say the same amount equivalent of TNT.

General GROVES. Yes, sir. No one knows what the exact amount is. We made an attempt to determine it, but you couldn't prove it. We have not discussed, Senator, the bombs in detail, and I would prefer not to discuss them in open hearings.

Senator CONNALLY. General, does the power of the bomb increase in proportion to the size or amount of material in the bomb?

General GROVES. I don't mind answering that one here.

Senator CONNALLY. Leave it to secret session, if you like.

General GROVES. I would like to leave most of it in secret session, but there is one thing that I think should be made known, and that is what happens in an explosion anyway.

What really happens is that you develop an explosive force, and then that blows apart.

Now, the question is if you put too much material in there it doesn't all explode because it is blown apart before it has an opportunity to explode, and there is a definite limitation on just saying, "Well, you made one bomb of this size; let's put two of them together and have twice as much material and we will have twice as big a bomb."

Senator CONNALLY. If you have any hesitation, don't answer any of these questions; but there was an old theory of chemistry or physics of which I have a very hazy recollection, that you don't get any more power out of something than you put in it. Is there in these atoms a latent power that is just there that needs touching off? I am speaking industrially now, more than about this theory of ruining everything with bombs; automobiles, and everything. Do you get any more force out of the bomb than you have to put in it through all these manufacturing processes and expenditures of fuel and energy and so on? If that is a secret, don't tell it.

General GROVES. I don't know the exact answer because I have never figured out how much energy we put into it; but I think it can best be expressed by this illustration: If you dig coal you get a certain amount of heat out of that coal. Whether you used up more or less energy in digging that coal, what you would get out of it would remain the same. In other words, there is something in here which if we start to explain would be getting us into some of Einstein's theories and a few other things which I would find trouble in explaining, and I am sure you would not be able to understand my explanation. Essentially there is something that is already there which we take advantage of. We don't compress this energy and put it all in one package as it were; it is there.

Senator CONNALLY. Well, it is the old idea of the indestructibility of matter, on which I was basing my question.

General GROVES. This might be based on the theory of the equivalence of mass and energy.

Senator CONNALLY. That explains the whole thing to me, General.

Senator RUSSELL. General, the papers tell us that some of the scientists are of the opinion that if a large number of these were exploded over the world that it would reach out into the elements in the atmosphere, and any other elements, and start splitting atoms there which would set the entire world on fire, and instead of being a world we would just be a new star and all life on the planet would be extinguished almost automatically.

Do you have any theory on that to give us?

General GROVES. My only theory is that I don't worry about it, because if it happens it will be all over and we won't have that to worry about. We won't have to explain that one, but the theory is not concerned with getting a number of these bombs but with getting one that is big enough to do that. No one knows what that size is. It is all highly theoretical.

The CHAIRMAN. That is where this thing was 3 years ago?

General GROVES. That is correct, but 3 years ago there was an agreement among the better nuclear physicists that these theories were correct. I don't believe there is that agreement now. It is more or less the kind of thing that they will discuss as a possibility when they are just sitting around talking; theoretically they may be able to prove that such a thing is possible, but the best advice I have, and I certainly don't hold any personal views or knowledge on the subject, but the best advisers tell me that they are not a bit worried, and I, personally, am not worried. I feel it will be beyond my lifetime, and then I will let the next generation worry as to whether they are going to blow themselves up or not.

I think there are many other things that a crazy man who had power behind him, and who got enough crazy people with him who all wanted to commit suicide, could do to destroy life on this earth as well as by this means.

Senator RUSSELL. There is one other question. Yesterday you implied that you had some doubt as to the practicability of a thorough world-wide inspection or checking on the production methods or use of atomic energy. Is that due to the difficulty in exploring all the places where this energy might be developed, or just on your opinion that the people would object so strenuously to the measures that would be necessary that it would be impossible?

General GROVES. I believe it is both. In other words, if the people object too strenuously they can stop thorough inspection. This country has never been able to have thorough inspection on certain things.

Senator TYDINGS. Prohibition is a good illustration of that.

General GROVES. So are the moonshiners in certain sections of the country where you might say the people were not so solidly against the Government as they were with prohibition, but you have that problem and also it takes such an awful lot of people.

I didn't say yesterday that inspection wasn't something that should not be done. I pointed out the difficulties of it because I did not like the idea of anyone feeling that it was something that with a wave of the hand you could accomplish and have effective inspection.

I do not believe that it is safe to say that inspection gives us a 100 percent guarantee. It is just like all inspection of all kinds. It is the reason that an airplane on reconnaissance can tell you if they see something, but they can't tell you something isn't there if they don't see it. That is true of everyone who is out looking for things.

Even in the days when cavalry was of real importance in this world of ours, we had to have infantry go behind the calvary to make certain the cavalry had not missed some of the military information that we wanted to have. You have got to look at every foot.

In this case you have got to look much closer than is generally spoken of. You just cannot go to the big industrial plants and say, "What is going on here," and then walk out.

Senator RUSSELL. You have shown us various little gadgets where if you would hold some piece of some radioactive element you would have certain reactions. You don't think it is possible to have any machine or development expose the place where any work of this nature might be done?

General GROVES. No, I don't think that is possible at this time. You could get certain things, there is no question; but other things you could not get.

The CHAIRMAN. Those certain things would be necessary in order to make an atomic explosive, would they not?

General GROVES. No; I don't believe so, Senator. I believe that it could be fixed up. In other words, you could put shielding on certain things.

Senator RUSSELL. You don't think you could fly over in an airplane with one of these machines and tell?

General GROVES. No, sir. Just how much you can do with that no one knows. After all, we were faced with the practical problem a few years ago in trying to find out what was going on in Germany, and we had many theories presented as to how we could find that all out; some of the theories were good, but you could not do it. After all, you have got to have the men who are going to make the inspection come back. Certain things can be done by a general, broad inspection; but I believe also that there is one thing you could do to defeat broad inspection if you intended to. Certainly if you are going to conceal or try to get away with something, the first thing you would do would be to start fighting on the inspection method that was used.

Remember that all nations would probably find out what type of inspection methods were used, and then they would go out to beat those methods.

Senator RUSSELL. We have heretofore, I believe, used only uranium in developing this energy. Has any extensive research been made with other elements to determine whether or not it would be practicable to use them?

General GROVES. I think the answer to that is that our goal was to get a bomb, and we went after that goal and have done a considerable amount of research in trying to build up knowledge. We built this bomb with inadequate knowledge, particularly inadequate scientific knowledge. Every time we could guess at the answer, we guessed at it without knowing why that was the answer, and we have consistently tried to fill in those gaps in knowledge.

We are working on that today with the purpose of trying to know all that we can about fission.

There is a great deal of talk in various places about how ultimately you can split other atoms, and ones of more common material. They have talked about how fine it would be if you could split hydrogen and oxygen, and then nobody would have a monopoly on the air.

We don't know how to do that yet, and I don't think anybody even has a real glimmer of an idea. It may come in fifty or a hundred years. I don't see it coming within a few years; if it does come, then that will be something to be faced by the people who are then responsible.

But we are not neglecting the advancement of science. We are doing everything we can to encourage it and to encourage it in our own laboratories and at our own expense.

The CHAIRMAN. General, is this material uranium radioactive in the ground?

General GROVES. Yes, it is to some extent.

The CHAIRMAN. Airplane surveys with a suitable detecting apparatus would register the presence of uranium on contact in low flight?

General GROVES. That would all depend on the shielding of the uranium on the ground. You see, when it is down in a mine or down several hundred feet, it is shielded by the earth in between. But it would also depend on the equipment.

No one that I know of has yet been able to locate uranium deposits by flying over them in low airplane flights.

If you put a piece of uranium in a room, you could probably find it if you could get up close enough. It is the same thing with some of your detecting equipment which is such that, when you hold a luminous dial in front of it, it registers, and the man who designed the equipment says, "That is a fine piece of equipment; look what it registers." Then I held my hand in front of it and it registered the same way. That is the size of it.

If you get apparatus that is too delicate then you find it goes out of order. It is one thing to have delicate apparatus in a laboratory where it can be very carefully protected from shock, and it is another to mount it in an airplane and send it through the air and really know what you are getting. You could get suspicions, but you would get a great many false suspicions.

I think eventually something may be possible on that, and certainly if I had any responsibility for inspection, it would be one of the methods of attack that I would take to try to get that knowledge. I think that eventually something can be worked out.

The CHAIRMAN. General, I have just one more question. If, perchance, by intense work it were possible to develop this process for central heating within the next 2 years, assuming that hypothesis, it would be impossible to use it until the international control problems were settled, would it not?

General GROVES. You mean to use it in the United States?

The CHAIRMAN. Yes.

General GROVES. No; I don't know of any reason.

The CHAIRMAN. You would have to put guards around it?

General GROVES. Yes, and I don't care whether it is under international control or not. I think you would want guards around it, for you have got too much money in there alone not to have guards, and real guards, too.

The CHAIRMAN. Thank you, General.

Senator CONNALLY. Mr. Chairman, I just want to say this: I think the general has made a very fine and splendid exposition of this matter and I want to congratulate him on the great work he has done in connection with the whole program and its development.

General GROVES. Thank you, sir.

The CHAIRMAN. I might say that the general has done a splendid management job in the last 3 years and has accredited himself most favorably.

Senator JOHNSON. Before the witness leaves, Mr. Chairman, I desire to say this: I concur in what the Senator from Texas has said.

But going back to the question of detection, this committee saw the finest instruments that science can devise within 12 feet of tremendous radioactivity, and the instruments were in no way affected. A dime was borrowed from the Senator from Iowa and inserted in that machine, and when it became radioactive and was placed near that machine, it went completely crazy.

Senator TYDINGS. The machine or the dime?

Senator JOHNSON. The machine. That indicates to me, at least, that it is going to be pretty hard to detect radio-activity with any kind of device, because there you had a perfect example of the difficulties of it. Just a concrete wall shut it off.

General GROVES. I think I said earlier, particularly if I knew what the rules of inspection were, that I could hide the material so that the inspectors would not find it; I think that any nation would have enough representation on that body of inspectors so that they would know.

Senator JOHNSON. That is particularly true with respect to the material when it is reduced to a chemical compound, where there is very little or no radioactivity present?

General GROVES. I think in various portions of the process it would require less shielding, but the shielding is not an impossible task; I would rather undertake the shielding than I would undertake the separation, or, particularly, undertake the detection.

Senator JOHNSON. That is all, Mr. Chairman.

The CHAIRMAN. Thank you, General.

General GROVES. Thank you, sir.

The CHAIRMAN. Professor Urey.

STATEMENT OF DR. HAROLD C. UREY, PROFESSOR OF CHEMISTRY, UNIVERSITY OF CHICAGO

Dr. UREY. My name is Harold C. Urey. I am professor of chemistry at the University of Chicago. During the war I was at Columbia University in the city of New York and was director of the SAM Laboratory. SAM was code for "Special alloyed materials," which in turn was code for the laboratory doing the research on the diffusion process for the separation of the uranium isotopes and for the production of heavy water and other materials. I did not work directly on the production of the atomic bomb but on materials used in its production. Altogether I have worked about 5 years on this problem.

The CHAIRMAN. I notice, Doctor, that you would not state it, but, for the record, I believe you are a Nobel prize winner.

Dr. UREY. That is right.

The CHAIRMAN. And that award was made upon the basis of your successful experiments on heavy water?

Dr. UREY. That is right.

The CHAIRMAN. In 1932?

Dr. UREY. Yes; in the fall of 1931, reported in 1932.

The CHAIRMAN. Thank you.

Dr. UREY. The Smyth report gives a history of the whole Manhattan project from the very beginning in 1939 to August of this year. This report is very well written and does not need expansion. It states what was done and by whom and when it was done. Hence in this testimony I shall not refer specifically to the various methods used or not used in the production of the separated isotopes of uranium or for the production of heavy water or their uses. Since all production figures, costs of production, comparison of relative advantages of various methods, etc., are classified as secret, it is impossible to say more about these processes than is already published in that report.

Suffice it to say that the diffusion method was very successful for the separation of Uranium-235 and that the exchange method was very effective in concentrating heavy water but that all methods for producing this latter substance were not sufficient to produce this material in large enough quantities for large-scale use. Exact figures on production and costs would better be secured from the Carbide & Carbon Chemicals Corp. and other operating companies rather than the director of research in any case.

If the committee will secure clearance for classified information I would be glad to appear before the committee again in order to discuss technical facts which it wishes to have and which I am competent to give. Today I wish to discuss the over-all situation relative to atomic energy and the atomic bomb as I see it.

One: Facts in regard to atomic energy and the atomic bomb.

Atomic energy is stored within the nuclei of atoms and has been so stored since the beginning of the earth, solar system, or universe, perhaps. It should be referred to as nuclear energy, but popular usage has probably fixed the term atomic energy in our vocabulary. The amount of energy liberated in the fission of uranium or plutonium is pound for pound about 3,000,000 times as great as in the case of coal burned in air. An improvement in a fuel or explosive by so much as 20 percent would normally be a remarkable one. The factor of 3,000-000 is so great that the significance is not comprehended immediately. We have some conception of what 1,000 miles is but no conception of 1,000,000,000 miles. Even a large source of power after decades of development amounts to about 100,000 times the power of a horse. It will be some time yet before the people of the United States really appreciate that on December 2, 1942, a radically new source of energy for peacetime purposes was first discovered and that on July 16, 1945, a radically new explosive first appeared. This latter event changes the entire military position of the United States, as well as those of all other countries and in fact makes the defense of this country more difficult.

Senator VANDENBERG. What is the significance of the date December 2, 1942?

Dr. UREY. That was the first time that a spontaneous pile producing heat steadily without explosive characteristics was produced at the University of Chicago.

The atomic bomb which fell on Hiroshima destroyed what was reported to be 4 square miles of the city. The area of total destruction in the case of Nagasaki was reported as 10 square miles. If the third bomb of this type to be exploded was a definite improvement on the first and second bombs we may confidently expect considerable improvements in the future.

The CHAIRMAN. Improvements, Doctor?

Dr. UREY. It depends on how you look at it. If 10,000 bombs were made and each were properly placed and if each should destroy 10 square miles, these bombs would completely destroy about the entire area of the States of Indiana and Illinois. This weapon transcends all other weapons in destructive capacity.

Scientific men have repeatedly stated that there is no defense against the atomic bomb and that there cannot be any decisive defense. Such statements come from men who have studied offensive and defensive military devices throughout the war. However, such studies are not necessary and probably are not as convincing as observations on other weapons for which defenses are known. A defense is known for machine guns, for example, armor plate; nevertheless machine guns accounted for many casualties in this war. Defenses are known against submarines, nevertheless they sank large tonnages of ships in both the Atlantic and Pacific Oceans. Defenses against airplanes are known, but they destroyed the cities of Europe. And thus we could tabulate many weapons both great and small. Similarly, we may expect countermeasures to the delivery of atomic bombs and countermeasures to the countermeasures, but in spite of this the atomic bombs will do damage in future wars commensurate with their destructive capacity.

In another way we cannot even expect as good defenses against atomic bombs as against other weapons. Forts, trenches, tank traps, armor plate, armored ships, and planes are able to absorb some punishment from the weapons used against them in warfare as it was before July 16. It is not to be expected that such defensive measures against atomic bombs can be taken except at expense so great that they could not be applied to all the vital points or to all the population of a country.

It is necessary to accept the fact that there is no decisive defense against the atomic bomb.

The atomic bomb could be smuggled into a country and used to mine our cities unless we practiced the greatest vigilance, so great in fact that our liberties would be seriously curtailed.

The bomb could probably be delivered by plane, rocket, pilotless plane, or other means. It could surely be delivered in ways that would not disclose the military power from which it came. It would be delivered from points at considerable distance from the target.

Atomic energy for peacetime purposes is possible but it is not developed to so great an extent as the atomic bomb. For peacetime uses we do not wish to secure the three million-fold effect that was attempted and secured in the bomb. Though small amounts of fuel will be required, industrial power uses will still require apparatus of the size and complexity of steam generation plants and the cost of securing power from atomic fuels will probably not be less than that for power from coal for some time. Power for special purposes such as for naval vessels, where competitive costs are not so important, will undoubtedly be the first practical application of atomic power. Many other uses as tools for research, and many techniques and devices of use throughout industry will be possible and will surely become available if adequate effort is put into this side of the problem. However, I believe that the whole peacetime use of atomic power does not have comparable importance to us as a nation nor to the world as a whole as does the problem of avoiding the use of atomic bombs. I believe we could well forego the large industrial power developments of atomic energy if this would aid, as it may, the control of the atomic bomb.

Two: The course of a probable armament race and the subsequent war.

I wish to present the probable future course and development of atomic bombs, assuming that no prohibition of the manufacture of such bombs on an international scale is introduced and also assuming that a war does not break out during the course of the development.

In the first stage of this development we shall have bombs but no one else will have them. This is the present situation. We feel safe and secure, but the people of other countries do not. We know that we have no intention of attacking other countries, but they probably cannot be expected to take us at our own evaluation. If the situation were reversed we would be very much alarmed and with good reasons. Others undoubtedly are alarmed now and believe they are alarmed with good reason, too.

In the second stage we shall have a fair-sized stock pile of bombs and other countries will begin to get a few bombs. Ours will be the best unless the scientists and engineers of other countries discover and develop some better ideas that we may have overlooked. In this stage we may have sufficient bombs to destroy the cities of any probable enemy and they will not be able to retaliate. I cannot help but wonder whether we shall be as harmless at that time. Surely other countries will hardly think so.

In the third stage both we and other countries will have sufficient bombs to destroy each other's cities—and by and by all will have about equally effective bombs.

As this situation develops tensions will increase slowly at first and finally beyond anything we have ever seen, or experienced. In a few years we will begin moving our families far from big cities and industrial plants if we can afford to do so. Finally, every ripple on the international scene will make us wonder whether the atomic bombs may not arrive before morning. Testifying before a Senate committee is an unusual experience for me but it will be much more exciting when this building becomes an important and probably target for atomic bombs in that future war. Of course a scientific laboratory would be an important target, also. But probably the most important targets will be those that result in the killing of the greatest number of people.

The CHAIRMAN. You aren't inferring that if they landed one here we are the most important people?

Dr. UREY. Well, the scientific and governmental leadership of a country is very important indeed, and perhaps my estimate is not quite right. This, I think, will be one of the important targets in a future war.

We might start such a war, or another country might attack us. In either case the country attacked would probably have concealed the launching sites for its atomic bombs and hence would be able to retaliate and destroy the enemy's cities. So with all cities destroyed on both sides we start a war with ordinary weapons and finish it in that way. Of course an enormous supply of material would have to be accumulated before the war, for with industry crippled it could not support the war while it was being fought. Unless great care were taken we would have lost our governmental, industrial, and scientific leaders. But I could go on with this for a long time and that would be unnecessary since none of us know just what course such a war would take. However, any course that it took would be disastrous for victor and vanquished.

But we have the atomic bomb and hence hold a trump card. How should we play the hand? Where can we interrupt this fatal chain of events most effectively for our own selfish advantage and perhaps to the advantage of every other country? The obvious answer is at the end of the first stage when we have lots of bombs and others do not, if we can judge exactly when that will be. We can blow the enemy's cities off the earth and take possession of the earth, occupy it with our armies, and begin the job of running the world according to our own ideas. This is a large order and one that I should like to avoid. In fact, I would stumble into it only by mistake or be forced into it only by overwhelming necessity.

My choice of time to do something about this threatening series of events is now or preferably 3 months ago, if it were only still possible. Atomic bombs must not be made by any country and they must not be stored any place in the world if we are to have any feeling of security in this or any other country on this all-too-small planet. We are making bombs and storing them and are thus a threat to other countries and are guilty of beginning the atomic armament race. If continued it will lead to dire disaster.

Three: The problem of control.

Can we control the atomic bomb by agreement between sovereign states? Japan armed herself and fortified islands of the Pacific in violation of her promises. Germany did similar things. The whole course of the League of Nations, which was a series of agreements between sovereign states, showed how ineffective such methods of control are. I would not trust the word of any foreign power if it stated that it would not make atomic bombs and I most emphatically would not expect any foreign power to trust this country. I believe that we would live up to our agreement, but I would not expect that others would believe it. And as time moves on, circumstances and people change and a time will come when abrogation of treaties will occur or treaties will be ignored or even used to deceive other peoples. I do not believe that this type of control is feasible for political and historical reasons.

Could we turn the bombs over to the United Nations Organization for safekeeping or use in emergencies? I would suppose that other countries might insist on some atomic bomb plants and their extensive accessory plants being located in other countries than the U. S. A. Also they would probably suggest that bombs be stored in other countries than ours. Also the big powers would insist on equal numbers of bombs in each of their countries or on some 5–5–3 formula. Or perhaps bombs could be stored in central Africa. In this case we would all become afraid of central Africa. I believe that there would be no satisfactory place to store bombs.

Also bombs would not be useful in an emergency. I cannot see how bombs could have been able to have solved the Spanish, Ethiopian, Manchurian, Czechoslovakian, and other troubles with which this war was begun. Further, we now have a supply of bombs. How could they be used in the Indonesian difficulty or the Chinese civil war? These bombs could have been used to destroy Madrid or Rome or Tokyo, but no one would have given such orders when the difficulty started. Only when the lines are drawn and the war ready to start could the atomic bombs be used and then an atomic-bomb war would come. Perhaps not so suddenly as otherwise but it would come nevertheless.

I believe that we should attempt to establish a control over atomic energy under the United Nations Organization which would be so effective that no person or group of persons in any nation could manufacture atomic bombs without detection and without being brought to trial and punishment. This means a sacrifice of some of the national sovereignty of this and other countries. I would rather submit to this, with police officers armed with sidearms able to arrest me for violating a law not to make atomic bombs, than to be threatened along with an entire city with destruction by atomic bombs from United Nations Organization planes for a similar violation. Also, I believe either of these would be better than an atomic bomb war. Of course the control must cover all countries of the world.

I believe that it would be technically feasible to determine whether a country as large as the United States were making atomic bombs, providing that inspectors could ask any questions and receive answers to them, could visit any scientist or engineer and see his work, inspect any plant or facility that they desired. It would be necessary to watch the movements of scientists and engineers, mines, ores, special materials and types of apparatus, and the appearance of any new developments. The existence of the Manhattan project and its general purpose were probably known by thousands of scientists in this country, and the extent of the operations and state of advancement would have been known had they been allowed to receive answers to questions. An inspector might have asked where any of dozens of prominent scientists were; and if he were told and then visited any of these, he would soon have learned what was being done and the approximate state of the work. Of course, any refusal of the privilege to visit or inspect personnel or facilities would be a suspicious act and also lead to disclosure. Covering up activities on such a broad scale would be very difficult.

In considering the problem of control there are two assumptions that might be made: First, that there would be no peacetime large-scale power plants; and second, that peacetime power plants would be permitted on a large scale.

Senator VANDENBERG. You mean power plants with atomic energy?

Dr. UREY. That is right. In order to secure power for industrial purposes from atomic energy, it is necessary to have very large scale plants. If these large-scale plants were all in existence, as they might be some 10, 20, or 25 years in the future, they would contain considerable amounts of fissionable material that could be used for bombs. It would then only be necessary to withdraw the material from these plants and manufacture this material into bombs.

This would be comparatively easy and would be much more easily concealed than if such plants did not exist.

If we have no large peacetime plants of this kind, and if it were necessary then to do a development job on somewhat the scale of the Manhattan project, I think the whole development would become quite obvious to any inspectors in the country; and I say that because the development of the Manhattan project was quite obvious to all our scientific friends not working on the project during the past few years.

The CHAIRMAN. Doctor, do you know of any invention in history, or any improvement in science, that was ever suppressed in peacetime use?

Dr. UREY. No; all weapons have been developed by other countries in time. The only case in which such things are not done is in the case of very backward countries. I don't think we need to worry very much about China and India getting atomic bomb plants; not for some years, anyway. But in the case of industrialized countries, I think that it is not possible for us to say how long it will be before they could produce them.

Great progress can be made in a relatively short time in a country that has an extensive system of technical education.

Senator JOHNSON. Reducing your "relatively short time" to years, how many years, Dr. Urey?

Dr. UREY. My guess is that it will take 5 or 10 years for other industrial countries to secure atomic bomb plants. It depends somewhat upon which country, and it depends upon the effort that is put forward.

When the bomb exploded, the most important fact was known. From that point on, any foreign country could move with confidence, and this is a great advantage; whereas we had to feel our way along on this problem, set up many alternative methods for doing this work, follow many lines of research, many of which were discarded. The foreign country at the present time would be able to set up its production sites, its bomb-production laboratory, and establish with confidence such laboratories as we had at Columbia, Chicago, California, and Los Alamos; and this would be a very great advantage.

Of course, my opinion as to how long it would be is a guess on my part, but I think that we should not think of a longer time than about 5 years. It may be longer, but I think it would be best to be pessimistic, or optimistic, depending on which way you regard the low side at the time.

Senator CONNALLY. Let me ask you one question.

You were talking awhile ago about the situation where we would not have any peacetime industrial use for the bomb at all and had none of those factors.

If we didn't, wouldn't it require, for the manufacture of bombs, such a large plant and equipment that it would be easily detected by these inspectors if there were somebody trying to bootleg the bomb?

Dr. UREY. I don't know whether you went to Oak Ridge or not.

Senator CONNALLY. No; I didn't.

Dr. UREY. The plants that are located at Oak Ridge, particularly the diffusion plant, are the largest chemical plants I ever looked at. It would be difficult to build that plant in pieces; it must be built as one unit. In order to build such a plant we need railroads, many roads, a large accumulation of people, and above all, we need concentrations of scientific men and engineers. Probably the scarcest commodity that is involved in producing these big plants is the scientific and engineering talent, and so the whole development becomes a very big thing which would be quite difficult to conceal.

Senator CONNALLY. That is what I was getting at; that of course if we had the industrial development it would be a simpler process for them to abstract materials and go off somewhere and make the bomb. But if we did not have the industrial development, you could not hide a plant that was making the bombs, could you, from an intelligent inspector?

Dr. UREY. I don't believe so.

Senator TYDINGS. Doctor, would I be diverting you if I asked some questions on what you previously brought out, or would you prefer that I wait until the end?

Dr. UREY. It makes no difference to me.

Senator TYDINGS. Assuming that other countries had learned to make the atomic bomb, using the Jules Verne imagination, would this circumstance be possible: Let us assume that any enemy country with atomic energy in its possession desired to stage a Pearl Harbor raid again in 15 years. Let us assume that they came to the city of Washington and hired three garages in three different places in the city and operated trucking lines, say, to Leesburg, Va., Baltimore, Md., and Richmond, Va., and operated these trucking lines for 6 months; and that on Pearl Harbor day of the future these trucks were driven back from their runs and in each of them was an atomic bomb that had been gotten in surreptitiously from a ship on the coast, or what not, and these trucks were put in three different garages in the city of Washington, and with time devices were exploded simultaneously during the night and killed the President, the Vice President, and Members of the Congress, the Cabinet, the Joint Chiefs of Staff, and similar other persons.

That is a very farfetched illustration, but that is not without the realm of possibility, is it?

Dr. UREY. I should say it would be quite possible.

Senator TYDINGS. Just as Pearl Harbor astounded our imagination when it happened, it could be done; there our fleet was caught flat-footed, so to speak. That would be the logical Pearl Harbor of the future under existing conditions, wouldn't it?

Dr. UREY. I should think so. I would say that exactly what you outlined would be wasteful. It would not be necessary to have atomic bombs in each one of these trucks. Three or four would be quite sufficient.

Moreover they could probably be brought in in pieces, piece by piece, and assembled at strategic points, and then as you say, set off with an alarm clock.

Senator TYDINGS. Then we would have no President, Vice President, or anybody in charge temporarily under our constitutional form of government, and if, simultaneously with that, other attacks were made at other places, from carriers at sea, or whatnot, we would have a demoralization far beyond any comprehension of which we are now capable.

Dr. UREY. The people of all the other cities of the United States would be very anxious to get out of them immediately, because they would be afraid that those cities were also mined in the same way.

Senator TYDINGS. The fear which I have just expressed for my own country would be the fear of any other country if international tension were developed to a point where war was possible?

Dr. UREY. I would suppose so.

Senator TYDINGS. Thank you, Doctor.

Dr. UREY. There are difficulties in connection with the possibility of inspection. Industrial executives would not like the idea of having inspectors come into their plants and find out all about what they were doing; but what alternative is there?

I believe that when the alternative of the possible destruction of the industrial plants of our large country is brought home to these people, that they also will realize that the loss of a few industrial secrets is really a small price to pay for the security of this country and for their own industrial enterprises.

The atomic bomb only high lights the fundamental difficulty caused by modern wars. Other high-caliber weapons by themselves would also bring disaster to all countries. In addition other weapons such as bacteriological warfare, destruction of crops by chemical or bacteriological methods as well as others may easily prove as destructive in the future as atomic bombs are now. Any international control should include all weapons and other means of waging wars.

Four: Our present situation. At present we have no method of international control and no international organization sufficiently strong to enforce control of atomic energy. We do not know whether we are moving toward an atomic armament race or toward such international control. In the first place, let us assume that it will not be possible to secure an international agreement, at this time, in regard to the manufacture of atomic bombs. In this case, we must make atomic bombs, we must make them larger, we must make them efficient, we must develop what defensive measures we can. We can and we must devise means for delivery of such bombs to possible future enemies. If this is to be the case, peacetime applications are relatively unimportant and need not be considered.

In the second place, if we do not make bombs, that is, if there is international control, then the peacetime developments become important. There are many things which can be done that would be of great value to the citizens of this country. There is the possibility of power, which is not of paramount importance because of our store of other fuels. In addition to that, there are many possible peacetime applications of the details of the work that has been done in connection with the development of the atomic bomb. In case adequate international control is secured, it will be unnecessary to keep anything secret from any of the rest of the world. If there is an adequate international control preventing the manufacture of atomic bombs by any country we should publish everything we do in the field of atomic energy, since only in this way could the control be made effective. We should have the maximum liberty for universities and private industrial companies to work on this problem.

In the third place, we must consider the interim period, which in any case must obtain before we can go from the present situation in which we are making atomic bombs on a modest scale either to one in which we make an all-out effort to make more and bigger bombs or to one in which no bombs are made by us or anyone else. This is a very difficult situation, for the manufacture of atomic bombs will cause suspicion on the part of other nations and may prevent international control while failure to make bombs might lead to a weakening of our military position if such control proves impossible.

I should like to add a brief insert at this point, if I may.

Much of the thinking and discussion on atomic energy is confused and often contradictory. Because of this situation, no legislation with regard to the domestic situation can clarify our muddled thinking and arguments. Only a rapid solution of the international problem will be effective.

The War Department does not know just what line of development to take at present, and any commission would be in the same situation. Moreover, it seems doubtful if both the military and peacetime work can be carried on at maximum speed. We can hardly afford to keep as large a group of scientists and engineers on this problem as we have during the war because of the urgent necessity of catching up with other lines of development.

I refer particularly to the need of training new men in sciences which has been so largely neglected during the war.

Five: Secrecy. In our present situation it is not possible to decide with confidence what degree of secrecy should be imposed on research, development, and manufacturing facilities. The fundamentals in regard to atomic energy are generally known, as are the general facts in regard to the direction we took in developing the bombs. Our present secrets are not of decisive value in an atomic armament race, but they are not negligible either. I estimate that the time required by other countries to secure atomic bombs might be decreased by about 25 percent if we published every detail of our scientific data and manufacturing procedures. Another competing country would be saved very considerable effort and cost by such publication. We must remember that secrecy hampers our own scientific effort very greatly. It seems most likely to me that complete publication of our present results and any secured in the future would be of more value to us in an armament race than it would be to any potential enemy.

Again the situation on secrecy calls for maximum efforts to clarify the international situation in regard to control of atomic weapons and other heavy arms. Obviously we should not attempt the control of atomic bombs only, for if this were done a war would start with the use of ordinary weapons and be continued with them until the atomic-bomb plants were in operation and the war finished with these weapons.

The secrecy conditions within the Manhattan project are, as nearly as I can learn, quite exceptional as compared with those in other scientific projects engaged in the work of the war just ended. There has existed and now exists almost a mania for secrecy not only with regard to the late enemies of the United States but also with respect to our own allies, our own citizens, our own elected representatives, other branches of our armed forces, and the scientific and engineering men engaged in the work. Those of us entangled in this net did not know whether this was necessary and mostly still do not know the detailed facts in regard to the desirability of this constant interference with the transfer of information. My own belief is that it was, and is, largely unnecessary and that it did, and will, impede the progress of the work on atomic energy. This subject is one which may frighten us but it should not lead us to apply methods which all experience shows will stifle development, drive the best men from the field, and shift all rights to knowledge to those with least experience in the application of that knowledge.

I may say that I do not wish to place the blame for this situation on any particular group. It has existed from the very beginning of the work on atomic energy for over 5 years. I believe that it developed gradually, and to some extent universally, because of the very exceptional character of atomic energy and the atomic bomb.

Before the war we were all more nearly sane in regard to this question of maintaining secrecy in regard to scientific developments than we are now. The military have been accustomed from the beginning of history to keeping operational decisions secret. This is entirely feasible. Such things as the exact date of D-day, the point of attack on the coast of Normandy, the number of troops and ships to be employed are matters which can be kept secret and which obviously should be kept secret. Moreover, no advantage is to be secured by not keeping them secret. Moreover, these secrets can be told easily in a few words so that any reasonably intelligent spy can transmit the information.

The problem of maintaining secrets of this kind has led to definite methods of preventing any probable loss to the enemy. Thus compartmentalization of information has arisen. Individuals reporting to a higher echelon are not allowed to discuss their work with each other except when permission is granted by higher authority. Moreover, each individual is given only the information which in the opinion of the higher authority is needed for his own work. All of this type of organization is that needed for espionage work.

In World War I, and in World War II particularly, science has demonstrated its great effectiveness in developing weapons of war, methods of defense and operational methods and the military have come to appreciate these contributions to the art of war. But no one has had so great a field day as the "security officer." What vast numbers of "secrets' he has had. What great stacks, in fact tons, of secret documents. How he has risen to the occasion in compartmentalizing all these scientific espionage agents and controlling the movements of personnel and documents. And he has not realized that his methods are not applicable, that his efforts obstruct the work beyond anything that he can comprehend, and that all his efforts are bound to be futile in the end because scientific facts are the same and can be learned by the careful student of nature on both sides of any international boundary.

Perhaps the committee would appreciate some examples of what we mean by "compartmentalized systems" of controlling information.

The laboratory of Columbia University had the problem of separating the uranium isotopes. That in Chicago worked on the so-called piles. In connection with the work on piles, and especially the work at Los Alamos in New Mexico, the exact conditions which would lead to the explosion of our materials were studied and finally well understood.

The separation of the uranium isotopes did not require any such knowledge as that, and hence all flow of information from the metallurgical laboratory at Chicago and between the University of Chicago and the laboratories at Columbia University was interrupted and prevented. But at the same time, if material accumulates in our diffusion plants in sufficient quantities and in the right places, either an atomic explosion might occur or radioactivity of great intensity might be produced, both of which would be destructive of the plant and of the personnel involved. Of course, if any accident of this kind occurred we would lose our operating personnel which would make it very difficult to continue the work.

Throughout this time, great efforts were made, particularly by the Carbide & Carbon Chemicals Corp. which operated the plant, to secure for their own men the necessary data which would enable them to determine whether the plant that was being built might be explosive or not. Up to the last contact I had with this problem, no such permission was given. Competent men, Dr. Teller and Dr. Smith, were assigned from Los Alamos and Chicago, respectively, to the construction company, and they were expected to decide as to whether the plant would explode or not. They are very competent men.

We managed to get the plant built, and there was no difficulty of this kind, but throughout the whole period the operating company found themselves building a plant which might have been explosive, and had no way of securing information that would enable them to decide that question.

A similar situation, I am told, occurred in the case of the electromagnetic plant in which a solution of Uranium-235 made up in water would have been explosive, but the people operating the plant had no information which told them that such would be the case. By a rather rare accident and by a break-down of compartmentalization, this difficulty was discovered in time.

I could go on with many other illustrations of this kind. I might say one that I think was a little amusing occurred at the beginning of 1943, when I learned that the du Pont Co. was told not to inform me in regard to their method for the production of heavy water. I knew this because of my contact with my very good friends at the du Pont Co., and I also learned it by the backyard-grapevine route by which information leaks around compartmentalization barriers. The lack of necessity for that has always appealed to me as quite remarkable, for the method they used was merely boiling water through apparatus that is standard apparatus used in the chemical industry. It was not a problem in which I was personally greatly interested, but I was greatly annoyed by the fact that that information was interrupted.

Recently there have been questions about the cost of heavy water which are not known to people who would plan and think of using it. It is quite a vital item of information to the research man on a job as to whether a material he proposes to use is expensive or not. Also the amount of Uranium-235 which might be available for their plans were matters which they were not allowed to have.

These are a few samples. I could carry on examples of this kind; they could be brought up by the hundreds.

Senator HART. May I interrupt you there?

I think you said something which you would not wish to have misunderstood.

You were talking of the risks that were involved in certain plants, risks to personnel, I take it, because of what you term these extravagant methods of secrecy. Of course, there were risks all through, and no accidents did happen, which shows that very excellent provision was made to guard against them, and free insurance was carried, so after all you don't wish to be understood as saying that none of the personnel involved should have been facing such risks as those which are rather minor as compared with the risks which the men in uniform are taking, do you?

Dr. UREY. No; in a war we all expect we will take risks, and these problems were surmounted; but had accidents of this kind occurred, it would have seriously interrupted the work. How would we keep the personnel on the project? All the men would have walked out of the plant if they had realized there was such a great risk. At least it looks that way to me, and it was the opinion of the operating company that that was a serious difficulty they faced. It wasn't a matter that in a war you need to worry too much about a few human lives. Many are being lost, but it was important that the work should continue to go on.

Senator HART. Yes; but, Doctor, did you mean to say that that condition is what you consider an extravagant method of secrecy?

Dr. UREY. It is one illustration of what I think are the extravagant methods of secrecy.

Of course, the important part of this side discussion is not what was done in the past. I am perfectly willing to let the Pearl Harbor investigation take care of such matters, but if this constant frustration of scientific and technical men by artificial barriers to the flow of information is continued in the future, it will be a very discouraging feature to many scientific people. They will prefer to work in fields where no such interference with the information which they need occurs; and that is the important thing for us—nothing of the past, just what is the bearing upon the problem of future development.

While operational secrets can be told in a few ordinary words, scientific facts can only be told in many pages of highly technical discussion. Within a large scientific project the distribution of information is a very difficult problem. The reading of the German documents on atomic energy must be done by men who understand the subject matter. Scientific details are difficult to transmit to others, even to other scientists. For this reason compartmentalization of scientific information is unnecessary and only obstructs the necessary dissemination of information among men who need it. Of course, if scientific information were freely published during a war it would be of value to the enemy, since this gives us an opportunity to study the scientific details.

Certain types of information in our problems partake of the character of operational secrets, that is, the fact that a problem is being investigated, probable dates of completion of phases of the work, amounts of production, sizes of weapons, general processes being used, nature of critical materials used, and so forth. Some of these were made public in the Smyth report.

I think we were entirely justified in making those public in the Smyth report, for most of the information was of the type that would have leaked very quickly in any case, and perhaps already had leaked before the Smyth report came out. Unfortunately, most of these cannot be compartmentalized without, at the same time, treating scientific data in the same way. Also certain information of this kind bears on public policy and during peacetime should be available to the public. Thus the rate of production of bombs and the number stored should be known to the people in the same way that the size of our Army and Navy is known to them, and in both cases is then necessarily known by the governments and peoples of other countries.

Before the war the distribution of scientific information was not restricted in any way unless it related to the detailed construction of weapons or defenses against weapons. We should go back to this same situation in the postwar period, since the advantages to be gained from a free science so greatly outweigh the immediate advantages of a few temporary secrets that no other course would be sensible.

Specifically, secrecy regulations under the assumption of no international control should be limited to the mechanical details of the bomb and certain details of construction of plants. It should not cover any scientific facts whether or not they are necessary for the construction of the bomb and plants. Only in this way can work on the improvement of the atomic bomb and on industrial uses be done effectively.

Moreover, as a matter of public policy, our capacity to produce atomic bombs and the number stockpiled should be known by the people of the United States. To keep such matters secret would be comparable to having a secret navy or army. Making these matters public will inform all other countries of our strength in this respect, but unless we intend to abandon an important aspect of our present system of government, these facts should be known.

Senator HICKENLOOPER. Mr. Chairman, may I interrupt?

The CHAIRMAN. Yes, Senator.

Senator HICKENLOOPER. Doctor, I do not mean to take issue with you on this argument about the number of atomic bombs except to raise this question: I cannot quite follow the desirability of announcing to every other country the exact number of our store of atomic bombs, assuming that we elect to keep a store of them. It would seem to me to be a whole lot like the moving-picture versions of the detective who counts the number of shots in the crook's revolver, and when he shoots six times goes in and gets him.

When the other nations, assuming we want to use this for war purposes, know we have a thousand of these bombs, or 500 of them, or the exact number, they might be able to perform the best defense possible against our use of them by merely dispersing their population and their industry until we shot all of our 500 bombs, and then know that we, at least at that moment, did not have any more.

That argument would appeal to me as being against the announcement of a particular number of bombs, as differentiated from statements concerning the size and number of our ships, for instance, or our military forces—information readily obtainable by any good spy.

Dr. UREY. Well, atomic bombs are a weapon of such a large magnitude that they represent something of the order of magnitude of capital ships in their importance.

I would also, along with my idea in regard to people of the United States knowing what number of bombs we have, believe they should know how many ships we have in our Navy or how many soldiers in our Army.

I am only saying the atomic bomb is a major weapon, not a minor one at all. It is equivalent to an entire air force, or an entire navy or an entire army, and the people of the United States should know whether they are building up an army, a navy, an air force, or a stock of bombs.

Senator HICKENLOOPER. Well, I agree that the widest information should be given on these things, but I believe that perhaps we announce very glibly the number of ships we have and the size of our Army because we know anybody can find it out anyway.

In the case of the atomic bomb, which is a major weapon and perhaps for the time, anyway, a controlling weapon, there might be a little different element of human nature in there that would dictate whether we should conceal the fact if we elect to go on with the atomic bomb as a war weapon.

I hope we can arrive at a solution where we do not have to. If we elect to use it as a war protection, I conceive that it could be concealed just as we conceal the number of battleships and carriers we have, and, if we could do it successfully and hide them so no foreign agent could find them, I have no doubt but that we would be concealing the exact number of bombs.

Dr. UREY. My own idea would be the matter of whether we considered ourselves at war, or in an armament race where we expected to get into war, or considered ourselves at peace. But if we are at peace, my argument applies. If we are essentially at war I would agree with you.

Senator HICKENLOOPER. Thank you, Doctor.

Senator JOHNSON. Mr. Chairman, may I interrupt?

I understand your position, Dr. Urey, as being opposed to all military secrets, not only the atomic bombs, but every other kind of military secret.

Dr. UREY. Well, that is a rather broad statement.

Senator JOHNSON. Well, that is what I understood from your prepared statement.

Dr. UREY. No; I say that if we are going to engage in an atomic-bomb armament race, the things that should be kept secret are the details of the bomb, as we do in the case of all other weapons.

We do not tell the details of our bombs, or the details of our planes, or the details of our ships and things of that sort.

But also we do not suppress the scientific data upon which all of these things are constructed, and the same distinction is the only one that I ask in the case of the atomic bomb.

Senator TYDINGS. But what you say, Doctor, with a great deal of emphasis, as I got your testimony, is that we ought to try to establish a line between what might be classified as purely scientific research and development as differentiated from its application to weapons.

Dr. UREY. That is right.

Senator TYDINGS. In other words, to take a far-fetched example, if Einstein's theory is discovered, or if the philosophy or formula for the splitting of the atom is discovered, that should be passed along?

Dr. UREY. That is right.

Senator TYDINGS. But you are not attempting to say that all of the application of that theory to the actual mechanics of producing the weapon should be publicized?

Dr. UREY. That is right.

The CHAIRMAN. Then your point is, as I get it, that it would not be possible to develop—to use the Senator's illustration—an Einstein theory in the compartmentalization treatment of scientific matter?

Dr. UREY. A genius such as Einstein would probably bring forth his theory of relativity without a great deal of discussion with many scientific colleagues; but most scientific work is not done that way. I may say that the development of the theory of relativity was not done entirely that way, either. A professor of the University of Chicago tells me of the seminars they had in Berlin at the time Einstein was working on his theory of relativity, and I have no doubt but that Einstein found those discussions exceedingly stimulating at that time.

But somebody of that kind may from time to time bring out a startling piece of work without a great deal of stimulation from his colleagues, but that is very rare. Nearly all scientific work proceeds by one man making a discovery, moving the subject forward by a small amount, publishing his data, presenting it at a scientific meeting, everybody discussing this thing, and someone in the group goes home with an idea of his own that might be slightly different from that of the man who presented the work. Then he starts to work and he presents some paper, and somebody else picks up another idea. This constant interplay of many minds working on the problem is what makes the whole field of science go forward. If we must have secrecy on this problem within the United States in the next coming years, all compartmentalization lines should be destroyed so that we get as much discussion among the scientific people within the project as possible, so that a maximum number of good ideas can be brought forward.

That is my objection to the compartmentalization. If we must have secrecy, then the whole project should be in one unit in order to bring as many minds into one group as possible.

The CHAIRMAN. Did you protest this compartmentalization while it was going on?

Dr. UREY. I think, as I said, that the scientists somewhat helped it along. I believe that it started about in 1940, which was my first contact with it, and it was certainly in full swing at that time.

I believe the scientists dropped into it themselves because they did not realize how damaging it was, nor to what proportions it could grow, and only after swimming in this molasses for years have they come to realize that this sort of thing stifles their efforts and frustrates them more than they ever imagined when the thing started.

Senator HART. Doctor, I think I understand you better now. You are arguing against the continuation of the methods of employing secrecy which we carried on through the war?

Dr. UREY. That is right.

Senator HART. You are not particularly finding fault with the fact that they did carry them on during the war?

Dr. UREY. The whole job on the development of the atomic bomb was done, I think, very well. I could go through and find fault here, there, and some place else, but if you were to turn the whole thing back to the beginning and try it again I don't know whether we would have done any better or not. I doubt it.

I am not complaining primarily concerning the things that were done in the past, and I am distinctly not blaming any particular person or any particular group. I think it is a thing into which we all dropped for a rather natural reason because of our appreciation that we had in our hands a very important development.

I am only saying at this time, "Let's not do it in the future; let's get out of our tank of molasses and make some progress in a much more effective way than we have done in the past."

Senator TYDINGS. But you even limit that statement to the qualification, as I get it, that the theoretical or scientific development, or the art itself should receive freer consideration; but as to the weapon itself and the technique that goes into it, you are not complaining of the secrecy imposed on that?

In other words, you want science free to explore without disclosing what it has done in the way of this weapon?

Dr. UREY. That is right.

TNT, trinitrotoluene, is a substance which we can investigate in chemical laboratories and find its properties all we wish to. But just as soon as it is being made into bombs, then we do not publish our results, and the same thing should be done in this field.

Senator TYDINGS. It is inherent in your testimony that the degree to which we transmit scientific knowledge should be international; that is, there should be reciprocity.

If we find that scientists are working in other countries under the restriction of their governments to transmit nothing to our science. I imagine you would approach the freedom of the interchange of ideas with more hesitancy than if there was a freedom everywhere.

Dr. UREY. I would say this: If we must have a competition on this subject with foreign countries, then we ought to have as large a degree of freedom in the United States as possible in order to get the maximum benefits. But of course there is no reason, if we are going to compete seriously with another country, why we should give them information and they not give to us.

Senator TYDINGS. You are requesting an interchange of international knowledge within the limits that could be exchanged without impairing our national safety?

Dr. UREY. That is right.

Senator JOHNSON. Dr. Urey, I think I understand your position much better now. The paragraph that threw me off was your second paragraph under "Secrecy," wherein you state [reading from a copy of Dr. Urey's prepared statement]:

> * * * the situation * * * calls for maximum efforts to clarify the international situation in regard to control of atomic weapons and other heavy arms. Obviously we should not attempt the control of atomic bombs only, for if this were done, a war would start with the use of ordinary weapons and be continued with them until the atomic bomb plants were in operation and the war finished with these weapons.

That paragraph led me to the conclusion that you did not want secrecy with respect to any of the weapons of war.

Dr. UREY. I would say this: If we can secure an international control which we believe is adequate and can trust, it will necessarily lead to control on other weapons than the atomic bomb. Inspection would immediately disclose the developments on other weapons as well as the atomic bomb.

If that were the case, if we could secure such control, then we should publish every single thing we do. If we cannot get that control, then we must have a certain amount of secrecy within the framework of our own group, and I am only pleading that in this second case the compartmentalization rule be broken down so that all people working on the various phases of this project can know about it.

Senator JOHNSON. I agree completely with that statement. However, until we get the international control in the satisfactory position such as you describe, I think you are making too much of a distinction between peacetime and wartime. I think we are continuously at war and must consider ourselves to be continuously at war until we have stabilized peace, the international peace to which you referred.

The argument which you made about everything being satisfactory in wartime, and not satisfactory in peacetime refers to the kind of peace that we have been enjoying, which is nothing more than a temporary armistice, an unstable peace.

Dr. UREY. That is exactly the reason why I plead so repeatedly for rapid movement on the international scale so that we can make a decision as to what we ought to do. I don't believe we can make any decision as to what we should do at the present time.

Senator TYDINGS. You are not advocating that we carry out anything you say tomorrow?

Dr. UREY. No.

Senator TYDINGS. You are simply projecting it as a possible premise upon which we might proceed when the circumstances permit it?

Dr. UREY. One of our difficulties is that none of us knows whether we should try to produce atomic bombs in great numbers at the present time, or whether we should not develop them at all and pay attention to peace.

What you do in one case will be quite different from what you do in the other. Until that situation is clarified, you cannot make up your mind what you ought to do.

In the first case, if we don't have to make bombs, we can publish everything we do. In the second case, where we must make bombs, we still must get as much freedom to the groups working on this in the United States as possible to get a maximum effort in the field.

Senator TYDINGS. Have you thought of this angle—and evidently from your testimony you have: All countries manufacture, perhaps in peacetimes, disease germs which can spread epidemics in hostile populations. I assume that many countries on the face of the earth during the war kept laboratories where these germs were made and could be dropped if any other country started that.

It was not done, for the very obvious reason that there was the fear that the other fellow might have a worse bunch of germs or a better bunch than you had yourself.

Have you given thought to the fact that if we have a store of these atomic bombs, it might stop the other man from using the atomic bombs that he has, because retaliation would come sooner or later, and even though he got the initial advantage by a surprise attack, if we had some bombs all over the country and the transportation facilities available so that atomic bombs would eventually be dropped on him, too, that the horror of the whole thing might restrain him?

Dr. UREY. I have thought about that a good deal. I don't think I would trust it. Take the case of poison gas. We undoubtedly did not use poison gas for humanitarian reasons. Perhaps the Germans did not use it for fear of retaliation; but back of the failure to use poison gas was probably a judgment that incendiary bombs were more effective than poison gas, and hence the effort went into the production of incendiary bombs rather than the production of gas in Germany.

Having proceeded along this line, they had not gotten ready to defend their population against poison gas, and hence did not wish to start it later.

I think it is very likely that the analogy, for example, to poison gas is not good. In the case of bacterial warfare, I don't know. Turning bacteria loose in the world is dangerous, because if you produce a very large diseased spot in some part of the world, the diseases have a natural way of spreading to places where you don't want them. Atomic bombs, the ones we drop, will not spread back on us.

Senator TYDINGS. No, but the other country has the germs to bring back on you, in the form of another atomic bomb.

Dr. UREY. Yes.

Senator TYDINGS. I think, if we had a large stock of these bombs, and some possible enemy had a large stock of these bombs, there would be a hesitancy on their part to start a war with us because of the inevitable retaliation that would come.

I am wondering whether you have pursued that very far, and what your opinion on it would be.

Dr. UREY. My opinion is that it would not be a sort of protection which I would like to trust.

Senator TYDINGS. Have we got anything better for the time being?

Dr. UREY. The only thing that appears to me to be worth while as a means of trying to avoid the destructive effect of atomic bombs is to try to induce the other governments of the world to agree to an outlawing of the bomb and to backing it up with an inspection to find out whether the outlawing is obeyed, and also with some means of bringing violators of law to justice.

I believe that means we must not manufacture bombs, because that enables us to introduce an inspection system. If we are manufacturing bombs at various places, I don't know how we would introduce an inspection service.

Senator TYDINGS. You made that clear in the first part of your remarks. I believe you looked ahead for 20 or 25 years to the period when probably five or six nations would have an ample store of these bombs.

The CHAIRMAN. He didn't say 20 or 25.

Senator TYDINGS. I am just assuming that.

The CHAIRMAN. He said 5.

Senator TYDINGS. Well, let's assume 20, 15, or 10, and they all have a large stock of these bombs.

Now, if that situation should come to pass, there would be no hope in the world that a war would be fought without atomic bombs.

Your assumption is that we ought to try the other thing and see if we can work it before we face that alternative, if it is humanly possible. That is the general line of your reasoning, isn't it?

Dr. UREY. That is right.

Senator TYDINGS. The other may not work. The alternative may not work, it may fail, but you think it is better to explore it and try it than it is to rely on the day 20 years from now when there will be no restraint and every nation will have these bombs available?

Dr. UREY. Yes. Toward the end of this statement I have pointed out the difficulty of keeping scientific men on the job of making atomic bombs.

Scientific men don't wish to work on destructive weapons; they would rather work on constructive things. If they have a choice—and we still have a choice in this country to work on what we wish as individuals—they will drift into fields of work in which they will see constructive results of their scientific work. As a result, I don't know how you are going to maintain research on atomic bombs, except in one way. You will have to see that the international situation develops in such a way that each individual scientist is convinced himself that that is the only thing that can be done to defend the United States, in which case he will go to work on atomic bombs. I don't believe any artificial method will get an active development of atomic bombs except that feeling of necessity in the heart of every man that has to work on them.

Senator TYDINGS. Would you say, from your contact with fellow workers in the scientific fields—and imagine that contact is on a rather wide scale—that it is the universal opinion of the men who have built this Frankenstein creation, so to speak—and I say that with a smile, not with criticism—that the hope of the world lies in finding some means of dealing effectively with the atomic bomb so that its probable use will be prevented, and that any other thing that is allowed to drift means the ultimate destruction of the whole earth, let us say 50 years from now when it has gone through its whole evolution? Is that your thought?

Dr. UREY. That is right. I do not see this line of argument. The atomic bomb is exceedingly destructive. A picture in a morning paper shows what area of Washington would be destroyed by one atomic bomb. It is very destructive.

Second, there is no defense for it, and therefore we must make a large number of bombs.

The last step, somehow or other, does not follow logically in my mind from the first two. I do not believe it is a solution to the problem posed by the first two statements, and I would like to see us propose something that is at least a partial or a possible answer to the first two statements.

Senator TYDINGS. In other words, the ultimate conclusion of the first two statements is so horrible that you are not willing to accept that as a final answer without working with all your might and main to find, even though you fail, an alternative?

Dr. UREY. Well, making a lot of bombs is no defense to us; it is only the retaliation that you mentioned, Senator Tydings, that is the only defense involved in it. It still will not prevent our cities from being destroyed and people from being killed.

Senator TYDINGS. Scientists share your view, don't they?

Dr. UREY. I think they do.

Senator TYDINGS. Those I have talked to do, and I wonder if your experience was the same.

The CHAIRMAN. Doctor, I don't want to delay you unduly, but I wish to ask you the question I asked General Groves yesterday. You were probably in the room.

If country A was to take over country B, a small country, by fifth-column methods, and the attack was to come from country B although promoted by country A and although we had no proof of that fact, the only retaliation we could have would be on the basis of suspicion, would it not, that maybe country A did have something to do with it?

Dr. UREY. Yes, sir.

The CHAIRMAN. Now, it is possible that country A might be suspicious, but maybe, on the other hand, it would not have anything to do with it because a small industrial country might get these bombs to do the job.

Dr. UREY. I don't know what we would do in such a situation. It is a very difficult thing to answer. To attack the first country because you suspected them of having something to do with country B would be immoral, to say the least. I suppose that our country in that case would have to make some sort of a decision, and maybe just attack country A. I don't know.

The CHAIRMAN. We might be wrong?

Dr. UREY. And we might be wrong.

Senator TYDINGS. You heard General Groves testify, Dr. Urey, that in a war in the future, let's assume 25 or 30 years from now, between major powers we might have 40 large industrial cities partially or totally destroyed, and probably 40,000,000 people killed and that we would still fight on.

Do you care to comment on that statement, to enlarge on it?

Dr. UREY. Well, I mentioned in my direct testimony here that I feel in such a case we would have to to have very large stores of material before the war started in order to be able to continue it.

Mostly we have fought our wars recently by letting someone else hold the enemy for a year or so while we built plants to make materials with which to fight a war, and then as the war progressed we kept up an enormous production to fight that war.

I don't see how we could possibly follow that pattern in such a future war.

Senator TYDINGS. That is gone.

Dr. UREY. That is gone. We would either have to have a large store, or else hope the other fellow was in exactly the same position so that we could fight it out on equal terms by much more limited methods of warfare than have obtained in this war.

Senator TYDINGS. But if the atomic bomb is in production among three, four, or five of the leading powers and there is a surprise attack on a big scale, the modern conception of Pearl Harbor 25 years from now, and our population is in the stage it would be in with the killing going on, what is your conception of what would take place after that surprise attack had pretty well been carried out with moderate success, let us say?

Dr. UREY. I would like to make a further assumption, namely, that our atomic bomb launching sites were not destroyed. We would destroy the other fellow's cities next. I think after that that the war would languish. I think we would all be so busy taking care of our own homeless and wounded people, probably without leadership, for our leaders would probably go with the first Pearl Harbor attack, that we wouldn't pay very much attention to the war for quite a long time, and neither would our enemy. That, I think, would be the probable outcome.

Senator TYDINGS. We would hunt the open spaces, wouldn't we?

Dr. UREY. We would hunt the open spaces and try to get enough to eat to take care of ourselves, and it would be pretty much of a stalemate from that time on.

The CHAIRMAN. If we had 100,000 bombs and if you adopt Senator Tyding's example that he gave about the trucks that would come into Washington, for instance, it is possible that we would not know who planted those and so we would not know at whom to launch the hundred thousand. What would we do—throw them widespread?

Dr. UREY. It would be an anonymous war, and I think it would be the greatest mystery of a long time as to "Who done it?"

Senator HART. I, like Senator Johnson, am afraid I misunderstood you.

In the first paragraph of your discussion on secrecy, you said that you thought we had more to gain than we had to lose by publishing everything that we know right now.

Dr. UREY. Yes, sir.

Senator HART. To me that sounds considerably like our noble experiment of the early 1920's, when we tried to get the world to disarm by example. It didn't work.

Would you wish to enlarge upon that, Doctor?

Dr. UREY. I told Senator Johnson that if we must get into a definite armament race I think we will have to have secrecy around the borders of the United States, as it were, and so that statement is somewhat inconsistent with what I have said there.

But in reply to your analogy, I would say this: There is a very great damage to scientific effort imposed by these secrecy conditions. You see, it isn't a clean-cut decision. We wish to get a maximum amount of effort and development on our side, and to minimize the effects of leaks to the enemy, and some place between the two postulates of publishing everything we do and keeping everything carefully compartmentalized and secret, there probably is an optimum position, and I think the optimum position lies far toward the side of making public our scientific facts, but probably not so much of our scientific or industrial "know how." That is, where I would place the maximum is probably close to the side of maximum publication.

Senator TYDINGS. Are you doing anything with the powers that be to achieve such a policy of a little more freedom in scientific research, and making headway?

Dr. UREY. I have been asked by General Groves to serve on a committee looking toward the declassification of scientific documents that have accumulated on this project during the war. My argument before that committee sounds very much like the one that I am presenting to this committee.

Senator TYDINGS. I imagine, then, there is an agency set up working on this problem to see how far, within the limit of what is conceded to be the Nation's interest, scientific freedom can be granted without jeopardizing our security.

Dr. UREY. That is right.

Senator TYDINGS. So that problem is being worked on?

Dr. UREY. That is right.

The CHAIRMAN. When was that committee set up?

Dr. UREY. Oh, I should judge about a month ago. There was a meeting of the committee on Monday preceding October 16, which was a Friday.

The CHAIRMAN. About 30 days ago?

Dr. UREY. Yes.

The CHAIRMAN. It wasn't set up before the War Department prepared their legislation on this subject?

Dr. UREY. No.

The CHAIRMAN. Go ahead, Doctor.

Dr. UREY. Six: Specific provisions for prospective domestic legislation.

I might say that that is a field in which I have a few suggestions to make, but I am sure the gentlemen on this committee are far more skilled in matters of this kind than I am.

The commission, in whatever form it is set up, should be responsive to the President and the Congress. This is especially important in the case of the control over atomic energy, which is moving very rapidly and involves so many points of foreign and domestic policy. Two forms of organization would seem possible to me.

A director of atomic energy might be established, appointed by the President, with the advice and consent of the Senate, and removable by him, as are Cabinet officers. This director is bound to exercise vast powers, and some check on his activities is desirable. This might be supplied by the use of the courts, though they are likely to find themselves uninformed on such a complex technical problem and hence unwilling and unable to review acts of the director which may be regarded as arbitrary by persons with whom he deals. In order to avoid this difficulty it may be possible to establish an advisory and appeal board.

A second form of organization would seem desirable to me. A full-time commission of, say, three or five men, with the Secretaries of War, Navy, State, Commerce, and Interior as ex officio members. The full-time members should be scientists or engineers and should be appointed by the President, with the advice and consent of the Senate, and removable by the President, just as Cabinet officers are. The commission could then appoint its administrator, with the approval of the President, who again should be a civilian without any other loyalties. This administrator should be a civilian for two reasons: One, he should owe allegiance to no other authority than the commission, and two, he should have had experience in handling men and organizations on a peacetime, nonmilitary basis.

Either the director, in the first case, or the administrator, in the second, should be men of broad experience, with the ability to handle very large problems, such as those which will occur in the case of atomic energy control. If it is feasible to do so, the salary should be high enough to attract a man in competition with industrial positions.

The powers of the director or commission should be adequate for this problem, but any blanket grant of powers should be avoided. Amendments to laws are always possible; and if the original powers granted are not sufficient the Congress can extend the first grant of power. Since this development has been carried through with Government funds, it is only reasonable to attempt to avoid monopoly by private persons. At the same time, the control should not be so strict that development is stifled by lack of incentives.

The director or commission must have the following powers:

One. The right to know where and by whom scientific, development, or industrial work on atomic energy is being done.

Two. The power to make rules and regulations covering hazards incident to such scientific, development, and industrial work and the power to inspect establishments to determine whether such rules and regulations are followed.

Three. The power to keep inventories on all fissionable elements and their separated isotopes. Ownership of U-235, Pu-239, and other elements of similar fissionable properties should reside in the Government.

Four. The right to use all patents and other information for work on atomic energy. The patents should be made available on a compulsory license basis.

Five. Certain legal and business powers dealing with organization of corporations, making contracts, etc.

Six. The right and, in fact, duty of licensing fissionable and other special materials on an equitable basis to private persons for use in research.

Seven. The right and duty of encouraging research, development, and manufacture of atomic energy and equipment for peaceful purposes.

In addition to these, other powers may be necessary. I believe that the Navy and Army should be permitted to carry on experimental and developmental work on phases of atomic energy having to do with national defense. The commission should also be permitted to conduct such studies.

I believe that the commission should not operate its own research and development laboratories but should secure the development of atomic energy through private laboratories or by letting contracts for such research and development with private persons. This suggestion runs counter to opinions of other people, and some explanation is necessary.

I may say that I am not sure I am right about this; that is just my opinion.

The commission, if it had its own laboratories, would be making grants to private laboratories and its own laboratories. It would immediately get a proprietory interest in its own laboratories and almost certainly would favor these laboratories relative to private laboratories. I believe that there would be an almost unconscious tendency to divert the work on the more promising lines to its own laboratories. Such things have occurred in the past in the minds of a number of people, and the effect is to make people in the private institutions very wary of any contact with the commission and its favorite "pet" laboratories. I noted with satisfaction that both the Magnuson and Kilgore bills on a National Science Foundation specifically required that the Foundation should not establish its own laboratories.

The Commission or director should have the power to classify information in accordance with the requirements of the Espionage Act.

Severe penalties should be provided for violation of regulations relative to safety hazards, diversion of fissionable materials, or failure to keep the commission informed relative to research or other work on atomic energy.

I believe that there should be no specific penalties for violation of matters covered by the Espionage Act but that the penalties of that act should apply to the work on atomic energy as it applies to other activities.

In order to secure maximum effort on atomic energy, every effort should be made to make conditions for individuals and institutions such that they will be attracted to this work, and this means that these conditions shall be as favorable for work in this field as they are in other fields of research and development. Specifically, penalties which can be applied in arbitrary and unusual ways should be avoided. I am a believer in free enterprise and do not believe that this system should be completely abrogated in this new field of energy utilization.

Finally, I wish to add on brief remark on conditions necessary for the development of atomic weapons. Scientific men are not particularly attracted to work on destructive weapons but would rather devote their talents to constructive development. The enthusiastic work during the war on weapons of all kinds by scientific men was done because all of us realized that this country was in great danger and not because the work was particularly interesting. As we enter a peacetime situation, it will be difficult and probably impossible to keep the more capable and brilliant men working on weapons of war. I believe that this would only be possible if these men are convinced that such work on weapons is absolutely necessary for the defense of this country. Again I urge that all possible efforts be made to secure international control of atomic and other weapons. If these efforts are made and fail, our scientific men will rally again to the support of this country. Otherwise, I believe that the overwhelming majority will be attracted to other fields of effort.

Senator HART. Doctor, would you add the management and governmental operation of those big plants to the powers you have laid down for the commission?

Dr. UREY. Yes; I think they shall have to operate those plants.

Senator JOHNSON. Doctor, in the proposals that you make for the specific provisions of prospective domestic legislation which you name, are they based on conditions without an international agreement or with an international agreement?

Dr. UREY. I should say that it doesn't make so much difference. I am assuming that the commission or the director will do what is needed in view of the developments in regard to this field.

If in the one case it is necessary to develop atomic weapons, I should think that a director, an administrator, or a commission would take their orders from the President of the United States and direct their efforts in that direction; and that would be done.

If, on the other hand, peacetime applications are necessary, they would direct their efforts in that direction as well.

Senator JOHNSON. Then you are not in conflict with the President's message to Congress making the domestic controls entirely independent of the international controls?

Dr. UREY. I am not, sir.

Senator JOHNSON. That was his procedure.

Senator RUSSELL. You of course read the joint statement of the President, Mr. Atlee, and Mr. King as to international control?

Dr. UREY. Yes.

Senator RUSSELL. Do you care to comment on that as to whether you think that is the best approach to the problem?

Dr. UREY. I think that is the way we should move on that problem. I was very glad to see that statement. I was only sorry it was not issued 3 months before. What is needed is as quick a follow-up with effective establishment of such a commission as possible. Immediate steps should be taken. I don't know whether those are being taken or not.

Senator RUSSELL. You are convinced then, Doctor, that a system of international inspection can be thoroughly effective in preventing the use of atomic energy as a weapon?

Dr. UREY. As General Groves has told you, I think it might break down and might not be perfect. I think that that is a danger we will face no matter what we try to do. No matter what scheme we try to work, out, there will always be the possibility that there will be imperfections in it.

I believe that the international inspection, providing the countries of the world agree that it shall be done, should be feasible. I cannot imagine that the inspection would work if the countries of the world have it imposed upon them in some way or other from without against their consent.

I am assuming we would secure agreement from the major industrial countries of the world; and if that agreement were given, then I think it would not be difficult to tell whether the large-scale development we have in this country were going on.

Senator RUSSELL. If it developed that any one of the nations refused to assent to that proposal, and refused to have anything to do with international agreements on this subject, do you think we should continue to manufacture these bombs?

Dr. UREY. Yes; I don't see anything else we can do. I think we ought to indicate to the other countries of the world our great willingness and great desire to discontinue our manufacturing, our willingness to dismantle our present store of bombs, and to disperse them into only peacetime uses, and that we ought to indicate to the world our willingness to do that if any adequate machinery can be set up for control.

Senator JOHNSON. Dr. Urey, on page 5, along the line of the question which you have just answered, the last paragraph in part II of your statement, you say:

> My choice of time to do something about this threatening series of events is now or preferably 3 months ago, if it were only still possible.

What is the particular significance of "3 months ago"? That takes us back to the 28th of August, if your paper is dated today.

Dr. UREY. I wish very much that the President, Mr. Atlee, and Mr. King's statement had been made in August instead of now. I believe our international situations are being poisoned day after day because we are accumulating a supply of bombs. At that time we had no supply.

Senator JOHNSON. Prior to August 5 or after August 5?

Dr. UREY. I think after August 5.

Senator BYRD. Would you destroy, Doctor, the bombs we have made?

Dr. UREY. I would indicate a willingness to the people of the world to dismantle those bombs.

Senator BYRD. What do you mean by "dismantle" them?

Dr. UREY. There is an explosive charge which is fissionable material, and there is an auxiliary mechanism to set it off. I would take it all apart. I would take the material, and dissolve it and put it in the form of ordinary chemical substances, and tell everybody exactly where it was under those conditions.

Senator BYRD. We would have to destroy them so far as they could be used?

Dr. UREY. I would not destroy the fissionable material; it is valuable for other purposes.

Senator BYRD. Then that would be available to be put together?

Dr. UREY. Oh, yes, after a time.

Senator BYRD. Actually we would have bombs which the other nations would not have.

Dr. UREY. We would have material from which we could make bombs in perhaps six months.

Senator BYRD. And you propose to keep the other nations from having that same material?

I am trying to find out whether you would put this country on an equality with other nations.

Dr. UREY. The point is that if we do not intend to make the bombs, if the conditions were imposed that we were not to make or have large industrial plants and have only a limited amount of fissionable material in the country, I would judge that what fissionable material we have at the present time comes within those limits.

Senator BYRD. In other words, other nations should get the same amount of that material?

Dr. UREY. Surely, if we can get an international control we must expect that other nations will go forward to the same extent we think we ought to.

Senator BYRD. You have to start the use of this atomic energy to get that material. They would have to start the preliminary processes?

Dr. UREY. Oh, yes.

Senator BYRD. And then you would want them to stop at that particular point and not go further?

Dr. UREY. Yes.

Senator BYRD. It seems to me that is quite a weakness in your argument.

Dr. UREY. Let me point out this: If we ran these piles at rather limited power, we would produce all the radioactive materials that we could use for medicine, for industrial research and things of that sort. That would be a very valuable peacetime effort, but still would not accumulate for anyone a large stock of atomic bombs.

Senator BYRD. We are faced with this partical situation: Before action can be taken, we will have made a good many bombs. They will be in existence.

Dr. UREY. Yes.

Senator BYRD. Now, if we are to be on an equality with other nations, we have got to destroy those bombs or put them in some other kind of condition, and then permit the other nations to do what we have done.

Dr. UREY. Yes. There is no possibility of securing an agreement with any other country unless we are willing to establish a level and expect them to reach it also.

Senator BYRD. In these preliminary stages where you set this material back for some other conditions than what it is now, then the other nations can go that far and no further. That would be hard to police and inspect, it seems to me.

Dr. UREY. Perhaps you went to Oak Ridge; did you?

Senator BYRD. Yes.

Dr. UREY. You visited the pile down there?

Senator BYRD. Yes.

Dr. UREY. That pile is a very nice-sized pile for experimental work in the production of radioactive materials, and so forth, and it is not a very big plant, as you have seen. I think it would be feasible.

This would be my opinion, and certainly it would be subject to review by others than myself, that if we had piles of something of that order of magnitude in other countries, it would not be a serious threat to the peace of the world and would come within a level of activity which could be controlled by inspection.

Senator BYRD. But I am speaking of the actual bombs that will be made before this agreement you mentioned could be effectuated. They will be in existence, and something has got to be done with them. They have got to be destroyed or put in some other form, or something, and whatever we do in that respect we have got to permit other nations to do.

Dr. UREY. There is no level to get down to, except that we admit to other peoples the same rights we ask for ourselves.

Senator BYRD. You would not destroy the bombs?

Dr. UREY. I would not destroy the material, but dismantle the bombs.

Senator BYRD. Then we should permit other nations to go as far as we go in this preliminary stage in making the bombs. You have just said we could make them in 6 months if we had that preliminary.

Dr. UREY. That is a guess on my part. I did not work on that part of the problem.

Senator BYRD. What I mean is that we still have got that element of danger in existence, haven't we, under your plan, because of the fact that we have got the bombs or will have more bombs when this thing is finally settled.

Dr. UREY. If your argument is correct, Senator Byrd, and we can only control the atomic bomb by pouring fissionable materials down the Mississippi River and letter it go, I think it is worth while to destroy it completely rather than run the risk of atomic bombs, if that is the only way it can be done.

Senator BYRD. I have not made any argument; I have taken no position. I am trying to find out what your plan is with respect to these bombs that are in existence, and I think that is a very important question. They must be destroyed, or somethng must be done with them. We must permit other nations to have exactly the same opportunity that we have had toward the manufacture of the bombs.

Dr. UREY. That is right, the same attitude, and if necessary we will have to destroy the materials of our bombs as well.

Senator BYRD. I think that is a very vital question in this whole matter, as to what you are going to do with what you have already got in existence.

Dr. UREY. And the more we have got, the worse the problem is.

Senator JOHNSON. Dr. Urey, the members of this committee and, insofar as I know, no one else unless it be General Groves and some of the people at the top, know exactly the amount of the compound that we have that is ready to go into the development of bombs.

It seems to me your paper displays a lack of faith that others might have in us.

Now, how are you going to convince the world, for instance, that we don't have a sizable amount of this compound stored away which can never be detected, never be discovered, that we are holding back from the world? You do not seem to think that the other nations will have very much faith in the United States' good intentions. Now, how are they going to have any faith in the amount of this compound that we have on hand, and I am not talking about the piles; I am talking about the compound that is ready to go into the manufacture of bombs?

Dr. UREY. In regard to the question of good faith between nations, I feel about it like I do when I make a contract with my brother. I love him, and all of that, but I put it all down on paper just the same.

I may feel that a country is intending to deal with us honorably, but at the same time I propose to make laws and regulations so that there will be no question about enforcement. That is just one remark on one side of it.

As to how much we have, a scientific or engineering man from any foreign country, if he visited the plants in the United States, could determine their capacity from the figures that we have on them, and I think it would be very, very difficult to deceive him in regard to how much we have made.

If we wish to convince him how much we have, the records on the plants will be adequate to do so.

Senator TYDINGS. This may be oversimplification, but as I have listened to your testimony very carefully here this morning, I take it that as a scientist who has been with this from the time it was born up until the time it was a grown man, so to speak, and who has looked ahead to see its possibilities, your testimony is predicated on the fact that we have at last invented a weapon which, if used with its ultimate evolution of further development, might conceivably destroy civilization?

Dr. UREY. Yes, sir.

Senator TYDINGS. And might conceivably wipe out a thousand years of progress?

Dr. UREY. Yes.

Senator TYDINGS. And faced with that alternative and the knowledge that sooner or later other nations will probably be in a position to do what we today can do, it is your considered opinion that international agreement is necessary for the control of this element, that everything that we can do to implement the success of that agreement by inspection or any other thing that may be conceived of is necessary, that that process may fail, that it may be a fond hope that will never be realized, but it is the only alternative to the complete destruction of all that we have worked to achieve.

Am I correct in that summary?

Dr. UREY. That is a very good summary.

The CHAIRMAN. Are there any further questions of Dr. Urey?

Doctor, on behalf of the committee, I want to thank you most sincerely for the careful and studied statement that you have made, and I am going to take advantage of calling you back again for further testimony at the proper time.

Dr. UREY. I will be very glad to appear.

The CHAIRMAN. We will meet again at 10 o'clock tomorrow morning.

(Whereupon, at 1:05 p. m., the committee recessed until 10 a. m., Friday, November 30, 1945.)

ATOMIC ENERGY

FRIDAY, NOVEMBER 30, 1945

UNITER STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to adjournment at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Prsent: Senators McMahan (chairman), Russell, Johnson, Connally, Byrd, Tydings, Vandenberg, Austin, Millikin, Hickenlooper, and Hart.

Also present: Edward U. Condon, scientific adviser; and James R. Newman, special assistant to the special committee.

The CHAIRMAN. Dr. Langmuir is our first witness this morning. Will you give your name to the reporter and the official position that you occupy in industry?

STATEMENT OF DR. IRVING LANGMUIR, ASSOCIATE DIRECTOR OF THE RESEARCH LABORATORY, GENERAL ELECTRIC CO.

Dr. LANGMUIR. My name is Irving Langmuir. I am associate director of the Research Laboratory of the General Electric Co., and have been in that laboratory since 1909, engaged mostly in fundamental scientific research in physics and chemistry, but also have had considerable experience in industrial research.

Senator VANDENBERG. I think the record ought to show that in spite of the doctor's modesty he is also a Nobel prize winner in chemistry.

Dr. LANGMUIR. Yes, sir, in 1932.

The discovery of the accessibility of atomic energy opens a new era in human affairs. If used for peaceful purposes, it promises to be of untold and unpredictable benefit to mankind. But, if it should again be used in warfare, it threatens to annihilate a large fraction of the human race and to give to an aggressor nation a complete domination over all populations which are permitted to survive.

International control of atomic energy and, particularly, of all possible manufacture and use of atomic weapons is thus of the utmost urgency. Since such progress toward an effective world government can only taken place gradually through successive steps which build up world confidence, it is imperative that we devise adequate but sound legislation for the control of the knowledge and of the processes which we now possess in the field of atomic energy.

I propose to analyze the proper objectives of such legislation and of the forms that it must take if it is to be effective.

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Peacetime applications of atomic energy: Much of the discussion of the human value of atomic energy has been based on the thought that such energy may displace coal and oil as sources of industrial power. This, I think, is a relatively trivial matter. Even if coal or oil cost nothing as fuels, this would not have a very great effect on our civilization: we would not use our automobiles much more and our electric power bills would not be cut as much as they already have been within the last 15 years by the improvements that have occurred in power production.

The greatest benefits that will accrue to mankind from our new knowledge of nuclear reactions will more probably come through its indirect effects in speeding up progress in science. We may now expect a series of great discoveries in biology, in chemistry, and in physics. Through such better understanding we may have better means of preventing and of curing diseases, such as cancer. We may similarly develop new or better and cheaper chemical materials and alloys. It is probable that most such benefits can be had by relatively small scale production of the new radioactive products that are by-products of the manufacture of plutonium.

Large-scale atomic power production will probably first be important for ship propulsion, but even this will be of vital importance only for naval ships or submarines if these still prove to be of value in an atomic age.

Our present ability to obtain vast stores of energy from the nuclei of atoms forever eliminates any danger from the exhaustion of coal and oil reserves, but this is something that, in any case, would not be important for a century or so.

The threat of atomic bombs: We now have atomic bombs and no other nation has them. As long as this condition exists we are in a secure position.

England and Russia, however, have already announced plans to produce the substances that will give them atomic power. Such materials could also be used to construct atomic bombs.

France, Switzerland, and Sweden are other nations which might successfully undertake programs aiming at the production of atomic power or atomic bombs.

It has already been brought out by all scientists who have worked in this field and have spoken about it that there is no "secret of the atomic bomb" which can be permanently kept. The Smyth report and the fact that successful bombs can be made by several processes enable any nation attempting to build bombs to concentrate on one process and to start work simultaneously on separate phases of the problem.

The laws of nature await discovery by anyone properly qualified and equipped. Thus, all the basic scientific knowledge needed for the construction of atomic bombs can surely be obtained by any of several nations. The difficult technical processes that are involved in the manufacture have been, so to speak, "right up our alley," but we must remember that the Russians long ago held the world's record for long range airplane flights and that during the war they devised and built in quantity tanks as good as the best made in Germany.

They are now engaged in the construction of a large experimental plant, of the order of $100,000,000 to operate a blast furnace with oxygen instead of with air. They have plans for using oxygen for all their blast furnaces at a possible cost of $2,000,000,000. Such undertakings prove an ability to carry out large complicated projects like that needed in the development of atomic energy.

We must consider also that the Russians have continued the training of scientists during the war to a far greater extent than we have. Furthermore, they have available, in any atomic energy program, the knowledge and technical skill of German scientists and technicians. Russia certainly has ample resources in uranium.

If Russia decided that the incentives were great enough, she could mobilize her resources on such a program, just as she did between 1934 and 1939 in her preparations for war with Germany, and getting her people to forego a higher standard of living, devote 10 percent or more of her total production capacity to a 5 year atomic energy plan. Before the war the United States devoted about 0.04 percent of its national income to research and this increased to perhaps 0.5 percent during wartime. That is excluding the atomic bomb project.

National prestige at home and abroad may well induce nations to undertake atomic energy programs. A still greater incentive, however, can be furnished by the feeling of insecurity which results from our possession of atomic bombs and from any failures we have made or may make in the future in establishing the "atmosphere of reciprocal confidence in which political agreements and cooperation will flourish."

The insecurity which Russia may feel as to our possible use of atomic bombs may well be based on a misunderstanding of the American people and of our Government. But we also have much misinformation regarding Russia. What can we expect when, according to a recent letter from Moscow by Edgar Snow, there are only 260 Americans in all of Russia and only 2,000 Russians in the United States? How many Americans read or speak Russian? The Russians have recently taken a great step in fostering understanding by starting to teach English to all Russian children.

We can better understand Russian doubts about our policy of holding atomic bombs as a "sacred trust" by asking ourselves: What would American public opinion now be if we had had no atomic energy development but, near the end of the war, atomic bombs had been dropped on Berlin by the Russians without warning? Would our insecurity have been entirely relieved if the Russian Government, a few months later, had announced that it held an increasing stock pile of atomic bombs as a sacred trust?

It is thus reasonable to believe that the insecurity, which Russia may feel for the future, acts at the present time as a very powerful incentive to build her own atomic bombs.

If, in this way, an atomic armament race develops, I believe the Russians will produce their first atomic bombs in about 3 years. Thereafter, however, there is a definite possibility that the Russians might accumulate atomic bombs at a far faster rate than we do. The following factors give them certain advantages in such a race:

1. They have a larger population and it can be regimented, and is willing and has been trained to sacrifice living standards for an extensive defense program.

2. They have a remarkable system of incentives which is rapidly increasing the efficiency of their industrial production.

3. They have no unemployment.
4. They have no strikes.
5. They have a deep appreciation of pure and applied science and have placed a high priority on it.
6. They have already planned a far more extensive program in science than any contemplated by us.

These conclusions are based in part on my own observations of scientific work in Russia made when I attended the two hundred twentieth anniversary of the founding of the Academy of Sciences of the U. S. S. R. in Moscow and Leningrad last June.

Ever since 1933 the Russians have lived in a state of insecurity. During the war, as their armies became victorious, they looked forward confidently to an end of their insecurity. In June I found that all the scientists with whom I came in contact expected a long era of peace in which the devastated industries and territories could be repaired and then their standard of living could be raised to a level as high or even higher than that in America.

The atomic bombs in August must have shattered such hopes and brought back a state of insecurity like that of the years 1933 to 1939. I believe the impairment of the relations between our two nations since that time is a reaction to their disappointment regarding future security.

The security which we now possess through the possession of atomic bombs will thus be short lived. It will probably end completely within 5 or 10 years if an atomic armament race continues.

I believe all of the United Nations now desire future security above almost anything else. During this period of 5 or 10 years it is of vital importance that steady progress be made to develop means for the effective world control of atomic energy. Any steps that reduce insecurity will tend to remove incentives for an all-out atomic armament race and will thus extend the time available for the working out of the completely effective control mechanism. It is thus essential that such steps be started as soon as possible and that they be followed as rapidly as possible by other steps that will develop world confidence.

The November 15 declaration by President Truman and Prime Ministers Attlee and Mackenzie King is a most constructive program aiming at this world control of atomic energy. I hope that the Governments of the United States, Britain, and Canada make immediate contacts with the Russian Government to secure, if possible, their tentative agreement instead of relying solely on the more cumbersome machinery of the United Nations Organization.

I believe that this declaration will receive the wholehearted support of all Americans. The council of the National Academy of Sciences on November 15 approved unanimously the declaration of that date.

Although I believe that this program will ultimately succeed, we cannot now foresee how long the step by step progress toward effective world control of atomic energy will take. In the meantime it is essential that we have adequate but wise national control. The proper objectives of legislation designed to this end may be considered under the following headings:

1. The legislation should conform to and support the program aiming at world control as outlined by the November 15 declaration.
2. Security regulations which attempt to maintain secrecy in any fields of fundamental science must not be contained in this legislation.

Any such secrecy as we had during the war under military control would stop nearly all progress in those sciences. We may hope that other nations will reciprocate in an exchange of scientific information but whether or not they do, it is to our advantage to see that fundamental scientific knowledge is published as soon as possible.

At the June meeting of the Russian Academy of Sciences many Russians, as well as scientists of other nations, expressed the view that foundamental science had always been international in character and that everyone had profited by the cooperation and good will among scientists. All expressed hope that such cooperation would always exist.

Even during wartime the secrecy regulations in matters of fundamental science were not lived up to. Most of the scientists working on the atomic bomb project frequently had to violate the regulations to exchange information with one another in order that the work could get ahead effectively. In peacetime such regulations would be completely unworkable for any attempts to enforce them rigorously would drive all able scientists out of the field.

As an example of the ineffectiveness of military security regulations even during the wartime, I should like to tell of an experience of my own.

I had had only a trivial connection with the atomic bomb in some consultations I had at two of the laboratories during 1942 or 1943. I had been invited to Russia in May 1945, had accepted through the Soviet Embassy, had received my passport, and was told that the American delegation would be taken to Russia on a C-54 plane with transportation arranged by the State Department and by the President. The day before we were scheduled to leave two Army officers, who did not know on what grounds the request was based, asked me to decline to go to Russia. This would have meant that I would have had to invent excuses on my own responsibility. Since there appeared to be direct conflict between the War Department and the State Department, I refused to withdraw my acceptance at the request of the War Department and demanded that the matter be taken up with the State Department canceling my passport if necessary. I wholly disapproved of the manner in which this matter was handled. When others interceded and the War Department was made to realize how little I knew of the atomic energy project, I was finally allowed to go. Other Americans, however, who had been invited, were not permitted to go after having accepted.

This, of course, the Russian Embassy knew. They knew also that no physicists were among those who accepted the invitations.

When I reached Russia I was told by the English group that eight British physicists, who had accepted the Russian invitation, had had their passports canceled after they had reached the airport ready to fly to Moscow. All of the scientists and the whole of the British delegation were much incensed at these tactics. They believed that the passports were canceled because these men had worked on the Tuballoy project, which is the equivalent of our Manhattan project. I also heard the opinion expressed that this action must have been taken at the request of the American Government because no one outside of the American Army could be so stupid.

The English newspapers gave great publicity to the cancellation of the passports and called Prime Minister Churchill to account before the House of Commons. This was all known in Russia, but it was never published in American newspapers.

I believe that these attempts to maintain secrecy resulted in giving to the Russians the very information which the Army most wished to keep from them. Any sensible Russian scientist knowing of these facts would have believed that we were developing an atomic bomb and were keeping it secret from the Russians.

3. Everyone agrees, I believe, that security regulations are needed at present to cover the manufacturing processes for making the materials used in the atomic bombs and, particularly, the details used in the construction of the bombs. These, however, should not go beyond those which are common in the manufacture of war weapons.

4. Fundamental research in nuclear physics should be stimulated and supported in universities, in Government laboratories, and in industrial laboratories. This may perhaps best be done through the machinery that will probably be set up through the science legislation, such as that proposed in the Kilgore-Magnuson bill.

5. Research, engineering, and development of better methods of manufacture of materials capable of releasing atomic energy should be planned on a large scale.

6. The peacetime utilization of atomic energy requires that the Government should furnish to research workers in this, as well as in other countries, materials such as radioactive substances and sources of neutrons of moderate intensity. This will greatly increase the rate of progress of scientific knowledge in this field. The results of all work done with these materials should be published.

7. As I pointed out previously the development of atomic power is of secondary importance. Exploratory, large-scale experiments should, however, be made to find what the possibilities are. It will probably be many years before profitable large-scale developments can be made from these experiments.

That ends the prepared part of my statement, but I would like to add a few more paragraphs.

The CHAIRMAN. Go right ahead.

Dr. LANGMUIR. Much fear has been expressed about the possibility of control of atomic power by monopolies. I think this will not be a possibility for many years. At present and for a long time to come, it is not an attractive field for industry. The possibilities should be explored, but obviously all rights should be retained by the Government.

Later, it might be necessary to help industry get started on applications of atomic power, if and when such developments become desirable, which I think will only occur after we have some form of international security.

I would like to add an eighth section.

The organization of the board to control atomic energy and the form of its administration is something that I do not feel qualified to pass judgment on. These are matters that our Senators and Representatives must decide.

I do feel, however, that the organization should be one which encourages cooperation on the part of scientists and places upon them a full share of the responsibility for planning and carrying through scientific programs. In particular, the scientists should participate in the establishment of all security relations, for they are more likely than others to understand the harmful effects of unduly severe restrictions.

I spoke in one section about coordinating the work of the atomic energy board with that of the National Science Foundation, which may be set up under the Kilgore or the Magnuson bills when they become law.

There are two ways in which that can happen. First of all, it is very important that work in fundamental nuclear physics should be continued. The National Science Foundation will naturally have an organization that will be able to plan such work through universities and other laboratories, and it seems unwise to duplicate any such work through two organizations. Therefore, it seems to me that this organization of an atomic energy control board should operate through any science foundation for fundamental research work on nuclear physics.

Dr. Urey yesterday thought that it would be undesirable for the atomic energy board to operate laboratories. I think that is perfectly true, for laboratories such as those can be operated by the National Science Foundation.

However, I think we must recognize that any manufacturer of materials for atomic power or bombs will continually need research work of a semiskilled kind, which should be done in intimate contact with the production facilities. In other words, any organization that manufactures these materials should have connected with it a laboratory which studies processes and even develops new methods or the possibilities of new methods, and so it would be very essential for this board to operate laboratories in connection with those industries.

The other point where coordination is needed between these two boards is in regard to the training of scientists. Any extensive atomic-energy program means that we must have students coming along who are enthusiastic to work along the fields of nuclear physics.

The CHAIRMAN. Doctor, you would agree that the move taken, as reported in the press this morning, about deferring young men who have peculiar scientific ability, was a good one, would you not?

Dr. LANGMUIR. It is excellent and very important for these reasons, it seems to me: It is a very important part of the atomic energy program to coordinate the work with that of the National Science Foundation.

I have attended one of the hearings of the Kilgore-Magnuson committee and have been very favorably impressed by the way they have gone about these hearings, having 4 weeks of hearings, bringing in the best scientific opinion with free discussion.

Scientists have been almost unanimously agreed on the importance of the Government supporting and stimulating research on a very large scale under present conditions. There have been minor differences of opinion among them, but largely on the matters of administration which are things that automatically come down to Congress to decide and the President. I believe that whether or not the particular form of the board is a matter of discussion, it seems to me that that is a matter of relatively minor importance.

Most of the scientists I think would favor the control of the foundation residing in the board largely of scientists who chose their chairman, but if that proves to be politically unfeasible or unworkable, if it couldn't pass Congress, for example, or would be vetoed by the President, it seems to me in no case must such legislation be prevented.

The most important thing is that we have adequate support. The particular form that proves to be workable is a matter in which I think the scientists are only moderately qualified to express opinions.

Speaking of the educational program for training men in nuclear physics, it seems to me there again we see how vitally important it is not to have secrecy in fundamental science. Think of a professor trying to get students interested in starting research work on nuclear physics when the professor perhaps has been connected with the project and knows a lot of things which he cannot tell the students because of security regulations. The students would know that immediately, and the professor would have to explain that that is a thing which he could not talk about; yet perhaps that is the thing that the student wants to work on, and it would absolutely stymie the whole educational program if the professor were not allowed to talk freely abount fundamental science as well as other fields. Otherwise, students would be diverted from that field and would likely work in a field where they could discuss things freely and receive scientific stimulus.

This smashing of the cyclotrons is another feature that goes along with secrecy. I think it is a great mistake. In the future, it seems to me that will be compared with the burning of the books in Germany, or with legislation that occurred years ago forbidding the teaching of the theory of evolution in one of our Southern States. That is totally unnecessary. The cyclotron is not a device by which you can make atomic bombs; you can simply gain knowledge. Interference with the gaining of fundamental knowledge is always an unwise procedure.

I attended the hearing yesterday and heard Dr. Urey's testimony, and there are a few points there that I would like to touch upon and amplify to some extent.

In general, I agree completely with everything Dr. Urey said. He mentioned that in an atomic armament race there would be three stages. I would like to consider that there might be a fourth stage, and I would like to tell you what that is.

The three stages he spoke about are these:

1. We alone have atomic bombs. We are then secure at that time.

2. Other nations also have atomic bombs, but they haven't enough to destroy all our cities; but we have enough to destroy all of theirs. We are still relatively secure, and nobody is likely to start an attack under those conditions.

3. Two or more nations have enough bombs to destroy all cities, perhaps 10,000 bombs of the kind that we have now. That will probably come in an armament race. Retaliation, however, would be expected and that would be a deterring factor, but perhaps not decisive.

As was mentioned yesterday, and I think discussed by General Groves, 40,000,000 people might be wiped out in the United States by an attack of that kind, and it would not help us much to destroy 40,000,000 people in the Nation of attack.

The Chairman. Do you believe, Doctor, that any nation which suffered that kind of catastrophe could proceed with a war?

Dr. Langmuir. No; I think it would be crippled for perhaps hundreds of years, and with far less than 40,000,000 people. The 40,000,000 people that would be killed would be those that are in cities where industries are located. The whole of the Government would be wiped out, all our railroad terminals would be wiped out, and we would have to go back to living, as in the case of colonies, on the farm to survive as best we could. We might fight atomic bombs with pitchforks, but it is not a good means.

When we have lost 40,000,000 people it may be that the other nation still has again as many atomic bombs; so, if we start to construct plants to build such bombs, they would be destroyed one by one. It would be complete annihilation of the whose existence of the country as such.

There is, however, a fourth stage which would atomatically come sooner or later in any unlimited armament race. We can confidently assume that there are going to be discoveries made in this field. They may be made 4 or 5 years hence. They may be made 10 or 15 years hence, but it is almost certain that we will have atomic bombs a thousand time as powerful as those that now exist by means that are now undiscovered.

It could be done by a cheaper means of production. Instead of producing 10,000 bombs, it is conceivable that by cheaper means of construction you could have 300,000 bombs.

That would be enough to treat every square mile in the United States the way Hiroshima was. There would then be no retaliation. There wouldn't be 60 percent of the people left; there might be 2 percent of the people left, and under those conditions you can see what happens in the world.

Having wiped out one nation, the aggressor nation would then feel it necessary to control all others. There would be only one nation that could exist, and it has to operate the world possibly as a slave factor, or if they are troublesome wipe them out altogether.

It is a perfectly horrible state of affairs to look forward to, and yet it is the thing that will inevitably come sooner or later.

We cannot predict what discoveries are going to bring. We cannot predict whether we will be the one who gets to the fourth state first. It may be even a small country that succeeds in doing that by discovering bombs a thousand times more powerful, and perhaps cheaper. If they discover that first, and if they become aggressors,—and they are almost sure to become aggressors, because the state of uncertainty of the world at that time would simply be intolerable—you would be almost forced to take action under those conditions before the next fellow gets to that stage where he could destroy the entire nation in one blow.

Dr. Urey gave a very excellent discussion of the effective methods of world control and said, and I agree with him, that inspection will be one of the things that will be necessary, mutual inspection, inspection which is desired by all nations and not forced upon some nation but really desired for their own security.

One of the things that will be important in the preliminaries of the discussion is exchange of scientists on an informal basis first, and later a closer and closer cooperation.

When I was in Russia in June, I found that the Russian scientists spoke far more freely than we were allowed to speak. We were told we could not say certain things, but the Russians frequently told us the very things we were not allowed to tell them. There seemed to be no restrictions on this field of pure science. We didn't get into industrial applications, for that was not in the field of the Academy of Sciences.

When you go to Russia and you find that Kapitza, Fersman, Frenkel, and Joffe—all of those men who are working on problems that have nothing to do with atomic energy—when Joffe tells me and shows me the cyclotron started in 1938, work on which was discontinued during the war and is now just starting again, and tells me the cyclotron will be finished in December of this year—and he is the most prominent physicist that has had anything to do with nuclear physics—when you see that, you are convinced they are not carrying through a Manhattan project.

Later, if we had international control and if our scientists could visit one another, it would be obvious that if any large scale atomic project were under way, scientists would disappear and it would be impossible to reach them. That would be one of the first indications and one of the most powerful things in international inspection and control. Later, it would have to be followed up by visits to factories.

As Dr. Urey pointed out, if you were going to have factories that make these fissionable materials—uranium 235 and plutonium, on a large scale for power production purposes, and those plants could be converted within a short time, possibly within a time so short it could hardly be detected, if those could be converted in a short time to the production of atomic bombs, the difficulties of inspection are tremendously increased.

If there are no such large factories, it would be relatively easy to find that a factory is being built for large scale production, for that could be seen by simple observation from the air. With the disappearance of certain physicists and the construction of certain mills for the making of all kinds of materials, it would be relatively easy to find.

Others will feel the same need for security that we do in that field, and if we reach a point where through agreement with other nations it seems we might have international control, it may well be that others will agree that control would not be satisfactory if we have large plants for making plutonium for peace time purposes or allegedly peace time purposes, like atomic power, while they have practically none. That would not mean security for the other nations.

Under those conditions, as Dr. Urey pointed out, it would be far better for us to forego completely any production of atomic power. But I want to go a step further; I say we ought to be willing and even consider that possibility now that when the time comes that it looks as though international coperation or inspection would be possible, and if at that time it appears that the destruction of our plants, the renunciation of any power applications, the destruction of the bombs that we have and even all reserves of the fissionable material that could be used for peace time purposes was advisable, it may be highly desirable to destroy all of that in order to put ourselves equally on a basis with other nations.

We, of course, would not do that until we were satisfied that the control mechanism is adequate.

Senator Millinin. I did not understand, Doctor, to what you referred when you said we should destroy something.

Dr. Langmuir. In order to be on a par with any of the other nations that might want to agree with us, we cannot be on a par if we. say 5 or 10 years hence, have a stock pile of bombs that we have accumulated during 10 years. It would not be sufficient to take the plutonium out of those bombs and say, "We are going to use it for power purposes," because within six months we could put it back into bombs.

It seems the only way we could be on a par with another nation that had not been manufacturing these materials on the same large scale that we have, in order to accomplish that result, would be to offer to destroy the whole thing, drop it all in the sea, destroy our plants, destroy our bombs, and destroy all reserves of materials in spite of the fact that they probably will cost us $5,000,000,000. Five billion dollars is not an unreasonable price to pay for any adequate form of world security, and we must all look to having world security because the alternatives are simply appalling.

Senator HICKENLOOPER. As I understand it, you are discussing that phase of it solely from the standpoint of a military weapon, a military threat. In other words, you would not carry it further and say that our country having more automobiles than any other country in the world, we should destroy our automobiles down to the number existing in another country?

Dr. LANGMUIR. I am talking merely about the atomic bomb at present. The point is that you cannot have atomic power, or that you cannot keep plutonium which you have stored up and made during 10 years. You cannot put that anywhere in the world where it will not destroy the security of every nation. You could not agree to put it in Africa. You could not hold it in Canada. You could not do anything with it except completely destroy it.

The CHAIRMAN. You would not want the Security Council to hold it?

Dr. LANGMUIR. I wouldn't, because it is no good for police action. I don't say we should do this now. I say, if it should turn out that security or satisfactory world security should depend upon the destruction of that, then, for heaven's sake, let's destroy it. It would be a cheap price to pay.

However, if it progresses ahead fast enough, it may be we can come to some agreement which we cannot now foresee, but in five or ten years we may easily come to some agreement where it is decided to retain it only if we have safeguards that will prevent it being turned into atomic bombs.

Senator HICKENLOOPER. Wouldn't we run afoul of the very human tendency in the history of progress that no material advancement has ever been discarded by the human race?

Dr. LANGMUIR. This is quite a unique thing. It is a million times more dangerous than anything we have had before. That is the dominating factor.

Senator VANDENBERG. Suppose you could not get a satisfactory agreement. Then, what would you do?

Dr. LANGMUIR. Then I certainly would not give up the atomic bombs. I think under that condition you would have a 50–50 chance of being the one that wins the next war, maybe. But that is not satisfactory; there is no security in that. This whole insecurity problem is intolerable and will remain so, and sooner or later the nations will all agree that that has got to stop.

For that reason, we must make sacrifices, and it would not be too much to have us sacrifice in order to give security to other nations, to put ourselves on a par with them. In fact, I canont conceive of an agreement with any other nation by which we would not start off as equals.

Senator AUSTIN. Mr. Chairman.

The CHAIRMAN. Senator Austin.

Senator AUSTIN. Taking your testimony as a whole, in connection with this process you are developing now, isn't it the logical conclusion that we should go back to the position we were in before this discovery?

Dr. LANGMUIR. I don't think we can do it now. I was saying that all of these things should be done only when we have reached and obtained and perfected a mechanism which would give security, international cooperation, and development of the UNO to a point far beyond where it is now. Only when we can get in return for this action security to ourselves should that be done.

At present, if we should destroy our atomic bombs or our reserves or stop making it, we would be looked upon as suckers by some of the other people in the world who have no intention of doing any such thing. We would be the laughing stock of them and they would go ahead and take advantage of that position. We have to have security, or the promise of security, but the possibility of security may depend on that very thing, on our willingness to go back to equality with other nations that have none or have very little.

If it comes to that, then we should be prepared. We do not have to decide these things now, but I want to see this legislation designed in such a way that we preserve the freedom of action. Congress has got to decide these things now. All it can do is pave the way now going in the right direction, but we should have the vision ahead of us, and in that vision we should preserve our freedom of action. We don't, if we stop making bombs; and I don't think any nation now would expect us to stop making bombs, because they would not do it, if conditions were reversed. But we ought to stop making bombs if and when world organization progresses to a point where everyone wants security so much that they are willing to make real sacrifices.

Senator JOHNSON. Dr. Langmuir, how do you compose your two different viewpoints? On the one hand, you say that this country should appropriate $5,000,000,000 for scientific research; on the other hand, you say that this country should destroy $5,000,000,000 worth of the products of science.

The scientists, according to your testimony, have made the world extremely insecure. Science has made, according to your statement just now, aggression inevitable and yet, at the same time, you say that we ought to keep on pouring money into science.

Dr. LANGMUIR. Science is not a thing that we make; scientists don't create science in that way.

Senator JOHNSON. But you create atomic bombs, and now you want to go and throw them in the middle of the ocean because they have made the world insecure.

Dr. LANGMUIR. In order to get security—in other words, we buy something by that. It is a price. You cannot get security for yourself without giving to other nations.

We have no security now for the future, because we are in stages one or two. We are now secure, but we can foresee the case that this security is only temporary, that the time will come when not only we but no nation is secure, and we must do something about that. We must start now to do something about it, because otherwise disaster lies ahead, probably a worse disaster for us than anyone else.

Senator JOHNSON. It looks to me as though you scientists have made the world extremely insecure, and now you are coming to the politicians and asking us to go about and make the world secure again by some sort of a political agreement.

At the same time, you are asking that the scientists who made the world insecure be given further appropriations to discover still another and more terrible destructive element than atomic energy.

Dr. LANGMUIR. But scientists did not go out to discover atomic energy. You have absolutely no knowledge of what science may do. Science may more likely at any time develop a cure for cancer through the use of atomic energy. That is important, for it will save more lives in a couple of years than we lost during the whole World War.

Science is not destructive as a whole. Our standard of living, our whole existence of America, has been developed through science. The reason we won the war was the basis of our civilization, which has been developed through science.

Senator JOHNSON. Then, the atomic bomb was merely an accident?

Dr. LANGMUIR. An accident.

Senator JOHNSON. Purely an accident?

Dr. LANGMUIR. It was absolutely unforeseen.

The CHAIRMAN. Yes, but the scientists were put to work on it by the Government to do the job, and as good citizens they did the job. Isn't that your contention?

Dr. LANGMUIR. Yes. We cannot have a holiday in science because we don't like certain aspects of science, because science only discovers the facts of nature. The facts of nature are there to be discovered by anybody. England is not going to have a holiday in science, if we do; Russia isn't; France isn't; and if we stop progress and stagnate, we will deserve to be exterminated in 50 years. We would just be cluttering up the world uselessly.

Senator JOHNSON. Of course, I believe that with all my heart, and I am a coauthor with Senator Kilgore of the Kilgore bill. I believe our security lies in the laboratory and in scientific development; that is my religion, but I am unable to understand your two viewpoints.

Dr. LANGMUIR. I think it is one viewpoint.

Senator JOHNSON. It is my fault, Doctor. I apologize, but I am trying to get straightened out.

Dr. LANGMUIR. I think we have a situation where we are going to have future insecurity unless we do something beginning now.

Senator CONNALLY. Right on that point, we are all interested in devising some international plan, if we haven't already secured one, to preserve peace and guarantee security. A little while ago you went on to say what you would do until such time as we got that arrangement. Doesn't that always involve an uncertainty? We have to assume we have got it, but maybe we haven't; there is no perfect agency, and that would be a risk.

Dr. LANGMUIR. We haven't now, but I have a strong feeling that this situation is going to get more and more critical, and if we do not find some solution——

Senator CONNALLY. The point I make is that you think you have got one, and maybe you haven't. That is a risk we have got to take.

Dr. LANGMUIR. But it is not as big as the risk we are now taking if we do not do anything.

Senator CONNALLY. You have got to be practical. You are going to base it on an international agreement, and on the belief that all members will honestly and in good faith carry out their obligations.

Dr. LANGMUIR. I don't want to depend on an agreement at all. I want to depend on a working mechanism, such as inspection.

Senator CONNALLY. I don't care whether you call it agreement or mechanism, but the mechanism has got to be based on some agreement, of course.

Dr. LANGMUIR. On mutual desire for security.

Senator CONNALLY. We won't have anyone coming around inspecting us until we agree to it.

Dr. LANGMUIR. That is right.

Senator CONNALLY. I say that there is an element there which we have got to take a chance on. Some nation might agree and then not live up to it. That is true, isn't it?

Dr. LANGMUIR. Then, our Congress and our people have got to decide whether the security is worth the risk we take, and we cannot decide that now, because we do not know what those provisions will be 10 or 20 years hence.

Senator CONNALLY. It is easy to say that we will make an agreement and settle everything, but we have got a practical problem.

Dr. LANGMUIR. The alternative is a war of atomic energy, which is worse than anything else you can think of.

Senator CONNALLY. Unless we have more atomic bombs than anybody else.

Dr. LANGMUIR. That would not help much.

Senator CONNALLY. I am not advocating that, but I am looking to the future and the problems we have got to face. There are a whole lot of people that say, "Yes, we will just solve that by writing it out, and that settles it."

If you are implementing these things, like we are trying to do now before the Senate, taking a week to do something that should take a day, you will find out. You can't do it in a laboratory.

The CHAIRMAN. Doctor, I think it is rather important that you comment, if you will, on Senator Connally's statement that having more bombs than anybody else gives any security.

Senator CONNALLY. I withdraw that if it is going to disturb the chairman.

The CHAIRMAN. It doesn't disturb me, but I think it ought to be answered for the record.

Dr. LANGMUIR. As I said, in stage 3, two or more nations will have enough bombs to wipe out all of the cities of the other, and you can be sure they will have them so placed that when we do wipe out the cities of the other nation we will not destroy the site from which bombs are launched. Therefore, there will be retaliation which will result in destruction of practically all of our cities.

If we had twice as many bombs, then we could go into the open spaces outside the city.

Senator CONNALLY. Just a minute. I predicated that on your question that we would try to arrive at some arrangement and some mechanism to prevent it. You then volunteered the alternative would be an atomic war in which we would be destroyed. I merely volunteered the statement, "unless we had more bombs than the other fellow."

It was predicated on the fact that when and if the war occurred—I am not advocating the war.

Dr. LANGMUIR. No, but, you see, having more bombs is of little importance. If some other nation had enough to destroy all our cities in one blow and we have twice as many, it doesn't do us any good.

Senator CONNALLY. Of course not. If we have another Pearl Harbor, it won't do Pearl Harbor any good to be destroyed before we act.

Dr. LANGMUIR. But we can have no security unless we have something like 100 times the number owned by another country, and then we get to the fourth stage.

Senator VANDENBERG. But you would agree with Senator Connally that an agreement per se is not so certain?

Dr. LANGMUIR. No.

Senator VANDENBERG. We have got to have a mechanism which justifies reliance on the agreement.

Dr. LANGMUIR. The Senators know that far better than I do. I agree with them.

Senator VANDENBERG. Is it your opinion that it is possible to implement inspection and control to a conclusive degree?

Dr. LANGMUIR. I think so, if the mutual desire for security is large enough.

Senator VANDENBERG. That is a pretty big "if".

Dr. LANGMUIR. No, I think it will automatically come when several nations have atomic bombs, and because of that insecurity will arise; and I think the demand for security will be such as to make a real desire for inspection. Other nations will almost want to insist on inspection of our country, and will have to have inspection of their own. Then, we have to find effective ways of doing it.

One of the most constructive suggestions that I have heard in this inspection business is Dr. Urey's suggestions that we have no plants for peacetime applications of atomic energy or atomic power pending that time when we have really come to the agreement that we know from methods we cannot yet conceive of that there really is world security. We have no security. We don't fear any danger of New Jersey attacking New York by atomic bomb. The time may come where all over the world you have such a state of world affairs that you no longer have any insecurity. If that exists, that is the time to develop atomic power.

Senator VANDENBERG. I would like to project your prospectus just one step further, to see what your answer would be.

Suppose we have this agreement. Suppose we have the mechanism and we are all pretty well satisfied with it, and suppose the inspection discloses that country A is violating the agreement. What are we justified in doing, and what would we do?

Dr. LANGMUIR. We do what we decide to do at that time, probably go to war if we have much sense, which is what we would do if we didn't have the agreement.

Senator MILLIKIN. Did I understand, Doctor, that you couple with inspection a universal intent, having no exceptions, that there shall be no violation of the peace?

Dr. LANGMUIR. I did not get the first part of your question.

Senator MILLIKIN. I understood you to say, in reply to a question by Senator Vandenberg, that you rely on inspection plus a universal intent to preserve peace.

Dr. LANGMUIR. And desire.

Senator MILLIKIN. Would you say that that would involve a fundamental change in the human nature of the rulers of the world and of the peoples of the world?

Dr. LANGMUIR. I don't think there is any change in human nature. I think the thing would be done for purely selfish interests among the peoples of the world. If it comes about, it will be the most constructive thing that has ever happened from the atomic bomb, far more important than atomic energy. It will have brought a state of world peace.

Senator MILLIKIN. Of course, I agree, Doctor, if it comes about. I am now trying to prove whether it has a chance of coming about through the selfishness, the greed, and the ambitions of unscrupulous rulers, and sometimes, of aggressive peoples.

Dr. LANGMUIR. I don't think there is any certainty that it will come about. I think it is a very well based hope that it will come about and never could have come about except through the atomic bomb.

Senator MILLIKIN. But if it does not come about completely, then we are right where we are now. Is that not correct?

Dr. LANGMUIR. Yes; if the thing is not effective, we are as bad off as if we had not started.

Senator MILLIKIN. In the meantime, we have disposed of our bombs?

Dr. LANGMUIR. No, we will not dispose of our bombs until we have a different attitude. We cannot now decide that we are ever going to dispose of our bombs.

Senator MILLIKIN. Until we are thoroughly satisfied that there are no unscrupulous rulers in the world and there are no people who desire war?

Dr. Langmuir. I don't know what we have to decide. We simply have to be satisfied 5, 10, or 20 years hence that that is our best bet.

Senator MILLIKIN. Doctor, I suggest we will have to base ourselves more solidly than that, because we are just talking theories in that event.

Dr. LANGMUIR. No, it will not be done until we believe that things have been accomplished.

Senator MILLIKIN. That is my point. I suggest that we may have to wait eternally for that point, and in the meantime this threat you speak of is in our hands.

Dr. LANGMUIR. I don't think it is eternally. I think the thing will come to a crisis within 10 or 20 years, and it has to be decided by then or else we will have a war.

Senator CONNALLY. According to your view, the industrial use of atomic energy—according to the dangers you point out—is a secondary matter, isn't it?

Dr. LANGMUIR. Almost trivial.

Senator CONNALLY. If we didn't ever use an ounce of it for industrial purposes, it would be worth abandoning it?

Dr. LANGMUIR. For large-scale power purposes. I did mention that small-scale production, which offers no hazard, might revolutionize science and medicine and bring us some extremely important developments.

Senator CONNALLY. On the other hand, if you did permit the use for general industrial purposes, you would manifoldly increase the difficulties of inspection and holding the military aspects of it in proper control, wouldn't you?

Dr. LANGMUIR. Yes. I think it is very hazardous. I think we ought to consider that ultimate security or any world control will involve unforseeable uses, but we don't have to answer those questions.

Senator CONNALLY. But we can think about them; that is what we are trying to find out, is to get the basis of all these things.

The CHAIRMAN. Doctor, if I understand you correctly, you believe that control is scientifically feasible?

Dr. LANGMUIR. Yes.

The CHAIRMAN. Now, then, the second question arises: Is it politically feasible?

I gather that you are confident that it is, based on the fact that all people in the world want security above all else, and therefore they will be willing to forego some rights that they might otherwise have in order to attain that security.

Do you think that that desire, and in fact the compulsion of the situation could be brought home to the peoples of the world by demonstrations of the power of this monster?

Dr. LANGMUIR. I think it would be very helpful at a later stage, no doubt, after people have begun to more or less forget about Hiroshima, when I think it would be well to have through the United Organization a test or demonstration under proper conditions so that people can see just what this thing means.

The CHAIRMAN. I believe plans are going forward in the Navy Department to make a test on naval vessels. Do you think it would be desirable if representatives of other peoples could see the results of that situation?

Dr. LANGMUIR. Yes, I think full world publicity should be given to it.

SENATOR HART. Doctor, I gather that you do not advocate again making the attempt at disarmament by example, similar to what we did in the early 1920's?

Dr. LANGMUIR. No; I do not.

Senator HART. Doctor, referring to your testimony about secrecy during the war and the incident when your passage to Russia was somewhat interrupted and you felt somewhat resentful about it at the time——

Dr. LANGMUIR. The way that it was done.

Senator HART. Were you worried, at that time, lest Germany solve the atomic fission problem and create a weapon sooner than we did?

Dr. LANGMUIR. No.

Senator HART. You were not at all worried?

Dr. LANGMUIR. Well, not seriously. It was a possibility, but improbable, I thought.

Senator HART. Now, certain numbers of people of course, as you know, were very decidedly worried about it; and some of them were carrying the responsibility for seeing to it that Germany did not get any aid from us in that.

As you look back upon it now, can you blame their state of mind for taking overprecautions, or what looked to be overprecautions now, but which had a different aspect at that time?

Dr. LANGMUIR. 'I don't blame the intent of anyone who carried through these security regulations. I think it was all done with the very best intent, but I think the details of it went far afield in the methods that they used in many cases.

I think this is one of them. In the first place, the implication was that I would be drugged or tortured in Russia, which I don't think is a reasonable one for anyone to make. I was willing to risk my life. A lot of people had warned me that 16 Poles had been invited to Russia and did not come back; and that we were 16 Americans and might have better luck. I did not take that seriously.

Senator VANDENBERG. That is because you were an American and not a Pole.

Dr. LANGMUIR. As a matter of fact, the 16 Poles never were invited to Russia, you know.

Senator HART. Did you hold those same opinions then that you have been expressing this morning as to the ridiculousness of various of the security measures?

Dr. LANGMUIR. Yes.

Senator HART. You thought at the time they really were ridiculous?

Dr. LANGMUIR. Yes.

SENATOR HART. Another thing, Doctor: You said in your statement that the fundamental scientific information should all be disclosed now. Is it your thought that in Dr. Smyth's book that has not been done on a very considerable scale?

Dr. LANGMUIR. Oh, the Smyth report only contains a small fraction of the fundamental scientific knowledge, and it was stated at the end of the Smyth report that there would be other reports of a similar nature giving further progress; and the President's declaration says practically the same thing, that from time to time there will be other releases of scientific information. I hope that is implemented.

Senator HART. Have not some of your colleagues in the scientific field stated that 85 percent of the knowledge was disclosed in that report?

Dr. LANGMUIR. I don't know what they said, but I would not agree to that. The qualitative information was given; the more detailed information was not given, and yet that information can be obtained by anyone. They are facts of nature. As was brought out by Dr. Urey, the day and place of D-day is something you can keep secret, but you cannot keep secret the energy released by the fission of plutonium, because anybody can try that. It takes time to set up the apparatus, but the answer is in nature itself, and not in our hands.

It is absurd to try to keep fundamental knowledge away from the human race. It cannot be done.

Senator HART. You are talking now about the future, Doctor. I was trying to get the record straight as to what did happen and the statement that 85 percent of the disclosure has already been done.

Dr. LANGMUIR. I think that is largely a matter of definition as to what aspect of knowledge you are referring to.

Senator HART. In speaking of Russia you gave two estimates. You said Russia might catch up with us within a period of 3 years, and then I think you gave a somewhat larger estimate at another point. In making either of those estimates, did you take into account the devastation that has already gone on in Russia and the amount of work they have to do to restore before they can get ahead with anything?

Dr. LANGMUIR. Yes. Remember, the 3 years I gave was the time in which Russia could get her first atomic bomb. That would not be very important. It would take longer than that before she could reach one of these other stages. It would be more nearly 10 years, where we might have a serious uncertainty or hazard in the development of the atomic race.

Senator HART. One last question, Doctor, in the political field.

You stated that you did not wish to wait for the United Nations Organization to solve this question of world security, that you preferred that it be done by Britain, the United States, and Russia. Would you care to elaborate on that?

Dr. LANGMUIR. I did not mean to imply that the thing should in any way not be done through the United Nations Organization. I think it must be, but I think we should explore the possibilities of having a receptive approach to the thing by Russia by informal discussions which I presume are taking place. I hope so, at least, because I think that to propose the thing in a formal way and to go through the regular procedures—that is, if the motion could be brought before the United Nations jointly by the United States and by Russia, it would probably be helpful. The way for that might be paved by some informal discussions, but I don't put a great deal of stress on that.

Senator HART. Thank you, Doctor.

Senator HICKENLOOPER. Having seen the proof, Doctor, that fission is possible on substantial scales, and having been admitted to this at least first dawning of this great field of energy, is there any reasonable possibility that science the world over could be prevented in any way from dabbling in this thing further and going on?

In other words, science is inevitably bound to go forward with further experimentation in this field?

Dr. LANGMUIR. It is like the Catholic Church trying to stop progress in science. It just can't be done, because the knowledge already is there to be found. It is in nature, and to prevent us discovering the facts of nature is a hopeless job.

Senator HICKENLOOPER. And science will go on exploring this field despite what politicians or anyone else attempts to do?

Dr. LANGMUIR. If you regiment them here so they can not do it, they will go elsewhere.

Senator HICKENLOOPER. Therefore, in the light of that probability and almost certainty, I take it that it is your view that agreements and commitments and arrangements, whatever they may be, are about the only hope of solution of this thing to prevent destruction?

Dr. LANGMUIR. And all we have to have is a step-by-step progression toward something. We cannot ask now for an effective method of world control, for that would make it impossible to attain, because you know you cannot get it. That is utopia.

Senator HICKENLOOPER. I get back then to bringing up a line of suggestion you made a moment ago. I think probably it was a remote suggestion that we might destroy or suppress this. I take it you think that probably would not be a very practical thing.

Dr. LANGMUIR. I think that it is rather likely that in the progress toward world control it will become a desirable step.

Senator HICKENLOOPER. That is to suppress the bomb?

Dr. LANGMUIR. If you are going to suppress the bomb, you must suppress all the materials to make the bomb, and even destroy them.

Senator HICKENLOOPER. You think that might be a likely step in the future?

Dr. LANGMUIR. Yes.

Senator HICKENLOOPER. In the face of the fact that the thirst of science for knowledge in new fields will continue?

Dr. LANGMUIR. That has nothing to do with the thirst for knowledge. The thirst for knowledge in science comes in insignificant amounts of this material. We would not destroy all of this material, only that in pound lots.

Senator HICKENLOOPER. Experimentation in fission would go on in spite of everything, wouldn't it?

Dr. LANGMUIR. Certainly.

Senator HICKENLOOPER. And if they can explore new fields in minute amounts, that is the way this bomb was started.

Dr. LANGMUIR. That takes a long time, and by that time we hope we will have such agreement or such desire for agreement that even those things will be an international cooperative effort.

Senator HICKENLOOPER. It may be an arduous job to get from the laboratory to full production, but it still is an incidental thing in connection with this whole field of exploration—that is, the mechanical and engineering end of getting from the laboratory in minute quantities to the ultimate production line in substantial quantities is only a mechanical detail?

Dr. LANGMUIR. A mechanical detail, but it is the major part of the whole problem.

Senator HICKENLOOPER. But it is arduous?

Dr. LANGMUIR. It takes a tremendous amount of time. It is the thing that took the most time in the Manhattan project.

Senator HICKENLOOPER. As the laboratories increase their knowledge and produce different types of materials, and things of that kind, isn't it reasonable to assume that the methods of producing it in quantity will become easier?

Dr. LANGMUIR. I don't think so.

The CHAIRMAN. Doctor, now that the science exists, even assuming that we adopt your proposal to do away with it in any quantity, but of course leave certain minute quantities for experimental purposes——

Dr. LANGMUIR. Oh, leave enough for one atomic bomb, if you like.

The CHAIRMAN. You still have to have, because of the existence of the knowledge of science, an international inspection force to see that it does not go past the stage Senator Hickenlooper has outlined; is that true?

Dr. LANGMUIR. Of course, the whole problem, all of these details that we are discussing, really emphasize that we have got to learn to live with our neighbors in this world. We have to, and it is a question of relations between human beings. That is the real problem and the problem that has got to be solved.

Senator HICKENLOOPER. I understand that is your premise.

Dr. LANGMUIR. The mechanism by which things are to be facilitated is what we have to discuss at present. I think the magnitude of the problem is such that it is either existence or learn to get along with other nations.

Senator JOHNSON. How are you going to get along with a Hitler, a Mussolini, or a Tojo?

Dr. LANGMUIR. We cannot, but who takes the place of Hitler now?

Senator JOHNSON. I don't know.

Dr. LANGMUIR. I don't either.

Senator JOHNSON. But I hope he is the end of that string.

Dr. LANGMUIR. As far as I can see, I think every nation—I don't mean the people of Germany want everlasting peace, for we cannot trust them; we cannot trust the people of Japan, and that will have to be handled in a separate way—but I believe all the United Nations desire security more than anything else, and that was not the state of affairs before this last war.

Senator AUSTIN. Doctor, it really narrows down to a very simple, or perhaps oversimple proposition. Your ultimate remedy for destruction involves corresponding action by all countries, doesn't it?

Dr. LANGMUIR. Yes.

Senator AUSTIN. Therefore, we are really on a spiritual basis with the thing. It is a question of self-discipline by nations, is it not?

Dr. LANGMUIR. That is right. I just cannot see how we can ever get world cooperation except on a basis of substantial equality. You cannot go to a nation and say, "We hold bombs in a sacred trust, and we want it to stay permanently that way; you have got to trust us, but we don't trust you."

That is not world cooperation.

Senator TYDINGS. Doctor, would you advocate that a solution for this problem would be attempted by the three great powers, or through the United Nations, or do you think it would be well to consider a world conference to deal only with atomic energy at this time?

Dr. LANGMUIR. I am a scientist, and I am not a statesman. I don't think scientists should be asked to be statesmen. However, they are American citizens and they can all be able to express their opinions.

Senator TYDINGS. None of us are statesmen; we only work to try to be.

Dr. LANGMUIR. I personally would like to see the development of the United Nations. It will have to go way beyond what it is now.

When I suggested an informal conference before the United Nations I did it more as a way to paving action to present the thing to the United Nations, not only from England and America, but also Russia, because those are the ones that are mostly involved in this problem, obviously. Those are the Big Four, the United States, England, Canada, and Russia; so let us be frank about it and let us therefore present this thing to the United Nations if possible as the desire of all those nations.

If it can be done that way, it will go fast. If it cannot be done that way, then let us handle it through the United Nations.

Senator TYDINGS. Maybe you missed my question. I mean to ask whether you thought through the Big Four, as you delineate them, or through the United Nations, there was the best chance of finding the solution to this problem rather than by some conference called particularly to deal with it on an international scale.

Dr. LANGMUIR. I would say through the United Nations.

Senator BYRD. Doctor, you stated in the paper you read that Russia had ample supplies of uranium. Has that been discovered?

Dr. LANGMUIR. I don't know much about it, but I have had several conferences with people who presumably know a great deal about it. It is brought out very clearly that uranium is a widely spread material. It is known that some of the biggest deposits in the world are in Czechoslovakia, and I presume Russia could get those.

Senator BYRD. Do you know of your own knowledge that there have been supplies discovered in Russia?

Dr. LANGMUIR. No; I don't know. It is an element that is widely distributed in small amounts.

Senator BYRD. I was not here when you made this statement: "Russia certainly has ample resources in uranium."

Dr. LANGMUIR. Yes; but she doesn't need much, you know.

Senator BYRD. Is there any other source of atomic energy except uranium?

Dr. LANGMUIR. Not that we know of at present, but in the future there may be.

Senator BYRD. I have often thought that the inspection and the policing of it could be done more by the materials, by inspecting the materials that are used, than perhaps by the factories. What is your opinion about that?

Dr. LANGMUIR. My idea is that the control or inspection would come first by contacts between scientists, and that through mutual desire you would then implement that by inspection of factories and possibly the elimination of large plants, and probably simultaneously with the inspection of all production of uranium. It would be very effective and relatively simple.

I think there would be politically less difficulty in that than there would in a great many other things.

After that has been done, as I go on and say in my paper—that is a thing on which public opinion can really take grasp—if you have once set up the machinery for that, it seems to me almost inevitable and automatic that you extend it to all weapons of war.

Senator BYRD. Where are the known deposits of uranium now?

Dr. LANGMUIR. I don't know much about it.

Senator BYRD. Then you are not certain they have been discovered in Russia?

Dr. LANGMUIR. Not personally, no; but I have heard through various people, from some people who I believe know, that there are known deposits in Russia.

Senator BYRD. I was told on good authority that no deposits have been discovered in Russia, but of course there have been in Czechoslovakia.

Dr. LANGMUIR. Yes; but when you think what a large fraction of the surface of the earth is covered by Russia, and how little we know about it and how much the Russians know about it, it is reasonable to assume that there are such deposits.

Uranium costs $2 or $3 a pound, and nobody was interested in amounts of uranium at that price; but, for the purposes of atomic energy, you could afford to pay a thousand times that much, and that entirely changes the situation. Instead of paying $1 or $2 to work up the ore, you could now spend a thousand times that. You could takes ores that have a thousand times less uranium, and still get away with it.

No one knows how widespread these ores are which have a small amount of uranium in them which might become workable.

The CHAIRMAN. You just made an interesting statement. I take it that you believe that if we get an agreement to eliminate this most horrible weapon that it necessarily follows, if the nations agree to give it up, that they would be willing to give up other forms of armaments?

Dr. LANGMUIR. I think so. I think the whole machinery could be carried through, and it would be desirable. After all, if you have no atomic bombs and no weapons, you still have poison gases and you may have perhaps biological warfare and what not that might be almost as bad. You will want a good solution for the thing. The same kind of mechanism, the same desire, the same motivation would lie behind the complete renunciation of war.

The CHAIRMAN. In other words, you regard this as a catalytic agent that would bring to people of the world the determination to disarm?

Dr. LANGMUIR. I don't think personally we need to worry about those things. We must not make them issues at present, because we now know that the most important thing is the atomic bomb. If that were solved, we then would come back to these other problems which would be almost as bad. The difference is that atomic bombs could destroy a nation in 24 hours, and the others might do it in a year or so.

What we have done in this war, doing nothing in the way of preparation until the war came and then building up our defenses, is out with the atomic bomb.

The CHAIRMAN. We foresaw quick death; but you fellows think slow death might still be more attractive.

Dr. LANGMUIR. I think most people feel that slow death can possibly be averted; but if quick death comes, then you need not worry.

Senator TYDINGS. Doctor, as to your idea of disarmament, if we have civil wars such as happened in China, or unrest such as has happened in India for a long while, you would have dictators springing up pretty much if you had no armaments.

On the other hand, we all meet ourselves coming back sometimes, don't we?

Dr. LANGMUIR. We have a police force that carries guns or clubs, and I suppose you will always need something like that.

Senator TYDINGS. It seems to me that in big countries like India, China, Russia, the United States, or parts of the British Empire, that if you had no armies at all you would simply give hostage to new dictators who might decide not to stay in the United Nations, and it might be hard to track them down.

Dr. LANGMUIR. I hope the United Nations will have an organization that can handle the policing of the world; but it does not need atomic weapons for that purpose. You can not use an atomic bomb on India; you cannot use it on Java, for instance, or the civil war in China. That cannot be settled by atomic bombs. It isn't a suitable weapon at all, any more than it could be used against a city in Louisiana which decides to do something illegal.

Senator TYDINGS. Suppose some man, though, wants to call a mob to his colors and start marking on the capital; what would you do about it under the United Nations? What is your conception of it even without the atomic bomb?

Dr. LANGMUIR. Well, haven't we a police force?

Senator TYDINGS. Suppose some leader arises in one of these countries and surrounds himself with a lot of reckless spirits and starts to march on the capital. That would be civil war. Would we have a right to interfere in the internal affairs of another country?

Dr. LANGMUIR. I think that has got to evolve. The United Nations, I think, is going to evolve faster than anybody had any idea of.

Senator TYDINGS. I hope you are right.

Dr. LANGMUIR. What form it will take, or the possibility that it may not take a desired form, cannot now be considered as a reason for not making progress. We cannot predict the future.

Senator CONNALLY. Doctor, as I get your testimony, you think that ultimately the abolition of the bomb would result in probable disarming in other respects; but I don't understand you to mean that before we do anything about the bomb we have got to agree on all these other weapons.

Dr. LANGMUIR. I say the opposite.

Senator CONNALLY. If we could deal with the bomb and make a success of that, then you think that would give cause for spreading it still further?

Dr. LANGMUIR. The machinery set up for handling the atomic-bomb security could be such, if it worked over a period of years, that there would be an inevitable desire to have that apply to all other forms of war.

Senator CONNALLY. I am trying to get the point that you would not do all that with one stroke, because if you did you could not do any of it.

Dr. LANGMUIR. I think even the first thing is a matter that no final decision can be reached on in the next 10 years. It may take 10 years to get to that stage by constant effort.

The other thing may take another 5 or 10 years, but to put those in as prerequisites will kill the whole program.

Senator CONNALLY. Now, you went on to say that there will be development of science, with which I thoroughly agree. You don't know and nobody else knows but what science in the years to come may discover other materials out of which this atomic energy can be developed.

Dr. LANGMUIR. I said I think it is probable.

Senator CONNALLY. Just the fact that you found one method and one group of elements does not shut the door on future developments?

Dr. LANGMUIR. Of course, the field has been pretty well explored and we have made really great progress; but, nevertheless, I believe it is probable that other forms of atomic energy will become available before the next war.

Senator CONNALLY. Thank you.

Senator JOHNSON. Dr. Langmuir, how long were you in Russia?

Dr. LANGMUIR. Eighteen days. The whole trip was 30 days from New York back to New York.

Senator JOHNSON. Did you see anyone there, or did you have conferences with anyone, or did you meet anyone outside of scientists in Russia?

Dr. LANGMUIR. Practically not.

Senator JOHNSON. Is it fair to base a conclusion on Russia and Russia's political intentions by these few scientists that you met?

Dr. LANGMUIR. No; certainly not. In 18 days you cannot get a very deep view of a country. Nevertheless, the things I did find were in so many cases so different from what I have been led to expect that it is rather interesting, I think.

What I meant to say is that the Russian scientists are people you can cooperate with; that I know, and that is a step. That is why I like to see in the President's declaration a statement that they are planning to exchange scientists with other nations. That would be a useful step.

Senator JOHNSON. All scientists, whether Russian, German, or American, from whatever source they may come. are internationalists in viewpoint; are they not?

Dr. LANGMUIR. A great many of the Germans were not.

Senator JOHNSON. The very nature of their science causes them to be.

Dr. LANGMUIR. A great many Germans were originally, but under Hitler ceased to be.

Senator JOHNSON. Of course they were regimented under Hitler.

Do you have any knowledge of the secrecy imposed by the Russian Army? I have been told on pretty good authority that the Russian Army did not permit any observers, even of their allies, to come within many miles of their battlefront to see their weapons or to see their military techniques at all.

Dr. LANGMUIR. And they did not come anywhere near our Manhattan project, so there was no cooperation in fundamental technique.

Senator JOHNSON. And you said, "because no one outside of the American Army could be so stupid."

Dr. LANGMUIR. These were British people saying that, not Russians. I am repeating something the British said.

Senator JOHNSON. And given it considerable emphasis?

Dr. LANGMUIR. Yes. They had had contact with the American Army; they had been here and they knew.

Senator JOHNSON. Do you agree with that statement, that conclusion of the British?

Dr. LANGMUIR. I think there is a certain amount of justification for it.

Senator JOHNSON. You don't think the Russian Army gives the American Army any competition along that line?

Dr. LANGMUIR. I don't know anything about the Russian Army, but I agree that the Russian Army did not disclose anything about their weapons.

Senator JOHNSON. That is your criticism of the American Army, because they were too secret?

Dr. LANGMUIR. No, not at all, but the way they did it. The way they did this was the thing that was so stupid, not the fact that these men were not allowed to come, but the whole way the thing was carried on was such as to disclose the very thing they wanted to keep secret. It was a blundering process, but it is the kind of blundering process that takes place when military people try to control secrecy in fields in which they are not adequately trained. They have done a wonderful job as to keeping secret D-day, but when they come to try to control scientists, they don't know how to do it and they make a mistake in thinking they can.

Senator JOHNSON. Does anyone else know how to do it?

Dr. LANGMUIR. I hope not.

The CHAIRMAN. Doctor, you know Mr. Kettering of General Motors?

Dr. LANGMUIR. Yes.

The CHAIRMAN. Did you see his observation that, "If you lock the doors of a laboratory, you lock out more than you lock in"?

Dr. LANGMUIR. I didn't see it, but it is good.

The CHAIRMAN. Looking to the international science and the freedom of exchange, we owe a good deal to the development in some very important fields to scientists in England, Germany, and other countries of the world, do we not?

Dr. LANGMUIR. Yes.

The CHAIRMAN. Do you know where DDT originated?

Dr. LANGMUIR. I think it first was discovered by a German scientist a long time ago, and then its insecticidal properties were discovered by someone in Switzerland.

The CHAIRMAN. How about uranium fission?

Dr. LANGMUIR. That was done, I think, by Fermi—no, it was done in Germany.

The CHAIRMAN. How about synthetic rubber from alcohol?

Dr. LANGMUIR. I don't remember, but the Russians certainly have done a great work in synthetic rubber.

The CHAIRMAN. Penicillin?

Dr. LANGMUIR. England.

The CHAIRMAN. And jet propulsion?

Dr. LANGMUIR. Also England.

The CHAIRMAN. Radar?

Dr. LANGMUIR. England, and it was at least going on independently in the United States, but the English were the first ones to reduce it to practice and use it on a large scale.

The CHAIRMAN. Did you hear General Groves' testimony?

Dr. LANGMUIR. I only heard yesterday's questioning and replies to the questions asked.

The CHAIRMAN. He testified that in his opinion there wasn't any nation that would, unaided, arrive at the production of atomic weapons within 20 years. I take it you don't agree with that.

Dr. LANGMUIR. I don't agree at all with it.

The CHAIRMAN. Doctor, have you any recommendations to make as to ways in which the research on cancer with radioactive materials, and other diseases, could be immediately stimulated?

Dr. LANGMUIR. Apparently the difficulty in cancer is that we don't understand it. We don't know what cancer is. We know that growth processes go in wrong directions, but we don't understand those growth processes.

By the use of radioactive substances, radioactive carbon, for example, and other radioactive elements that are now available relatively cheaply as byproducts of the production of plutonium, we get an understanding of chemical processes. The method is just being worked out, but it is sure to be amazingly successful in studying the complicated processes that take place in biology.

I believe that in a few years when a large number of physicists have these tools available and get to use them in routine work in the studying of fundamental problems, the rate of progress will be speeded up manyfold over what it otherwise would have been. Although we might ultimately have reached a solution of the cancer problem in a certain number of years, now I think the chances are it will be reached in perhaps a third or a quarter of that time.

The CHAIRMAN. Common decency would require us, pending any arrangement for international control, to make some kind of interim arrangement to get small amounts of this material into the hands of men who can proceed experiment with it for the alleviation of these diseases?

Dr. LANGMUIR. I should like to see these materials given out, since we are the only ones that can produce them in reasonable quantity, not only to American scientists, biologists, chemists, and physicists, but also to those all over the world.

The CHAIRMAN. Doctor, you mentioned a project for cheap oxygen for blast furnaces being developed in Russia. Have we a comparable program in this country?

Dr. LANGMUIR: No, but I think the Russians have shown great vision in undertaking a program of that magnitude, and apparently with great success.

The CHAIRMAN. How did you find out about that?

Dr. LANGMUIR. It was told me voluntarily by Mr. Kapitza in Moscow.

The CHAIRMAN. Did he outline the program?

Dr. LANGMUIR. He told me a great deal about it.

Hhe CHAIRMAN. Did he discuss the scientific details with you?

Dr. LANGMUIR. A great many of them. I talked to him altogether 2 or 3 hours on the thing, and he gave me practically all the information he could have given me in that time. He answered all my questions very frankly.

Since then, when I came back, we have been trying to get in touch with them to get more information on five or six things I saw in Russia away ahead of the rest of the world, and we have been trying, through the State Department, to get in touch with the Russians to get additional information and have had no success whatever.

Senator TYDINGS. How do you rate the Russian scientists as a body in comparison with the scientists of France, Sweden, England, and the United States? Are they about as good, generally inferior, a little better, or what—taking them as a whole?

Dr. LANGMUIR. Well, it is hard to put any definition on that thing.

Senator TYDINGS. The reason I asked you the question is that I have a hunch, without any knowledge of it, for I have no Gallup poll at my disposal, that the American generally thinks of the Russion scientist as being much inferior to the leading scientists of other countries. Is that true, or is it false?

Dr. LANGMUIR. There are some excellent Russian scientists doing very fine work, but the number of scientists doing such excellent work as compared to those in America or England—United States and England are certainly leading the world.

Senator TYDINGS. You would not say they are top-flight scientists?

Dr. LANGMUIR. I don't know just what you mean by that.

Senator TYDINGS. You mean some of the better ones in the world?

Dr. LANGMUIR. A few of them are right up among the best in the world; but on the whole the Russian scientists have suffered from lack of good equipment, I should say, largely. Their laboratories, outside of Kapitza's laboratory, and some others who are building new laboratories, are equipped with the kind of equipment that would have been used in the United States 20 years ago.

Senator TYDINGS. Could Russia make those instruments, or would they have to buy them abroad?

Dr. LANGMUIR. Russia makes their own.

Senator TYDINGS. They have the precision tools, and so on?

Dr. LANGMUIR. Yes. In this oxygen development, for instance, that is really precision work, they have turbines and a lot of equipment there which represent a very high degree of mechanical perfection.

Senator TYDINGS. Let me ask you this question, which you have already covered, but pointedly: In your opinion, given a free hand under what you conceive to be the conditions and circumstances, how long will it be before it will be possible for Russia to turn out atomic bombs?

Dr. LANGMUIR. Well, I think I gave that.

Senator TYDINGS. Five years?

Dr. LANGMUIR. I put 3 years as about a minimum. That is, I put 3 years down, if Russia really seriously devotes her attention to it and starts on a big-scale production.

Senator TYDINGS. And they say publicly they are going to do that.

Dr. LANGMUIR. I haven't heard that statement.

Senator TYDINGS. Molotov made the statement that Russia would have the atomic bomb and more before long.

Dr. LANGMUIR. I think he said, "and other things."

Senator TYDINGS. That is right.

Dr. LANGMUIR. But he didn't say how big the project is.

Let me tell you about the project they already have.

The Academy of Sciences has six or seven institutes, and those are just for the rather pure scientific work, the basic science that underlies other things. We did not go to the industrial laboratories, of which there are a large number.

They have a new building for the Academy of Sciences, which has just fairly recently been completed, and they showed us pictures which looked to be about 10 times the size of that building which they are planning.

The whole emphasis that they place on it, the awards they give, the incentive system in pay and so on, all show that they place almost the highest priority on science.

In these meetings, they said that the whole future development of Russia depends upon application of science. They believe that the scientist should receive the highest possible facilities for his work, and they give the scientists the greatest freedom.

Senator TYDINGS. What countries do you envisage in the world that eventually would be capable of supporting a program for the manufacture of atomic bombs? The United States, Canada, or Britain, or Russia?

Dr. LANGMUIR. Of course, the United States already has the equipment and we know how to do it. We could extend that as far as we want. England, I think, has said she is planning to build them. Canada already has some plants for making some parts.

Senator TYDINGS. Russia would be fourth eventually?

Dr. LANGMUIR. Russia will be fourth at first. Russia, however, would far outrun England in the long run.

Senator TYDINGS. I am looking ahead 10 years or 15 years. What countries?

Dr. LANGMUIR. In 10 years, to my mind, it is very uncertain whether the United States or Russia will lead.

Senator TYDINGS. I am not asking who will lead, but what nations will be capable of producing atomic bombs if they make up their minds to produce them within 15 years?

Dr. LANGMUIR. Oh, many of them.

Senator TYDINGS. Well, name some of them.

Dr. LANGMUIR. France, Sweden.

Senator JOHNSON. Spain?

Dr. LANGMUIR. I don't know about Spain.

Senator TYDINGS. Czechoslovakia?

Dr. LANGMUIR. Undoubtedly.

Senator BYRD. Switzerland?

Dr. LANGMUIR. Switzerland would probably do it on a small scale. She would not have the necessary financial resources.

Senator TYDINGS. Germany, of course.

Dr. LANGMUIR. Of course.

Senator TYDINGS. Japan, when the military controls are withdrawn?

Dr. LANGMUIR. No. Japan, even if all controls are withdrawn, I think is going to be pretty weak.

Senator TYDINGS. But there would be some 8 to 10 of the leading nations within 15 years?

Dr. LANGMUIR. I would say in 10 or 15 years there is a possibility of German influence in Argentina, which might be very serious.

Senator TYDINGS. Suppose that eventually happens, and there are 8 or 10 nations that have these bombs, and nothing has been done—for the sake of illustration—to curb them or control them. In the next war, what happens?

Dr. LANGMUIR. I don't like predicting the future.

Senator TYDINGS. I would like to have it. I think we ought to have your views on this.

Dr. LANGMUIR. I think it is up to the United Nations to evolve the mechanism.

Senator TYDINGS. Some nation might violate its agreement.

Dr. LANGMUIR. As Dr. Urey said yesterday, the bombs may drop on Washington which will destroy the whole city, and simultaneously on Chicago, New York, and maybe some others, and everybody says, "Who done it?" Nobody knows, and never can find out.

The CHAIRMAN. There is no possibility of retaliation, because you don't know who to go after.

Dr. LANGMUIR. You don't know who to attack.

Senator TYDINGS. That is what I am trying to bring out. If 8 or 10 nations have these bombs and there is a formal declaration of war, not delivered in the Pearl Harbor style, what happens in the course of that war with the atomic bomb in the possession of 6 or 8 of the warring nations on the earth? What is your opinion?

Dr. LANGMUIR. Well, the warfare would continue one way and another until one nation came out on top. If it cannot get along with other people, it exterminates them and then goes ahead with a unified population of all one race or one group doing whatever is necessary to see that nobody else ever builds an atomic bomb.

Senator TYDINGS. Which would bring us right back to where we are today to start over again with the remnants of civilization.

Dr. LANGMUIR. It isn't a pretty picture to look at, and there is no nation in the world today that ever desires to be a victor in a warfare of that kind.

Senator JOHNSON. Doctor, do you know of any other nation on this earth, including Russia, which would have published the Smyth Report?

Dr. LANGMUIR. England probably would have.

Senator JOHNSON. Any others?

Dr. LANGMUIR. England almost did, you know. They have a report almost as good as the Smyth Report, which is a wonderful report. It is shorter and different from the Smyth Report, but it is excellent in the way of presentation of the basic facts, and a little more popular than the Smyth Report.

Senator JOHNSON. It followed though; it did not lead?

Dr. LANGMUIR. Simultaneously, I think, it was issued.

Senator TYDINGS. Doctor, in your opinion, in a country that contains one-sixth or one-seventh of the world's earth surface, how much actual acreage would be necessary for the construction of a complete plant for the manufacture of atomic energy?

Dr. LANGMUIR. Well, I would rather leave that question. I never visited these plants, and some of the Senators here have.

Senator TYDINGS. Assuming, for the sake of argument, that it would take 200 acres, or let us say a square mile, or let us even say 10 square miles. Many parts of the earth are very thinly populated and very seldom visited. Wouldn't it be possible, even after the international agreement with the best intentions of well-meaning people to work out control, for some nation to decide to build such a plant in secrecy and to produce the bombs under present conditions of government?

Dr. LANGMUIR. That is a scientific question which, with proper data, could be answered. I think a great many scientists have gone into that kind of question and think it would be possible to expect under those conditions. Of course, in Siberia you have enormous wastes. In fair weather we can see 100 miles either way, which is 200 miles wide. A dozen or two dozen planes across Siberia with photographic equipment could show up every building in the thing. It would take only a reasonable number of flights to get a map of the whole of Siberia, which could be done every year.

Senator TYDINGS. The reason I ask you these questions is that if all the nations in the world had free press and free speech, and you could go in and out, our problem would be a simple one. But all the nations don't have that, and unless all the nations do have that, can any sort of inspection ever be efficient?

Dr. LANGMUIR. I would like to see, in the United Nations, some discussion to get those points on which the nations can agree, and then take the points of disagreement and try to analyze to what extent they hamper progress toward world government, and bring these matters up. Nothing can be done about it for 2 or 3 years, but one of the things that impresses me in Russia is the rate at which things are changing, and in every case I think changes for the better.

Senator TYDINGS. I think that is true.

Dr. LANGMUIR. Now, what may that mean in 5 years?

I don't know, but I am hopeful. I am hopeful that Russia will have a free press and will allow interchange of knowledge, because it will become her need to do so.

Senator TYDINGS. Until we do get that sort of climate in which to live, we cannot accomplish the inspection, and the whole thing would then be hopeless, wouldn't it?

Dr. LANGMUIR. Absolutely, but I think that we have something like 10 years in which we can accomplish these things, so let us not be discouraged by the fact that we cannot do them in two, or three, or five.

The CHAIRMAN. Doctor, the statement has been made that in the building of an atomic bomb, it is necessary for us to keep our lead over other nations which may develop the bomb.

What is meant by and what would be the purpose of this so-called lead? In other words, we would be better off, if other nations had bombs as good as the ones we dropped in Hiroshima, if we had developed bombs 10 or 50 times better.

Dr. LANGMUIR. You see, in dropping bombs, you first want to pick out the most important target. The enemy would attack Washington first, Pittsburgh, and several industrial centers, and the destruction by those bombs would be terrifically high. Then they would have to attack smaller cities of less importance, and then they would attack the more unimportant towns, and finally they would be able to attack all the cities and all smaller towns; and still they have only covered perhaps one-thirtieth of the United States.

If they had still more bombs, they could drop them in open farmland; but what good is that? Not much unless you have 30 times as many so that you can cover all the farmlands and wipe out all the people, or probably 100 times as many. In other words, if you take the total number you need to completely wipe out a country, 1 percent of that is very effective. The next 1 percent, 10 percent, and so on, are almost useless. It does very little good to be able to produce enough to wipe out the cities, and then produce ten times that much, which is trivial in importance.

Being able to outproduce some other nation is of no importance if we can produce enough to destroy their cities. Beyond that, we do not need them unless we go to a different order of magnitude.

The CHAIRMAN. Does our set-up in the United States make us peculiarly vulnerable to atomic bomb attack?

Dr. LANGMUIR. We are particularly vulnerable. Our cities are badly distributed. We have great concentrations of cities.

We have certain areas in the East where industries are very much gathered together, and other nations—at least, a country like Russia, of course, is already far better dispersed and much less vulnerable to attack.

The CHAIRMAN. Doctor, do you believe that the Government should have an absolute monopoly on the production of fissionable materials?

Dr. LANGMUIR. Yes.

The CHAIRMAN. And the processing of them?

Dr. LANGMUIRE. Yes.

The CHAIRMAN. Do you feel it is too important and too dangerous to have it in private hands?

Dr. LANGMUIR. Except it may be desirable to get cooperation through private hands, but the title and ownership should reside with the Government.

The CHAIRMAN. Yesterday, Senator Byrd asked as to what we ought to do with the bombs we have if an international agreement for control is reached. Would you care to comment on that?

Dr. LANGMUIR. I think I already have. I would go so far as to not only destroy the bomb, but destroy, if need be, all the materials from which the bombs are made.

Senator BYRD. What about the factories?

Dr. LANGMUIR. Destroy the factories, too, if need be.

If that is a critical point, let's yield on that point. That would put us in an equitable position with other nations we are trying to agree with, and how else can we do that except by putting ourselves on an equal basis?

Senator BYRD. You are talking about reaching these agreements 10 years from now. Every nation will have bombs 10 years from now.

Dr. LANGMUIR. I think the number that will have them 10 years from now——

Senator BYRD. I mean the nations which we have reason to fear would have them. Maybe the small nations would not, but certainly there will be five or six of the large nations that will have bombs.

Dr. LANGMUIR. The more nations there are, I think the easier it is to get an agreement. I think the United Nations is likely to be far more effective.

Senator BYRD. What assurance has anybody got with a bomb that you can practically put in your pocket that all of them would be destroyed?

Dr. LANGMUIR. You cannot put them in your pocket.

Senator JOHNSON. You could put them in a suitcase.

Senator BYRD. What assurance have we got?

Dr. LANGMUIR. I don't see any possibility of that. If a gangster in his attic or cellar can go out and make bombs and destroy anybody, I think the world is about out.

Senator BYRD. We had gangsters at the beginning of the war and will as long as the world lasts.

Dr. LANGMUIR. These have got to be very big gangsters.

Senator BYRD. Human nature doesn't change. You will have totalitarian dictators as long as you have a world. We have had them before, we have got them now, and will go on having them.

Dr. LANGMUIR. I don't know what human nature is, and in the second place, I don't know that it won't change.

Senator BYRD. It has not changed for the better in my lifetime. I think human nature in the last war was at the lowest level ever known. If there has been any improvement in it, I have not been able to judge it.

Dr. LANGMUIR. Let's hope for something better.

Senator BYRD. We cannot base our future on hopes alone.

Dr. LANGMUIR. The alternative of not doing something is absolute destruction. The risk in whatever you do is better than total destruction. Don't think there is a risk in undertaking these things; it is the only possible salvation. That is the thing we have to make clear. The worst thing that could possibly happen is to do nothing, so, therefore, let us do something and let us make it good.

Senator BYRD. I believe in doing whatever we can do, but when it comes to destroying the factories and all the materials to make the bombs, I think we ought to know exactly where we stand before we do it.

Dr. LANGMUIR. How can you cooperate with anybody except as an equal? It is all right to hold bombs in sacred trust. I agree fully, but if, 10 years from now, we come to an agreement and say we are holding our bombs as a sacred trust, but we don't trust you, there can never be world agreement.

Senator BYRD. I can see a great deal of merit in your position, if what you mention could be done immediately; in other words, if what bombs we have on hand now—and I understand we have some—were destroyed before other countries had started to make bombs. But you intend to take action 10 years from now. Am I correct about that?

Dr. LANGMUIR. I think other nations will have them long before 10 years. I don't want to wait at all. I want to go ahead as fast as anybody goes ahead.

Senator BYRD. But you say repeatedly that you would not destroy the bombs in this country unless you were satisfied the other country would be in agreement with us. That cannot be done overnight.

Dr. LANGMUIR. No.

Senator BYRD. It has got to be done over a period of years, and in that time these other nations are going to have bombs.

Dr. LANGMUIR. We are not going to destroy our bombs unless they destroy theirs.

Senator BYRD. What assurance or guarantee can you get that they will destroy theirs? The bomb is not a large one, we will have to agree on that.

Dr. LANGMUIR. We will have to guarantee a time to destroy the bombs.

Senator BYRD. Would you take their word?

Dr. LANGMUIR. No, certainly not; and they would not take ours.

Senator BYRD. Here is a bomb that you can put in a satchel and carry around.

Dr. LANGMUIR. But the bombs can only be produced in plants employing hundreds of thousand of people, enormous plants. They have books and equipment which must all be inspected. Their records must all be gone over, like anything else in international affairs, and all cards must be put on the table before you could prove that you were really destroying all your bombs, and we would have to have similar assurances from other nations.

I cannot decide those things; I cannot even discuss them. It is a matter for the United Nations to work out, and it cannot be done next year.

Senator JOHNSON. I have one further observation to make, and that is that you scientists have gotten a long way ahead of human conduct, and until human conduct catches up with you, we are in a precarious condition unless you scientists slow up a little and let us catch up.

Dr. LANGMUIR. Scientists are not going to slow up; they are going faster.

Senator JOHNSON. Then, we will have to speed up.

Dr. LANGMUIR. You will have to speed up.

Senator JOHNSON. I am in favor of it.

Senator HICKENLOOPER. Mr. Chairman, I might suggest to Senator Byrd that we had one experience along the line he was discussing.

We sank a lot of battleships and other things, and the other nations didn't.

Dr. LANGMUIR. I don't recommend that.

The CHAIRMAN. Doctor, don't you think it would be more politically feasible to accomplish international agreement as to the setting of an inspection if this program was undertaken before other nations had atomic bombs?

Dr. LANGMUIR. Oh, yes. It must all be started, the sooner the better. The President's declaration of November 15 is excellent.

The CHAIRMAN. You will agree that if under the United Nations organization a commission could be set up and come back on the 1st of October of next year, we will say, with an agreed-on program that all nations are going into for the setting up of an inspection force, that is something you would like to see happen, isn't it?

Dr. LANGMUIR. Yes, but I do not believe the first time it is proposed that it is going to work. I think if nations could agree on inspection, fine. Then, it will have to be implemented; we will have to have teeth in it; we will have to have safeguards and all kinds of things which may take a few years to work out. If the intent could be expressed, and that may be done within a year, that would clarify the atmosphere tremendously.

The CHAIRMAN. I think it is dangerous, in view of your assertion that they could be produced by many countries within a period of 5 to 10 years, to give any impression to the American people that this is something that can be sort of taken easy in separate steps; but rather the desire should be to accomplish this just as quickly as possible in a working program.

Dr. LANGMUIR. Yes, but not to the extent of making an ultimatum that it has to be done next year or else.

The CHAIRMAN. I realize that.

Dr. LANGMUIR. That must not be done and we must not be disturbed or discouraged if it takes a little longer than we hope, because we must allow reasonable time in which these things can be done.

The thing that impresses itself on me is this: If you let things slide, as we did for 3 or 4 months after August, conditions get worse and worse and worse. They rapidly diverge and get into a more dangerous state of security.

If, on the other hand, you take constructive steps, get general points of agreement, when they first agree to inspect, that won't mean that inspection goes into effect right then and there. It means they begin to pave the way for mechanisms, and it may be 2 or 3 years before the thing comes to a point where there is inspection.

The CHAIRMAN. Winston Churchill gave as his estimate that unless we, so to speak—I don't suppose he would use this expression—buttoned it up within 3 years, that the prospects for any kind of world security and peace would go.

Do you remember reading that statement?

Dr. LANGMUIR. Something like that; yes. I think I would agree that what is done in the next 3 years is perhaps the most important of all; but if at the end of 3 years we have not got our world security, that would not worry me much. If we have made progress toward it, and if we have an increasing desire to see the thing through on the part of several nations, then I say we have made great progress and there is great hope.

The CHAIRMAN. Do you think, if an invitation were issued by this Government to scientists from other countries, that they would be universally permitted and allowed to come here?

Dr. LANGMUIRE. I think so; yes, within a reasonable time.

The CHAIRMAN. One further matter, Doctor. General Groves stated yesterday that many of the good men were leaving these projects because of uncertainties, which I believe is the way he phrased it.

Do you concede that that is the reason why these fellows are leaving these projects, these scientists, or do you believe that the fact is that they don't want to work on bombs?

Dr. LANGMUIR. Well, I don't think I am particularly qualified, for I don't know a great many of these men, but those I have talked to have expressed the opinion that the thing they like least of all are the security regulations and also they don't like to work on bombs. They are really scientists, and would rather work on nuclear physics. That is the thing that seems to them their life work. They have become engineers, and they don't like it; they would rather be scientists.

The CHAIRMAN. I might state, Doctor, for your information and for the record, that we have called for a report from the National Academy of Sciences. We have asked Dr. Jewett for a comprehensive report about the known sources of uranium and thorium. We will have that in a short time.

I want to thank you very much indeed, Doctor; you have been very helpful, and I want to thank you for coming down to talk to us.

The committee will meet on Monday at 10 o'clock.

(Whereupon, at 12:15 p. m., the committee recessed until 10 a. m., Monday, December 3, 1945.)

ATOMIC ENERGY

MONDAY, DECEMBER 3, 1945

United States Senate,
Special Committee on Atomic Energy,
Washington, D. C.

The special committee met, pursuant to adjournment, at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Russell, Johnson, Connally, Byrd, Tydings, Vandenberg, Austin, Hickenlooper, and Hart.

Also present: Edward U. Condon, scientific adviser; and James R. Newman, special assistant to the special committee.

The Chairman. The committee will be in session.

Dr. Bush, will you proceed?

STATEMENT OF DR. VANNEVAR BUSH, PRESIDENT, CARNEGIE INSTITUTION OF WASHINGTON, AND DIRECTOR, OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

Dr. Bush. I have a brief statement, Mr. Chairman.

First, to identify myself, I am president of the Carnegie Institution of Washington and director of the Office of Scientific Research and Development.

I have had official connection with the development of atomic energy since June 1940. At that time, the National Defense Research Committee was established by President Roosevelt under my chairmanship, and the Advisory Committee on Uranium, headed by Dr. Lyman J. Briggs, which had been functioning since the fall of 1939, was reconstituted as a subdivision thereof. It was reorganized at this time, its work was somewhat expanded, and it proceeded with investigation of the possibilities of fission. In June 1941, I became director of the newly formed Office of Scientific Research and Development, of which NDRC became one major part. Under this arrangement, work on the uranium project was expanded, and over-all responsibility for it continued to be a part of my assignment.

It became apparent during that time that there was a strong possibility that a bomb would be developed during the war. The recommendations I made at that time for an all-out effort were based on the recommendations of two committees, two strong scientific and technical committees set up by the National Academy of Sciences at my request, which reported unanimously and which gave strong recommendations.

By the summer of 1942, the point of large construction had been reached, and the project was thereupon turned over to the Manhattan

Engineer District, Army Service Forces. On certain auxiliary reseach, and in other ways in aid of the War Department's program, OSRD remained active. My own connection with the development work took the further form of chairmanship of the Military Policy Committee, with Dr. James B. Conant as my alternate. This committee was dissolved this fall. As a member of the Interim Committee also, I have had a continuing share in responsibility for the program.

Development of systems for the control and utilization of atomic energy is the most important task ever faced by the governments of the world.

The CHAIRMAN. Doctor, do you mind being interrupted?

Dr. BUSH. Not a bit.

The CHAIRMAN. This Military Policy Committee was dissolved this fall. Why was it?

Dr. BUSH. It had completed its work, Mr. Chairman. I will enlarge upon that somewhat.

In the summer of 1941, when an extensive program was recommended, the President instructed me to report to an over-all policy committee which consisted of the Vice President, Mr. Wallace, and the Secretary of War, General Marshall, Dr. Conant, and myself. I took up with that group all matters of major policy from there on. When the program was turned over to the Army, to the Manhattan Engineer District, there was formed at the instance of that committee a Military Policy Committee, of which I was chairman, with Dr. Conant as my alternate, and on that committee were General Styer, then Chief of Staff of the Army Service Forces, and Admiral Purnell for the Navy. General Groves was made executive officer and had complete management of the program. He reported to the Chief of Staff, but he was instructed to review all of the major programs and policies with the Military Policy Committee in regard to the construction of plants and the like, so that his reports and recommendations received the endorsement of that committee before they went to the Chief of Staff.

That committee had entirely a wartime function and assignment to develop a bomb for use; having completed its assignment, it was dissolved at the time that the parent committee was dissolved, the major policy committee, at the end of the war.

For the continued progress of civilization, it is imperative that people be safeguarded against sudden destruction by atomic bombs. It is highly to be desired, for the betterment of living for mankind everywhere, that the great resources of useful power offered by further development of atomic science become generally available.

No more intricate and exacting problem was ever posed to governments than this one. It is inherently complex because the science of the atom is complex. The fact that the deadly military potentialities of the atomic bomb and the beneficent industrial applications of atomic power are almost inextricably intermixed complicates it further. The urge to prevent wars is very strong in all minds, for we have just emerged from a terrible war. The desire to enjoy the better life promised by applications of atomic power is strong also. Because the means of producing this peaceful power can readily be converted into an atomic bomb for destruction, the mechanism for world peace and the mechanism for world control of atomic energy are profoundly interrelated. Preventing war is a long task, which must be done bit by bit, step by step; so also is the development of peaceful atomic power. The two must be related in our thinking, and what we do toward achievement of the one must be weighed in the balance of its effect on the other.

In a nationalistic world, all peoples will seek to attain an equal footing with respect to anything so powerful as atomic energy. If the mechanism of world peace is available and is strong enough, peoples may be expected to relinquish something of their traditional nationalism to attain that equal footing through international organization.

The CHAIRMAN. Wait a minute. You say, "In a nationalistic world, all peoples will seek to attain an equal footing with respect to anything so powerful as atomic energy," which means that all powers who are competent to do so are striving for it now; isn't that right?

Dr. BUSH. They either are now, or they will be in a nationalistic world, certainly.

The CHAIRMAN. If they relinquish nationalism to an international organization, they wouldn't try to stop getting atomic energy, would they?

Dr. BUSH. I think not, but my point is that if there is a strong enough international organization, instead of doing it independently, they may be expected to relinquish some of the nationalistic viewpoint in favor of attaining an equal footing through an international organization.

If no dependable mechanism is available, a secret arms race in the surreptitious development of atomic bombs may be foreseen. Any well thought out plan for orderly progress toward the banishment of war will start here, with the prevention of such secret preparations. The end of open preparations may then follow, to be followed in turn by the end to war itself. The start of the journey toward this great goal is in such a seemingly simple thing as the establishment of the complete flow of information—particularly of basic scientific information—across national boundaries.

The three governments which shared knowledge and skill to enable scientists to achieve the chain reaction and industry to create the materials for the bombs that ended the war have fittingly made the first move toward the establishment of mechanisms for the control of atomic energy and for the development of peace for which that control is an essential requirement. The declaration which grew out of the recent conference of President Truman, Prime Minister Attlee, and Prime Minister King is a very important document. It would have been important simply as a declaration for a peaceful world. It is of the very greatest importance because it chose the right path to that goal, blocked out the journey into practical, sensible stages, and clearly mapped the crucial first marches. The declaration is notable, moreover, because it entrusts to the United Nations Organization this momentous international responsibility. It is of the utmost importance that the member states, especially the great powers, upon whose cooperative effort success depends, do all within their capacity to assure that success. The way to international collaboration and control has been opened. But it will be a long way. As we progress along it, the separate national states must set their own houses in order, establish their own internal systems of control, and thus bring into being agencies which can support the international agency.

Eagerness to assure world peace is laudable enough. The great hazard is the kind of over-eagerness which cannot endure the long patient work which will be needed, and which therefore argues for quick answers, such as "outlawing" the atomic bomb. Premature outlawry could well be disastrous, for it is impossible to outlaw when there is no effectively supported law. The first task is to create this. A good start has been made. The best possible support which our Government can bring to that good start is the expeditious passage of sound legislation for domestic regulation and development of atomic energy. During the lengthy period necessary for creation of an international system, it will be possible for this Government not only to enact the needed legislation but also to operate, test, and if necessary revise the domestic control system which that legislation establishes. By the experience of so doing, we may well secure experimental evidence that will be helpful in the performance of the international task.

Moreover, the passage of suitable domestic control legislation is urgently needed for purely domestic reasons. The present state of world affairs demands a strong United States. This is no time to let delay dissipate our strength, to let doubt and indecision hamper the great program of atomic science on which we are well embarked. People are getting tired of hearing about the atom, and when people get tired, they tend to turn away from issues. This is an issue which cannot in conscience be so ignored. Between the First and Second World Wars, the United States experimented with disarmament in an unorganized world—to sad result. The sort of thinking which that involved should long ago have been discredited. If we are to do our fair share in the exacting, patient work of international regulation, we must vigorously get at the domestic task now. Though the problem itself is great and new, it is susceptible of solution by the same means which have brought governments into being, gradually rendered them more efficient as agencies for the general betterment of man's lot, and reached a high point in the United Nations Charter. Those means are hardheaded analysis and honest good will. The first, used to the full in determining our internal control system, will clear the way for the second in international affairs.

From this point of view, then, let us consider general principles which legislation for internal control and development of atomic energy should embody.

The vast physical plants, the stock piles of materials, the varied applications of knowledge which taken together constitute the Manhattan Engineer District belong not to any men or group of men, nor to any corporation or group of corporations. They are the property of the people of the United States through their Government, in which are vested title to the physical properties and patent rights covering the engineering processes. This is as it should be, for the power of this development, for good or for ill, is too great to be otherwise held. Legislation for the further control and the further extension of this development should fortify this condition. At the same time, it should make proper provision for the active participation of private individuals and private corporations in the further utilization of atomic energy, under sound regulatory procedures embodied in a sensible licensing system.

For the years immediately before us, the deadly rather than the beneficial power of atomic energy will continue to hold first place in men's minds. Until suitable and effectual means for international control of military applications of atomic energy have been established and proved, the atomic bomb will continue to be a menace. Rigorous provisions for security concerning military exploitation of atomic energy, therefore, will continue to be essential. Our experience here will be of double value in the international effort, for it can become the basis for provisions to eliminate from the war machinery of nations not only atomic weapons but also other weapons nearly as deadly, by which we should be seriously imperiled in another war if atomic bombs had never existed. To solve the problem of the bomb is important in itself and of greater importance still as a contribution toward solving the entire international problem of war.

The manufacture of fissionable materials is by long odds the most dangerous manufacturing process in which men have ever engaged. The process is accompanied by the production of radioactive byproducts as poisonous as the basic material itself; should the process used in producing power be ill-managed and get out of hand it would produce a great and deadly volume of such poisons. Improper or incautious manipulating of substantial amounts of fissionable materials by inadequately trained or irresponsible investigators is a danger to the public safety which Government must avert. Legislation for the internal control of atomic energy would be short-sighted, indeed, if it did not make thorough provision in this regard.

No better illustration of the complexity of the atomic energy problem can be had than the dilemma posed by this need for security and public-safety provisions as against the need for scientific freedom in the further study and investigation of atomic science. Atomic energy as we now know it and as we have employed it in the making of atomic bombs came about as a result of long and patient experimental investigation. If we are to press forward with the further development of atomic science for employment in peaceful power installations, if we are to explore to the full the beneficial possibilities in medical use of the radioactive byproducts of the fission process, if we are to go ahead with the search for pure knowledge in the field of which our present atomic knowledge is but a small part, we must so arrange controls that the research worker will possess the right and the freedom to carry on his studies.

A nice line of distinction hence must be drawn in security and safety provisions, in order to make possible not only untrammeled investigation but also the publication and sharing of results through which alone can we be sure of the fully productive thought on which scientific advances are based. The best way of determining this line is to define the critical situation that trenches on safety or security and provide for regulation up to that point only.

The United States is on record in favor of open doors in laboratories throughout the world and has declared its readiness to open its own doors if others will do likewise. Our legislation must be so drawn as to give substance to this declaration. Study of safety and security provisions must in addition take into consideration such questions as whether we should go beyond the declaration and open our laboratories before we are sure that this is world policy, and whether we should specifically provide for the dissemination of our findings regardless of reciprocation.

The CHAIRMAN. I notice that you do not come to any conclusion in that paragraph, which interests me very much and raises the question: Are you studying further the question of opening the laboratories?

Dr. BUSH. As matters now stand, I think that question is not too pertinent at the moment. It is clear it will be some time before our internal legislation is enacted.

We know now that the United Nation's movement for some form of commission is likely to start as early as January. Certainly what we do in our domestic legislation depends upon the progress being made internationally. I think it might be much easier to approach that question specifically when the legislation is more nearly ready to issue.

Extreme care in the formulation of the legislation, extreme judiciousness in the selection of men to administer the legislation once drawn, are essential if we are to insure against freezing the science at its present stage, hamstringing further study, and repelling able minds from this field.

Not at once, but surely in a reasonable time, it will be practicable for man to use the controlled energy of the atom for direct peaceful purposes. Atomic energy as a source of steam power and of electric power will in due course—and not necessarily a long course—become available. If only because the best way to insure against the existence of atomic bombs is to separate and distribute their components in industrial installations, we should seek to bring about the industrial use of atomic power at the earliest moment. There are many regions of the earth where a supply of cheap power would be the greatest of boons. Wise legislation will therefore encourage to the full this undertaking.

The foregoing five principles, it seems to me, must be properly recognized in legislation for the domestic control and development of atomic science. Such legislation should insure to the American people their control of plant and process, should safeguard knowledge of the military applications of atomic energy, should properly guard the physical well-being of the people against the many hazards to life and health which the investigation and production of atomic energy involve, should provide for free and full research and interchange of knowledge in this new and promising field, and should reckon with the future task of putting fissionable materials to useful work. The five parts of the problem are of unparalleled difficulty; to meet them successfully will demand unprecedented authority and responsibility on the part of those whom the Government calls to carry out the provisions of its laws in this respect.

I hope to see the Congress enact legislation which will provide for all five of these issues and which will bring into the public service to effectuate it a group of men selected for their competence, disinterestedness, and judgment. Under the leadership of two farseeing Chief Executives and with the guidance of two farseeing Secretaries of War, the Manhattan Engineer District under General Groves has enabled American science, engineering, management, and labor to bring about an achievement of profound significance in the history of the human race.

It is imperative that as we move ahead into a world rendered more promising and more difficult by this achievement, and as others take up the burdens that have been thus ably carried during the emergency, we have leadership and wisdom of equal stature.

To this end, I hope that through its atomic energy legislation the Congress will make the grant of authority fully as broad as the task demands, and that it will so constitute the resulting agency that the most qualified and public spirited of our citizens will be proud to serve thereon. This is imperative both to insure the effective internal control of this vast new wealth and to give firm basis for the United State's effective international collaboration in dealing with a problem of vital concern to every living human being.

The CHAIRMAN. Senator Tydings.

Senator TYDINGS. Dr. Bush, I take it from your testimony that the hope of the world in the field of the atomic bomb is by international agreement.

First, your premise seems to indicate that they will promise not to manufacture the atomic bomb. Is that correct?

Dr. BUSH. I would put that rather late in the stages.

Senator TYDINGS. I mean eventually, not tomorrow.

Dr. BUSH. Eventually, most certainly.

Dr. TYDINGS. They will agree, by treaty through the United Nations or through some international medium, never to manufacture the atomic bomb.

I think that it will be necessary, under the premise you lay down, to have very rigid inspection all over the world on the theory that nations will not keep their word, and we cannot afford to take a chance.

Dr. BUSH. Quite right.

Senator TYDINGS. That will entail a great change in the internal policies of some of the governments of the world, access in and out, more freedom of speech, more freedom of the press and the right to publish what you want, and so forth and so on. Do you agree to that?

Dr. BUSH. Yes, sir.

Senator TYDINGS. It will also entail some sort of transportation system because many areas of the earth are not settled, and therefore we will have to have international airplanes that will have the right to fly over without interruption, and to survey, just as we would plot topographically the area of any other country.

Dr. BUSH. Yes, sir.

Senator TYDINGS. I take it that that international force would have the right to go into any plant where suspicion seems to indicate that atomic energy or atomic bombs might be in the course of manufacture.

Dr. BUSH. I think ultimately that would certainly be the case.

Senator TYDINGS. And without all those things—and they are not all, but some of them are preliminary things—there is no hope of an international agreement worthy of the name that would be effective.

Now, therefore, our task seems to be not only to get this international agreement which might come quickly, but to get the implementation of that international agreement so that it would be worth something.

Dr. BUSH. Quite right.

Senator TYDINGS. So, in order to get that, we would have to ask nations to alter their present governmental systems to the extent that they would fit into the premise.

Dr. Bush: Let's say their practice under the system, and not necessarily the system.

Senator TYDINGS. Their system of ingress and egress, and so on.

Dr. BUSH. Yes, sir.

Senator TYDINGS. How do you suppose we could best bring that about?

Dr. BUSH. I think we would bring that about, sir, to best advantage if we realize at the outset that it will take time, and if we have planty of patience. I believe also that it will come about to best advantage if we utilize the mechanism already set up under the United Nations Organization for that purpose; but in so doing we ought to use care on one point particularly. We should not overload the United Nations Organization with tasks that it cannot perform at the outset. Certainly everyone wishes the United Nations Organization to be a success, and in order to be a success it must particularly be successful in the first tasks that it undertakes. Hence, I urge that our recommendations to the United Nations Organization involve at first only the parts of this long program which can be accomplished within a reasonable time and with almost certain prospect of success in their fulfillment, and to step on from there to the point where we arrive at the situation you describe.

Senator TYDINGS. There must be a certain amount of candor in these discussions, and no idea of hostility toward any nation if we are to achieve progress.

Have you given thought to the matter that the delegates to the United Nations from any country will probably have to telephone back to their own governments each time they commit their nation to any international program? That applies in varying degree, according to the country affected. Have you therefore given thought to the question, if an international plan is to be set up, considering all the difficulties which need not be mentioned of a change in the outlook of some governments toward inspection, and so on, as to whether or not that task could be best performed through the United Nations Organization or by a meeting of the heads of the three or four or five big powers of the world so as to prepare the groundwork and make these long interchanges of communications between the governments and the UNO workable?

Dr. BUSH. I think we all know, Senator, that any such large body as will be the United Nations Organization works to best advantage with some of the principal participants having preliminary interchanges and preliminary discussions on every work that is contemplated.

Senator TYDINGS. You have answered my question. I take it you think that the degree of success would be greatly heightened if, preliminary to turning this over to the UNO to implement the basic plan and the basic conditions, not all of them, not the mechanics in detail, but the basic plan and the basic implementation be first agreed to between the leading nations of the world.

Dr. BUSH. I think that would be excellent. I would go so far, Senator, as to say that the objectives and the general plan should be discussed, and then the first steps discussed in great detail, because no one, I think, can lay out the entire plan at the present time.

Senator TYDINGS. That was not my plan. First of all, there must be a meeting of the minds of the nations affected that they want to outlaw the atomic bomb, and then there must be a discussion of the ways, and there are three or four principal things without which you cannot make any progress unless those three or four things receive some degree of settlement.

Now, therefore, my question after this preliminary discussion is this: Do you favor now a meeting of the leading powers of the earth, apart from the UNO, through their chief representatives, whether they be presidents or marshals or prime ministers or what not, to explore and prepare the preliminary ground before this is turned over to the UNO?

Dr. BUSH. We have already had one such set of discussions, and I think successfully, and quite properly that first discussion occurred between the three countries that have principally participated in this affair during the war. I think, as far as time allows, the more such discussions there are the better.

Senator TYDINGS. Then, you would favor, I take it, now that the three have agreed on their plan—that is, Canada, Great Britain and the United States—and have presented it to the world, that before the UNO deals with it that those three invite three or four more of the leading nations of the world to see if they accept the proposition we offer, and under what conditions, and to see if a preliminary arrangement can be agreed to?

Dr. BUSH. Apart from the exact mechanism, Senator, as to how it is done, I certainly favor such discussions as are possible in the interval before the United Nations meet, realizing there is not now very much time.

Senator TYDINGS. When do you favor this meeting between the leaders of the nations in the future for this purpose?

Dr. BUSH. I think, Senator, that I could not prescribe that. It depends upon a great many things about which I know very little.

Senator TYDINGS. Do you favor it as soon as it can be held, or can we put it off?

Dr. BUSH. I don't think we could go into the details of specifying how or when. I simply say that personally I am in favor of all such discussions as can be arranged before we get into the large meetings.

Senator TYDINGS. I think, too, from our answers, the obvious idea involved is that to turn this over to the UNO without this preliminary spadework between the heads of the great nations is to turn it over to a society that will debate it to death, and that one will have to turn it back to his or her government over and over again before any action can resolve.

Dr. BUSH. We have no United Nations Organization at the present time. An organization consists of people, and consists, also, of people that have learned to work together. It will be some time before we have an effective working United Nations Organization.

To turn over to the United Nations Organization the entire problem at this time would, in my opinion, be absurd——

Senator TYDINGS. Thank you for that specific answer.

Dr. BUSH. As absurd as to talk today about outlawing the bomb before we have talked about the means by which outlawry of this bomb and other weapons of mass destruction can be made in force.

If I may add one other word, I think it is entirely proper to turn to the United Nations Organization the beginnings of the matter and to hope that they will take some initial steps fairly soon.

Senator TYDINGS. I think I follow you, but I would like to make it a little more specific, and with no idea of being captious with it at all.

I take it you say now that, if we turn this whole problem over to the United Nations Organization for settlement, the prospect of success, which is so essential to this first undertaking, is not too bright; and that therefore the great governments of the world should make sure, through preliminary exploration and conference, that when it is turned over to the UNO there is that promise of success which we all hope for.

Dr. BUSH. I think that they ought to make plans so that the United Nations Organization will have something specific to work on, with the definite assurance that the great powers are anxious to see the thing move along that path and will cooperate.

Senator BYRD. What plans can we make? What should be done prior to the meeting of the United Nations Organization to consider this matter? What do you have in mind that can be done?

Dr. BUSH. I think one very great step was taken when the two Prime Ministers and the President joined, studied the entire matter, and made a specific proposal and plan.

Senator TYDINGS. But there was nobody present at that conference to accept it or reject it or to say, "That is all right, but how about doing it this way, or how about leaving that out and putting this in?"

Dr. BUSH. That was one suggestion; there may be others. There may be better ones, but there can be other conferences.

Senator TYDINGS. How can you get action if just three men give out a statement when the recipients to whom that statement is directed are not present? Do you see what I mean?

Dr. BUSH. I don't quite follow you, Senator.

Senator TYDINGS. I mean to say this: Do you think that you can achieve the preliminary success in this undertaking without a further conference of the leaders of the great nations of the world and particularly those that were not present when the three men gave out their original statement?

Dr. BUSH. But note, Senator, that the declaration itself indicated the desirability of further conferences among the great powers on this same matter prior to the United Nations operations.

Senator TYDINGS. Do you advocate that they have that further conference now?

Dr. BUSH. I was entirely in agreement with that conference, with that declaration throughout and that is one of the points in it.

Senator TYDINGS. I understand that, but we cannot let it hang right up there on the limb. Where do we go from here?

Dr. BUSH. Senator, that is someone else's guess, and not mine.

Senator TYDINGS. What do you mean?

Dr. BUSH. Well, that the President and the State Department proceed with the matter, as I judge they are doing at the present time.

Senator TYDINGS. And try to bring others in this field to see if they are in accord with this offer that has been made?

Dr. BUSH. Either formally or informally, I think there should be further conversation, and I judge such will occur, although I know nothing about it.

Senator TYDINGS. Until that is done, the hope for handling this successfully by the UNO is not too promising?

Dr. Bush. I think that the UNO will undoubtedly have discussion of this matter just as soon as it starts. I hope it will proceed toward the formation of a commission on this subject, because I believe in that commission, internationally, discussions in regard to details of the plan can prove to best advantage.

I think that that will go on from step to step, and I hope that through the next several years, when that is occurring, that there will be not only that procedure in the United Nations Organization, but also continued conferences among the principal members.

Senator Tydings. Dr. Bush, you and the other men who have preceded you have all indicated the same general approach to it.

As a legislator that may have to take a stand on this sometime, I believe the theory is pretty clear, but I think where we are weak is that nobody is presenting to us possible steps that should be taken. They say eventually it should be decided by the UNO, but the UNO may fall to pieces. It may be a great success. We may be a long time in meeting. There may be obvious difficulties, and they may take up other matters.

Now, in the meantime, isn't it important that what preliminary work has been done be immediately followed up?

Dr. Bush. Yes; I think it is important that all of this be followed up.

Senator Tydings. Where will we follow it up?

Dr. Bush. Let me point out that the declaration to which I referred did not talk in generalities. It made two very specific suggestions of immediate and rather simple steps that would go, in my opinion, a considerable distance along the path that you outlined a moment ago; and that path is exceedingly important as you outlined it, because I believe fully that even in the absence of international agreements to that effect, if there was free interchange throughout this world, a free flow of information that there is in this country among the States and which did not always exist, then we would have removed three-quarters or nine-tenths of the danger of great wars by that mechanism alone.

Senator Tydings. That goes back to my question that in some countries perhaps that free flow will not be permitted, and therefore how can you achieve what you think is so desirable—and I agree with you if it can be worked out—without having this meeting to prepare the ground so that we can make progress along these lines?

Dr. Bush. It seems to me, Senator, that the trend in this world is all in the direction of the free flow of information, the free flow of knowledge that we have talked about.

Now, it is not true today that it flows unimpeded everywhere, not by any manner of means; but the trend is in that direction, and I believe if we encourage it sympathetically, patiently, and in a realistic manner, that that can be brought about in time.

Senator Tydings. But how should we encourage it?

Dr. Bush. I think the first step should be by the interchange of scientific information of a fundamental and basic character.

Senator Tydings. Can that be done until the other governments of the world agree to meet us on that same basis?

Dr. Bush. I think the governments of the world will be anxious to meet us on that basis.

Senator TYDINGS. How can you achieve that without bringing the heads of these governments together?

Dr. BUSH. I think that will be almost, but not quite, automatic. Before the war we had full and free interchange in the scientific fields to an extraordinary extent. There may have been impediments here and there, but there were certainly no more impediments internationally to the flow of fundamental scientific information than there are internally in the flow of applied science in industry.

Senator TYDINGS. Hasn't that been changed somewhat recently?

Dr. BUSH. During the war every nation, of course, placed restrictions; but the point is that we do not need to create a wholly new situation. We simply wish to return to the situation that occurred previous to the war in regard to the flow of fundamental science and to improve upon that. We have had some indications in that regard already, and in this very field.

We had the courage, and I think the wisdom, to publish the Smyth report with a great deal of the fundamental information in it, which was certainly a gesture, it was certainly an indication that we wished to proceed down the path of free interchange of basic scientific information.

We have not yet gotten back to the point where scientists flow across boundaries easily, because of transportation difficulties; yet, a while ago, Russia invited a group of American scientists to visit them, and that was done quite successfully.

I believe that by encouraging that procedure, by making it clear that we as a country wish to encourage it, that we can bring that very simple point about without very much difficulty.

Senator TYDINGS. Assuming that that simple point, which is a good point, is of such transcendental importance, and that this whole problem is like Damocles' sword hanging over all of civilization, it seems to me that the natural result that would flow from what you have said is that there must be a meeting of the leaders of the great nations at some place to arrive at an undersanding of the fundamentals that must be present before any of these things can take place.

Dr. BUSH. When it comes to the particular mechanism by which governments and peoples get together, Senator, I think you are in a better position to judge what will work effectively than I am.

Senator TYDINGS. The reason I ask you this in such detail is that I share your belief, as you imply, that this is a pretty big task to hand over to the UNO as one of their first problems, and that if it fails, civilization will be consumed with fear, and the one instrumentality set up for the keeping of the peace of the world will be given an awfully fatal blow.

Therefore it seems to me that as we are in this stage where we don't want that to happen, and we are confronted with that problem, that it is a natural conclusion that the heads of our great governments—and I am a Democrat, understand me.

Dr. BUSH. I thought you were, Senator.

Senator TYDINGS. The heads of our great governments, some five or six of them in particular that I won't name, have got to get down to the table and see whether or not they can eliminate the fears that attend the interchange of information and the outlawing of the bomb, and all of that sort of thing, before you can proceed anywhere.

The United Nations cannot bind any government internally.

Dr. BUSH. We can remove the fear only as we make progress, and it will take us years to make progress to the point where the peoples of the world can have the fear removed from their minds on the atomic bomb.

But we can't get there in a moment by wishful thinking. It is going to take patience and hard work. Hence, the things that I urge are, as far as our influence extends, as far as the United Nations operates on this matter, that we urge that they go step by step and deal only with such steps as can be carried into effect effectively, and do not try to take the whole problem at once and jump to a quick solution which does not exist.

Senator TYDINGS. One of your first steps is that we must have this interchange of scientific information to eliminate fear and to free genius, so to speak. How can you do that unless the leading nations of the world agree on the fundamentals that must be present when that solution is arrived at?

Dr. BUSH. I think there will be no difficulty whatever in getting the nations of the world to agree on the ultimate objective. The ultimate objective is to abolish war. Short of that objective, there are other objectives that are more easily attained, and those can be placed in steps.

I would point out this: First, it will be possible when there is an adequate system for obtaining full knowledge—and I don't call it an inspection system; it is not necessarily in that explicit form—to remove from the world at that time the fear of the use of atomic energy in bombs, and also of other weapons capable of mass destruction, for there are others that are just about as bad and might be worse.

Short of that, even, it may be possible by international agreement and with full knowledge to remove the threat of sudden surprise attack. If we could remove from this world the fear of sudden attack by atomic bombs, or otherwise, we would have gone some distance. Now there is a long path to proceed.

Senator TYDINGS. But before you can eliminate one single "if" with which your whole premise is studded, how can you remove one of them until the leading representatives of these great nations, in many but not in all cases the only men who can speak for their nations, eliminate the weeds and the undergrowth so that you can get a foundation in which you can plant this seed?

Dr. BUSH. I have already said that I hope they will do just that.

Senator TYDINGS. And you would advocate it in general terms?

Dr. BUSH. Yes.

Senator TYDINGS. Then I think I have the answer to my question, which I will summarize as follows: That this is too big a task for the UNO to take in its present form and under present circumstances with a reasonable hope of success.

Dr. BUSH. Without all the help that can be given by prior conferences.

Senator TYDINGS. And that nations, through such intermediaries as they may set up, either through direct dealings with governments—which is preferable—or something similar, must prepare a vast field of small but important details before any of these things that you desire or think are wholesome for ourselves in the world can follow.

Dr. BUSH. That is right.

May I go back to one point that you raised previously which comes right in on that.

You spoke about an inspection system that would go into every factory, that would go into great detail in every country.

Senator TYDINGS. Not necessarily go, but have the right to go.

Dr. BUSH. That is a very great difference. That is an ultimate situation. There are much simpler situations before that is necessary.

For example, for an early step I think that the nations of the world might readily agree that they would disclose to one another and make available completely through the United Nations Organization full information in regards to the sources of ore of the principal fissionable materials, that they would make known the movements of those ores, the extent to which they are prepared and shipped.

Senator TYDINGS. All the raw materials?

Dr. BUSH. All the raw materials. Now, we know what those are. We know just about where they are in the world in general, and it would not take a great inspection system to determine whether such facts as were supplied by every nation were correct or not. In fact, it would take very little beyond the visit of a few geologists to the principal sites of the world, mining engineers, to know what the facts are in regard to that.

Yet that very simple thing, if the nations of the world all knew what every other nation was doing in regard to the preparation of the raw materials, would be a significant step on the path that I have outlined, and a step that could be taken with assurance.

Senator TYDINGS. Obviously that would help, but let us suppose that in Canada—with no reflection on Canada, which I pick out because I am sure it would not happen in Canada—there were charted all the places where uranium exists that are known at present, and let us suppose that some place up in the Hudson Bay country that is not very accessible to the outside world a new deposit of pitch-blend or uranium was discovered; and let us suppose that a group of men who discovered it did not communicate that, for patriotic or other reasons, to the Canadian Government or to the world organization. What would you say to that?

Dr. BUSH. I think they would have a very difficult time, indeed, even if there were no international inspection system, because they would need to consult geologists and mining engineers. They would need to purchase mining equipment.

Senator TYDINGS. I don't mean to manufacture it; I mean to let it lie there. They would just discover that it was there, and would not do anything about it, but would not report it.

Dr. BUSH. Well, why worry?

Senator TYDINGS. Why worry? Well, I would want to know where the raw material is; it is essential that we know where all the raw material is.

Dr. BUSH. But it is far more important to know whether the raw material is being mined and processed.

Senator TYDINGS. You are starting out by saying, "If we know where the raw material is." What I am getting at is that then we might work on the supposition that there is raw material which we do not know about.

There wouldn't be any bank robbers if everybody would abide by the laws of the State.

Dr. BUSH. My policy is a small step, but I think a significant one and relatively easily enforced, because I think a relatively simple system of gathering of information would disclose the salient and principal facts. There might be some that would escape, but I don't think they would be significant.

Senator TYDINGS. Having in mind Pearl Harbor, and other instances which I won't delineate, as one who has some little responsibility I would be pretty reluctant to exchange information with the world unless I knew that the preliminary steps had all been taken first so as to make certain that exchange did not impair our own safety.

Dr. BUSH. Certainly; so would I.

Senator TYDINGS. Therefore I want to know before we exchange that information, if that were deemed wise on thorough thought, whether or not the other nations were really going to permit this exchange and have an open and aboveboard transaction, or whether we were going to be in somewhat the situation we are in today.

Dr. BUSH. That is why, Senator, I would proceed by stages, step by step, on a system, if you wish to call it so, of partial payments, so that the accomplishment of each step successfully will, in the eyes of the world, prepare the way for the next one, so that confidence in an international organization will be gradually developed over the years, and so that—incidentally, and a very important point—there will be developed within the United Nations Organization an inspection system under a commission which has great pride in its accomplishment and great esprit de corps. That is possible, and when that occurs we may gradually come to have confidence in its pronouncements and to feel that it knows the facts on which it makes those pronouncements.

When that day arrives, we will have come to the point where we can make enforceable national agreements for the purpose of removing from the scene the principal methods of mass destruction, whatever they may be, but not before that; and I believe that our steps at the present time should be planned to develop that situation gradually and definitely, and we should have all the patience in the world in so doing.

Senator TYDINGS. I have just one more question. There is nothing more difficult to outlaw than the atomic bomb, is there?

Dr. BUSH. Oh, I think it is equally difficult to outlaw any other mass weapon.

Senator TYDINGS. Why shouldn't we outlaw everything, while we are outlawing the atomic bomb—the battleship, the artillery, and the whole business? Why stop at the atomic bomb?

Dr. BUSH. The idea, Senator, is to stop wars. I am against wars of every kind carried on by every means.

Senator TYDINGS. I agree with you; but why do we limit this to the atomic bomb? Why don't we go at the whole thing at one time?

Dr. BUSH. I would not limit it to the atomic bomb. I would say, "Let's remove from the world the fear of every other weapon of mass destruction and let's remove from the world finally a fear of war itself."

Senator TYDINGS. How?

Dr. BUSH. By the path that you and I have discussed, and over a period of many years in which we will have to have patience and perseverance to work through the United Nations Organization and to support it; but if that doesn't work, to try again by other means and to keep on trying until we succeed in producing an international system under which we can remove wars.

The CHAIRMAN. Dr. Bush, I am more impressed every day with what Aristotle said, that politics was the art of the impossible, and it is rarely repeated.

I am a little bit disturbed about these long periods of time that you envisage in getting control of this problem.

Now, we have a weapon that, produced in any kind of quantity and used aggressively, could wipe half the population off the earth by action of the other half. This, I presume, is known to the statesmen of the world; I don't say it is known to all the peoples of the world.

Don't you feel any sense of urgency about trying immediately to accomplish an over-all control of this thing?

Doesn't it worry you any that these steps are to be taken years apart? Don't you feel that the accomplishment of the art by other nations will make perhaps more difficult the mechanics of control? Is there not something to be said for the laying down of an over-all control plan that is fair and equitable so that the fear of the peoples of the world can be removed at the soonest possible moment, and that we won't have to go along this long series of years with that fear overriding everybody?

Dr. BUSH. Senator, there is a difference between the sense of urgency and the sense of panic. I have, indeed, a sense of urgency. The problem should be attacked at once, as you gentlemen are attacking it. It should be analyzed, and we must proceed with expedition down the path.

But that is quite a different thing from the sense of panic that wants a solution overnight. There is no solution overnight.

The danger, as I see it, is this: The American people are a great people, but they have one fault that I know full well. They like immediate, over-all solutions, and on this particular matter we are, all of us, tired of hearing about atomic bombs and atomic energy. I may be more tired than you gentlemen are, because I have been thinking about it intensely for 6 years; but you gentlemen, everyone, are tired of hearing about this thing. We, all of us, wish we could suddenly remove this threat and could forget this element. We can't.

The danger, as I see it, is that in that mood, quick——

The CHAIRMAN. I don't want to interrupt, but don't you feel, Doctor, that mankind is so constituted that it depends upon the intent of the purpose with which you approach an objective as to whether or not you are going to get that objective?

Dr. BUSH. The point of view of mankind will depend upon whether progress is being made, not upon whether a solution is brought out immediately.

The thing that I am afraid of is that in the urge to get too quick solutions, we may do things that are not wise.

Let me go back to one other point of your remarks, which I want to enlarge upon.

Senator VANDENBERG. You discriminate between hysteria and prudence?

Dr. BUSH. Quite right, sir.

The CHAIRMAN. I hope that the questions that I suggested did not denote any state of hysteria on my part, Doctor?

Dr. BUSH. No; but I think you felt as I do, that there is some hysteria as this thing is thought about.

But I want to make two points: First, you spoke of a situation where there are enough atomic bombs in the world to destroy a large part of civilization. That situation does not exist today. Now, of course, I don't want an open session to go into the question of how many bombs are available, or any such thing; but every country, every people in the world, knows that today we have not got such great quantities that that statement would be true in its generality.

The CHAIRMAN. We would have to make that knowledge available, though, before we got any other country to agree to turn up the uranium sources they have, wouldn't we?

Dr. BUSH. We would; and under proper circumstances and proper controls I would be entirely in favor of making it known.

Senator HICKENLOOPER. I get the impression from your statement, Doctor, that there are two things involved here: One is the physical and mechanical development of this monster we have created, that that is our responsibility, that we have it along with England and Canada, but that we cannot hope to arrive at any point of mutual confidence in the world until the moral questions are settled.

Those moral questions involve the moral attitude of other nations.

I would like to ask you this: Do you think there is any remote hope of any security against the use of atomic energy as a weapon until those moral problems have been substantially solved within the nations themselves?

Dr. BUSH. Well, it is all according to what you mean by "moral," Senator.

Now, I come from New England. My forebears came from Cape Cod. There are small towns on Cape Cod that live in peace, and yet I wouldn't want to say that they do so because they are highly moral in the specific sense. But they have an understanding; they have a basis of interchange. The word "moral," I think, carries too much.

Senator HICKENLOOPER. I mean in the broadest sense. Perhaps I should amplify or explain that a little.

There are certain nations in the world today that are very vitally interested in controlling atomic energy because the peoples of those nations have a fair understanding of its potential or its actual power.

There are other nations. Let's, just for the sake of our discussion here, go back to the conditions in Germany before this present war started, where the people were kept completely in ignorance of many of the things that went on in the world and were fed a propaganda that only suited the needs of the leaders.

In that case, if there should have been, or if there were, any moral weight to be exercised by the people of Germany, it did not have a chance to be exerted or exercised because of propaganda that directed their thinking.

Now, until the peoples of the more or less enlightened nations of the world pretty universally know what they are facing in the possibility of this atomic power, do you think we have too much chance of getting any moral support—I mean the honest, well-intentioned support—of all of these nations?

Dr. BUSH. Yes; I do. Eight years ago there were two countries in the world whose people had been trained for over a generation to prepare for a war of aggression, Germany and Japan. The leaders of those countries had their peoples so propagandized and so under control that they did not know the world situation; and that was an enormous threat to the world, and out of it came a great war.

No such situation exists today, and those two nations are conquered and under control and should remain so. We have no nations in the world today that do not wish a long, fruitful period of peace; and in my opinion, every country is anxious to bring that about, not only the peoples of every country but the rulers of every country. We have no situation as then existed.

We will have misunderstandings; we will have friction; we will have difficulties. But I am perfectly sure, personally, that there is no danger of great wars breaking out until there has been time to work this thing out with care and deliberation, and fully; and in that sense, I am optimistic; I believe it can be done.

Senator HICKENLOOPER. Is it not possible that, either now or within some reasonable time in the future, the leadership of some nations may persuade their people that it is desirable to have space, that they may personally desire peace, and yet is it not possible that they may be willing to adopt a policy of war in order to obtain their own ends?

Isn't there a danger that the leadership of some nations might desire peace but still cling to the policy of war as national policy?

Dr. BUSH. We have got to be sure, of course, that there will be no more Hitlers or Tojos, all right. However, that is not a question merely of a rule of a country by a single person. We have got to be sure that no nation, over a long period of years, becomes oriented in the direction of conquest. That can come about if we have the right international understanding, so that the nation that became thus oriented would immediately become a pariah among nations of the earth.

Of course, we have gone through that. We have seen Hitler rise to power in Germany and, step by step, many of them rather obvious, prepare for this war. What he was doing was evident to every one, to all nations; yet the nations either did not have the courage or ability or vision to stop the march of that machinery working toward war.

But that is not the situation today, the situation I have mentioned. That situation is absent now. Then the nations of the earth did not join and make that nation, Germany, a pariah. If they had, we never would have had a war; Germany could not have started it.

Senator HICKENLOOPER. I like your statement very much, Doctor, and I think you have given us a lot of food for thought.

However, I had a rather strong feeling—I am not at all encouraged to think that we will be able to do too much, in immediate or positive agreements, until the peoples of the countries involved began to exert their moral influence. I feel that perhaps we will, whether we like it or not, face substantial delay; and I do feel that it might be in this period of delay that we perhaps might have to exert our greatest fortitude.

Dr. BUSH. This is the period, right now, when it must be done and when we must not lose time and when we should proceed with all possible diligence. Now is the time.

Senator TYDINGS. May I ask the doctor a question?

The CHAIRMAN. Certainly, Senator.

Dr. BUSH. I would be glad to have you do so.

Senator TYDINGS. Do you think it is possible to accomplish in the world a free exchange of scientific knowledge—in a world that does not permit the free exchange of religious knowledge?

Dr. BUSH. I haven't thought of that particular parallel, Senator. If you are making a premise that the world does not permit the interchange of religious knowledge and that that will continue, I would say "yes"; I think that is true.

However, I disagree with you when it comes to science, because I think that the flow of scientific knowledge can be brought about in the world largely as it was under the conditions which existed before this war.

Senator TYDINGS. Well, why can't the flow of religious knowledge, likewise, be brought about?

Dr. BUSH. Well, Senator, I am an engineer, primarily. I would not try to qualify as a man schooled in religion and its international aspects.

Senator TYDINGS. I agree with your premise that the spread of scientific knowledge all over the world would be a very desirable thing, if we could get it done, if it could be accomplished. I would like to have thought move freely and remove the barriers to thinking.

But I do feel this, that if we cannot do it in one field, what hopes may we have that we can do it in another field? If freedom of the mind is interdicted, so to speak, by the Government in one of the oldest and strongest traditions, why is it reasonable to believe that the freedom of the mind will not be interdicted in this other field of science?

Dr. BUSH. Science, Senator, has always been more or less free; it has always had a flavor of internationalism, you know.

Senator TYDINGS. So has religion.

Dr. BUSH. It has always been the practice of the scientist to publish his discoveries so that his colleagues all over the world can read them. And, as the scientists become more and more specialized, they will become more and more international.

There is a reason for that. Suppose we take the field of mathematics. The man who is in the top rank of mathematicians may publish a paper. In this paper which he may publish there may not be more than 8 or 10 men in the whole world who can read that and understand it, who can go into such an intensely specialized thinking. And those 8 or 10 will not be located in his country, they will be all over the world.

Those men will read that publication, no matter where they are located, and by reading that publication and understanding his thinking, they will be his colleagues. That is international.

Senator TYDINGS. But, suppose that man is not allowed to send out his thought?

Dr. BUSH. Well, I am simply saying that in this particular field it is easier to bring about the international pull than otherwise.

Senator TYDINGS. I think it is logical, as you say, that perhaps you can achieve more success in other parallel fields than in religion. Nevertheless, where there is a reticence on the part of the government concerned, where there is a feeling that the national safety might be endangered, there is another situation. Suppose that the government believed it imperative to suppress that knowledge;

whether or not it rightly believes so, they might hold that information back, having the preservation of the government in mind.

Dr. BUSH. Right, and it is that hesitancy to allow free interchange of knowledge that we shall have to overcome. I think we can overcome it. I think it will be comparatively easy, in the field of science.

Senator JOHNSON. I have heard what the other Senators on this committee have said about your presentation. I want to add that I think it is very logical and comprehensive, and I enjoyed it very much. I would like to refer you to some of the conversations between you and Senator Tydings before the Senator got into the question of theology, his first line of questions.

It seems to me that international factors are something like the game of checkers. First it is your move, and then it is the other fellow's move. Now, as I see it, Britain, Canada, and the United States, the nations possessing the knowledge of the atomic bomb, have made the first move.

They met at a conference and laid down a very simple formula for the interchange of atomic knowledge, and, especially, the controls to be placed over the atomic bomb.

The other nations have not made so much progress yet in the atomic bomb, but it is their move, isn't it? There is no way in which you can compel another nation to take an interest in the control of the atomic bomb, if they don't have that information. We have the atomic bomb. We created it. We have laid down a broad basis for its interchange.

Now, if they don't come along and say, "All right, I am interested, although I do not altogether like your terms; I would like to see some amendments to your terms, but I am interested," if they don't make such a move, you are almost stymied, it seems to me, in going about settling the question in which Senator Tydings is so interested, the international control of atomic bombs and atomic energy.

I would like to go to another question that you raised in your prepared statement.

You refer to atomic energy as a source of steam power and of electrical power. You say that we will, in due course, and not necessarily a long course into the future, have that available.

As I recall it, when Dr. Langmuir was here, he touched upon this question.

He indicated that the peacetime and domestic potentialities of atomic energy are trivial, as compared to its wartime possibilities, its destructive possibilities. I think he used the word "trivial." I think he was speaking in relative terms.

If I remember his statement correctly, he emphasized that you cannot create steam or other power with uranium; that you cannot use atomic energy for such purposes without that energy having an atomic bomb——

Senator VANDENBERG. Potentiality.

Senator JOHNSON. Yes; an atomic-bomb potentiality. That is, every plant which you are using for making power would be, essentially, connected with the possible creation of atomic bombs.

I listened to a discussion, not very long ago, where they were talking about the industries of Germany. They seemed to agree that we have got to crush the industries in Germany that are making steel bridges, that we have got to crush them, that we have got to destroy them, because an industry which can make steel bridges can make weapons of war.

The feeling was that war and industry are so closely interrelated in this machine age, in this advanced age, that every manufacturing possibility, every industrial possibility, is also a warmaking possibility.

Now, my question is this: Until the over-all international question of the development and the control of atomic power has been made, is it safe to go ahead and be thinking of the domestic and industrial applications of uranium energy?

Dr. BUSH. Well, Senator, there seems to be nothing safe in this world. Let me, however, expand on this point of yours a moment before I answer.

I think that before this committee finishes these hearings it ought to bring before it one or two engineers that can answer the questions you want answered better than I can, in regard to the industrial possibilities in this field. I am an engineer, it is true, but I think I am a bit rusty as an engineer.

I can suggest a number of people whose names come immediately to mind who know the power-plant situation. I think you should have those people to testify as to those matters.

As I understand it, I think that the situation is this:

The power applications of atomic energy are not trivial in any absolute sense. Water power——

Senator JOHNSON. I am talking about in a relative sense.

Dr. BUSH. Well, if you want me to go on to that point, I would say that it is very difficult to compare atomic energy in industry as opposed to its destructive power in war. They are not quite comparable. I would not want to try to give you a relative figure on that aspect.

But, speaking about the industrial power application of atomic energy, I say that I think it is not trivial. Water power is certainly not trivial. It is an important source of power, in spite of the fact that we have coal and oil.

Now, as I see it, the distinction is, with respect to the utilization of atomic energy, largely the same as with respect to water power, about the same kind of distinction. In order to develop power by atomic energy, you have to have an expensive plant. This is also true with a hydroelectric plant.

You have to consider the total cost that is involved in the price of the power. There is the cost of operation, including the cost of fuel and the cost of the plant, the amortization and the interest on it, and the other costs.

A hydroelecric plant has a high cost, yet hydroelectric energy competes with coal and oil and hydroelectric energy has been very important in the economic development of certain nations.

Now, in this field of atomic energy, looking ahead, there are certainly certain possibilities of developing power in large quantities for steam and electrical purposes without any fuel costs.

We do not know what the cost of the plants will be, the atomic energy plants, but I cannot see, myself, why they should be very much greater than the cost of the steam plants.

Now, if that is the case, it can make a very considerable difference in the economy of some of the other nations of the world. It may not make so much difference to us. We have oil, coal, hydroelectric power. We have our power sources pretty well developed. But it would certainly make a much greater difference in some of the undeveloped parts of the world, particularly where they have got natural resources and no power at the present time.

I believe, therefore, that ultimately and over a period of years we will see power come in this fashion. I think it will produce not sudden transformations but a gradual lowering of the cost of power, which will make a difference in the industrialization of the country which utilizes atomic power.

I do not think that we will see it running the family automobile; its subdivision is not easy. I do not think that we will see it immediately because there are problems concerned with safety.

Let me say another thing: I think it is fortunate that atomic energy has an application for power purposes as well as an application for explosive purposes. I use the word "fortunate" because there will be a great urge among the peoples of this earth to use such fissionable materials for power purposes where they can confer a benefit on the general national economy, rather than to leave them stored up simply in the form where they can be used for atomic bombs.

I think that will be one of the factors which we will face as we work toward a solution, as we work toward a general understanding, where the use will be for power purposes and not otherwise.

Senator JOHNSON. But, Doctor, in your comparison of electric power with atomic power, it seems to be that you overlook the fact that in the use of atomic power, uranium power, that that is just one step, one very important step, toward the creation of atomic bombs.

That is, it seems to me, that there must be two steps. First, you have to collect large amounts of uranium. That is the first and most important step. Then, the second important step is the process of creating explosives. It is a step in the creation of an atomic bomb.

Now, you do not have those two steps in hydroelectric power or in the creation of electric power, and I think that was the point that Dr. Langmuir was referring to.

Dr. BUSH. Now, if you are raising the question, Senator, of whether we should start making fissionable materials, at the present time, internationally——

Senator JOHNSON. No.

Dr. BUSH. I would say we are not ready to do that in any case, so we might as well forget that part of it. But fissionable materials are going to be made.

The CHAIRMAN. They are going to be made?

Dr. BUSH. They are going to be made, of course.

Senator JOHNSON. That is not my point. My point is simply that, until we have an international control set up over atomic bombs, is it safe to go ahead with the use of uranium in the creation of power? I have in mind the fact that we have been talking here about inspection and espionage and all those things, of discovering the amount of uranium that is available and whether anyone else has atomic bombs stored back some place in their safety vaults. We have all those questions involved.

Now, is it safe to go ahead and use uranium in the creation of power until these international questions are settled?

Dr. BUSH. My point, Senator, is this: Whether it is safe or not is beside the point. We do not have any means, effectively, to prevent it from being done, at the present time, and we won't have for some years.

"Is it safe?" you ask. It seems to me a question we cannot answer until the time when we have come to have effective enforcement of international control.

Now, at this time, I make this point: Since fissionable materials can be used in power plants, where they will confer a great industrial benefit, there will be an inclination on the part of nations, generally, to use that power, rather than to hold it in an inactive, nonproductive form, simply as material for bombs.

As I see it, if the nations of the world feel sufficiently secure in their international relationships, they will do that very thing and use fissionable materials to generate power.

Now, you say and it has been said by others that it can be taken out and made into bombs. Certainly it can.

You can do it. But when you do that, you shut the power plants down. It can be taken out as bombs but it takes a considerable time to do it. Certainly, if it is being used in the power plants, the danger of its sudden, surprise use is remote.

Moreover, if it is in use in the power plants, it would be very difficult indeed to take it out of there and make it into bombs without its being internationally known, because you could hardly do it without disrupting the entire power situation in the country where it is being used for important industrial purposes.

Hence, I say by all means let us bring the time up when this material can be used for industrial purposes to such great advantage. That is the way it should be used, for the good of the world, and that is the natural way that people will use it, for industrial purposes.

Senator AUSTIN. May I ask a question?

The CHAIRMAN. Certainly.

Senator AUSTIN. In your statement you speak of the five points that you think the legislature ought to consider in determining the policy or declaring the policy of the country with respect to this matter.

You speak of, first, this vast machine, the physical plant, the stock pile of materials and the varied applications that have been made or can be made of the scientific aspects of the matter, the special knowledge.

You say that we should consolidate our position rather than retreat from that and that we should maintain what we have gained thus far.

The question arises in connection with your last remark, concerning the cost, the money cost to the taxpayer of performing that first function to be carried on. My question is, can that first function be carried on and continued in our economy unless we do utilize these things in an industrial way?

Can we continue, in other words, to maintain a city of 75,000 people on our pay roll, operating a huge plant such as we have at Oak Ridge and as we have at other places, though not so large; can we continue that in our economy unless we do progress to the point where the thing begins to pay for itself?

Dr. Bush. Until we arrive at the time where we can disarm internationally, with assurance and with the guaranty and the knowledge that it is going to be done by all peoples in the world, until we arrive at that time and until we arrive at the point where we have international, enforceable understandings generally, this Nation has got to retain its strength.

There is no question about that. The cost of remaining strong is going to be large. There is no question about that, either. How should that cost be distributed among the various elements?

That should be determined by the people who study that and have great, detailed knowledge of it, who can say what size Army we need, what size and nature Navy we need, and what amount of money we need to produce atomic bombs, and so on.

I cannot tell you offhand what fraction of our effort should be thus distributed on the atomic-energy angle, but I do feel sure that the plants we have at the present time should be kept operating.

Senator Austin. You do feel sure, then, that we should keep organized this very technical group of scientists, who are, at the present time, gradually separating from the organization?

Dr. Bush. Yes. That group is rather disintegrating at the present time, naturally.

I feel that we should, at the earliest possible moment, complete a proper and deliberate study of what the legislation should be.

I think we should quickly decide whether it should be in the hands of a commission, the control over this matter, rather than in the War Department, as at the present time. The War Department itself has suggested that transfer to a civilian commission and I think it is a wise step.

The Chairman. Do you feel that some of the scientists have left these projects because of "uncertainty," whatever that may mean, or because they have been working on making bombs and they are not particularly interested in that?

Dr. Bush. Why, Senator, let me answer that rather generally, because that brings up an odd situation.

I was put in a position, during the war, by the action of President Roosevelt, where I had a great deal of responsibility for keeping the scientists in the plants, enforcing the security regulations and the like.

Now, no scientist likes to be regulated in any way whatever. However, it is necessary, we all know, in time of war, to have enforceable security regulations, which do not fit well with a group of scientists.

The Chairman. But which they obey under the compulsion of war?

Dr. Bush. But which they obey under the patriotic impulse, their patriotism in time of war, and which they accepted very well indeed in this country. I am proud of them, I am proud of what they did, these scientists connected with my organization.

I think we have a right to be proud. In regard to security during this war, they did a grand job, holding things secret that should be held secret.

Nevertheless, no scientist likes to be subject to control, that is inherent in a scientist and I would not expect him to like it and he would not be a good scientist if he did.

Now, we have had a very long period of time during which the scientists in this country have voluntarily submitted to arbitrary control. The question is not whether it was too rigid at one point or another or not rigid enough. Those are details. Those controls had to be there and they were there; but they did not like them.

When the war was over, I fully expected that the scientists in this country would begin to break loose of such controls and would make a great deal of the point that they have been kept under rigid control. I have been surprised that there has been as little said on that subject as there has been. I have been surprised that the scientists not only during war patriotically submitted themselves to an organization in which they did not feel natural, but I was also surprised that, at the end of the war, so little outcry has been made about it. The scientists have done very well indeed and I am proud of them.

The CHAIRMAN. But that is one of the reasons, this release from patriotic compulsion, war compulsion. Don't you think that that is the reason why a good many of them have left?

Dr. BUSH. Yes, for that reason, of course, with the war being over. Most scientific men, engineers, and so forth, felt a great inclination to leave the development of weapons, and so forth, and get back to their normal pursuits. That is only an inclination which is natural, not only natural, but a wise one.

It is wise, because we need in this country plenty of scientists in industry to aid in reconversion. We need, also, men in the colleges to train returning veterans. Due to our manpower policies during the war, we have a decided deficit in scientists and technical manpower. The effects of this deficit in this country we will feel for many years.

There has been a natural inclination for scientists and technical men to leave war work and get back into industry and universities and that is where they should be. That disintegration, as you called it, that has extended throughout the entire range of war research and development is going on in my own organization. We are down to about 5 percent of our maximum operation.

We are carrying on a certain amount of work, primarily on medical research, on new instructions from the President, rather than having an abrupt termination. However, practically all of our work on weapons has been stopped since the war has been over.

So, of course, the men want to go back and they are correct. They should go back.

Now, in this particular field, these scientific men have done a very difficult job; it has been a hard work and they are all tired out, they want to get away from the war.

Senator RUSSELL. The scientists and the soldiers are GI Joes under the skin.

Dr. BUSH. That is right, they have the same feeling about it. The scientist, due to the nature of his training, had to serve in the laboratory rather than in the field, but they both think the same way about it.

Senator VANDENBERG. I imagine you could not compete with industry, in the scientific field, when it comes to pay?

Mr. BUSH. In the Manhattan project, under contract with some of the companies we had competition. I think there is no reason why we shouldn't be able to compete in a reasonable way.

However, I do not think that that is quite the point. I do not think that the matter of salary usually enters into it.

The CHAIRMAN. I have some more questions, but I do not want to monopolize this hearing. Do any other Senators have questions?

Senator HICKENLOOPER. I have just one question here.

The CHAIRMAN. Certainly, Senator.

Senator HICKENLOOPER. And I just wanted to ask you this, Doctor. Assume that a nation of the size and resources that we have will make promises not to use atomic power for bombs. Assume that secretly, in the minds of its leaders it intends to go right ahead and pursue a policy of making bombs.

In your mind is there, at this time, any effective control against such deception?

Dr. BUSH. At this time?

Senator HICKENLOOPER. Yes.

Dr. BUSH. At this time——

Senator HICKENLOOPER. At this time or within the reasonably near future. I mean, is there any effective control except in the sense that we might be prepared to use immediate force when we find out about it? In other words, other than force, the use of force at the present time, do you think that we can defend ourselves against a nation which might be following what might be called a dishonorable attitude, giving lip service toward peace and seemingly in conformance but secretly not?

Dr. BUSH. Well, there is nothing improper about any nation arming itself in order to maintain its security to a reasonable extent. We are doing so, other nations are doing so, and it is quite appropriate. I feel that the way in which they do it is up to the nation, that it is not our affair at the present time and should not be until they have arrived at international cleavage. There is no violation of an agreement, because none exists.

Now, if you are looking toward the future where there may be such an agreement, I would say let us approach this problem in such a way that when those agreements have been made they will be kept and not avoided.

In order to do so, let us go forward, let us make those agreements in such steps that each step will be one which the nations can and will wish to carry out.

Senator HICKENLOOPER. And that is the reason for your strong recommendation that we take this matter progressively by stages?

Dr. BUSH. Yes, sir.

Senator HICKENLOOPER. And not attempt to rush full-blown into it in the very immediate future?

Dr. BUSH. Yes, sir.

Senator HICKENLOOPER. Thank you.

Senator RUSSELL. I have just one question. It is not really a question, I will ask it merely for the purpose of my own information.

My attitude toward scientists, to use an illustration, is pretty much like the attitude of the boy living in the country going to the country doctor. He thinks the doctor can do anything.

Dr. BUSH. Some of the scientists do, too, Senator.

Senator RUSSELL. I am glad to hear that.

Now, I would like to know what are the possibilities of generating atomic energy from other elements, other than uranium.

Dr. BUSH. Well, I am not a nuclear physicist, of course, and I think that you might get better testimony on that from some other men.

My understanding on the matter is this, that the utilization of atomic energy at present can be found only among the elements at the extreme of the periodic table, primarily in the very heavy elements, such as uranium and polonium. Hence, if other elements are brought in, I think that they will also be the very rare, unusual elements that are beyond uranium in the periodic table.

Personally, from what I have learned and from what I know about it, and I have associated with these men for many years, I think it is highly improbable that atomic energy will be produced out of any such things as common materials.

Senator RUSSELL. Lead, for example.

Dr. BUSH. Lead, for example.

Senator CONNALLY. Well, they will keep on trying, will they not, scientists will keep on experimenting, will they not?

Dr. BUSH. Well, even scientists do the things that they think can probably be done.

Senator CONNALLY. That is true, but they will be trying other things, they will be working in other fields and among the other elements. Maybe they think that they will fail, but they will keep on trying.

Dr. BUSH. I think the better answer will be that I am quite sure that the efforts of scientists will be devoted to those elements that are at the extreme of the periodic table, because that is where progress can be made and where they will feel that there is a probability of success.

The CHAIRMAN. Dr. Bush, you stated in answer to Senator Johnson's question that fissionable materials are going to be made. You mean by several countries or continued in this country?

Dr. BUSH. Russia, I believe, has already stated that they will. I believe Molotov made the statement to the effect that they propose to develop atomic energy. From Great Britain there have been statements in the Commons, I believe, to the effect that the Government is developing a plan for making atomic energy available. I think, as any other country becomes economically in the position where it can undertake such a project, it will.

The CHAIRMAN. Now, Doctor, you spoke about our economic resources with reference to power in this country and how well developed they are as compared with some of the other areas of the world.

I take it that you feel—if I misunderstood you, I wish you would correct me—that it would be an unfair requirement, or shall I say an unlikely requirement, unlikely in the sense that they would not agree to it, to specify, in some kind of an international agreement which we might go into, that the peacetime use of atomic energy not be permitted?

Dr. BUSH. No. Think what you would be asking the world, Senator. In the first place, it is not the atomic bomb alone that threatens the world. Let me make that clear.

I will make it clear this way. By the use of incendiaries we wiped out great areas of the Japanese cities. The most effective of those incendiaries was developed in my organization. I knew what it could do, I knew from the studies which had been made what it could do to the Japanese cities.

The decision to use them was made by President Roosevelt, after due consideration of what it meant. It was a difficult thing to answer: Would we wreak devastation on Japan's cities, realizing that in order to wipe out the industries within those cities we were bound to kill innocent people?

We did, because only in that way could we shorten the war and save lives. At the time that that decision was made, I had a serious problem in my mind as to whether that was justified, but fortunately I did not have to make the decision myself.

I had the same question when the atomic bomb came along but to me it was not much of a question in my mind because I knew that it would end the war and save many lives.

The point I make is that it is not the atomic bomb alone that this world needs to fear. If there had not been atomic bombs, the application of science and technology had reached such a point that another great weapon——

The CHAIRMAN. For instance, bacteriological war.

Dr. BUSH. Yes. Science could produce devastation beyond thinking. We must avoid war, not just control an atomic bomb.

Now, other methods of warfare, involving incendiaries, rockets, aircraft, guided missiles, or what have you, came out. These weapons involved the entire industrialization of the Nation.

Are you going to say that no nation shall have any industrial capacity of building war materials? That, certainly, is impossible. In the same way, we are not going to say that no nation shall be industrially dependent on atomic energy.

We are going to say, rather, that all industries shall be for peaceable purposes and we will make international agreements to be sure that they do not get diverted to making war materials. I would say that would apply to atomic energy plants, as well as to any other kind of manufacturing plant or power.

The CHAIRMAN. Isn't much of what you have said based upon the feeling that it is impossible to suppress anything that is good for the health, comfort, and wealth of nations, because it goes against the very essence of human nature?

Dr. BUSH. We don't want to suppress this, gentlemen, if we could.

The science of atomic energy is in its infancy. It is probably in the stage where electricity was at the time of Faraday. Let us go back to an earlier time than that. Let us go back to when gunpowder first appeared.

When gunpowder came out, there was an attempt to outlaw it internationally. When the crossbow first appeared there was an edict of the Pope against its use in war.

Gunpowder, nevertheless, came in as an explosive. Certainly it might have been outlawed as an explosive. If that had been the case, it would have been of no good to man. Its utilization as an explosive material was merely the entering affair; it led to a vast chemical development, out of which have come all sorts of chemical industries, out of which have come a contribution to the rise of our standard of living.

In the same way, electricity came in. We can use electricity for guiding a missile from a launching platform to hit a target. But we can also use it and we do use it for communication and light; electricity has created a rise in the standard of living of the world.

In the same way, atomic energy comes in, first as an explosive. Any new thing is likely to come in the simplest, easiest way. Uncontrolled explosion is, on the whole, much easier than the controlled use for development of power.

But no man can say today where this new path may lead. If we believe that the path of expansion of knowledge, expansion of man's control over his environment, that long path—if we believe that that path is, on the whole, upward, then we must believe that this new knowledge will also take its ultimate place where it will be useful for man's purposes for good and to where we will learn to control it, for the purposes of good.

The CHAIRMAN. Doctor, to reach the objection proposed by Senator Johnson and also advanced by some of our other witnesses, that peacetime use of atomic energy in power plants complicates the problem of control, would it be possible or feasible, do you think, to have any such peacetime power plants, controlled under the United Nations Organization, to be internationally maintained with, perhaps, a stock to be owned on a basis of contributions, such as the UNRRA organization. That is, each country putting in that portion which their national income will justify for international control of these power plants, internationally inspected and internationally operated?

Dr. BUSH. It certainly would be possible, whether it would be desirable or not.

I think, myself, upon that question that, in certain places, owing to certain considerations, such as territories under trusteeship, that such an arrangement could be used to bring atomic power to remote districts, that it might be advisable.

However, I have no idea that nations that do not have power plants owned by the nations themselves would like it. I think it is necessary to avoid that. I think that that is just one feature of the whole international economy which needs a better understanding if we are to eliminate war from the world.

The CHAIRMAN. Doctor, it has been testified, or I believe there has been published, information that we are continuing to manufacture bombs. Have you any comment on that policy?

Dr. BUSH. I would make simply the comment that we are also continuing to maintain an Army, although it is rapidly becoming very small. We are continuing to maintain a Navy. We are continuing to maintain the varied elements of our armed forces for our own defense which we think necessary.

So long as we proceed down that path, to the point where we have a reasonable strength, I do not think that any nation in the world will think that we are building that strength for aggression.

I do not think, therefore, that it will interfere in any way with the procedure of coming to international understanding with other nations which are doing the same thing.

The CHAIRMAN. Doctor, this fissionable material that we are making to fabricate into bombs could be used right now, some of it, for peacetime purposes—in medicine, for example?

Dr. BUSH. No, not quite, Senator. Some of the byproducts would be useful for medicine. Just as soon as the commission is set up, I hope that it will make arrangements as rapidly as possible for getting those byproducts disseminated for medical experimentation and other scientific experimentation, but that is a byproduct.

Now, as far as the fissionable material itself that is useful for bombs, it will also ultimately be useful for power purposes, but not immediately. We need a period of time, a period for development.

Senator VANDENBURG. What do you think it is, a year, or 2 years, or what?

Dr. BUSH. The first step could be taken almost at once, and that is the development of heat for industrial purposes. I could see its being used right now for heating. For instance, it could be used for heating the buildings in Washington. We could today, I believe, let a contract to a company to change the installation we now have over to atomic energy, if we wanted to. That is a very simple step, the only problems would be problems of safety, of taking care of the radioactive materials in such a manner as to be sure that there was no danger of poisoning the population.

Senator BYRD. What about the comparable cost?

Dr. BUSH. Within a few years——

Senator BYRD. What about the comparable cost?

Dr. BUSH. I think probably today, Senator, the comparative cost, if we did it immediately, would probably be more than it would be if we waited. I don't think we would want to plunge into that tomorrow. While we could place such a contract, I think we would not. But I do think that within, oh, 3 or 4 years, as industrial companies study and work on this matter, the application of atomic energy for heating purposes will be made economically feasible in many parts of this country.

Senator JOHNSON. The water would be radioactive?

Dr. BUSH. No, not with proper precautions. That is the point I have brought in, that there has got to be ample precaution taken to control the radioactive products.

I feel quite sure that can be done and done with reasonable cost.

Now, suppose we go beyond that, suppose we go to the use of atomic energy for developing power. That is somewhat further out. How long it will take I don't know. It depends on how hard we are going to work on it. Until that time comes, of course, we have no use for fissionable material except for storage. It does not deteriorate and we can store it and, when the time comes when it can be used for generating power, it will be available for that purpose.

The CHAIRMAN. Doctor, most men in the field have had some estimate as to how long it would take other nations to get into production of fissionable materials. I suppose that estimate would have some bearing upon our sense of urgency in arriving at a system of control.

Now, what, if you would care to give it, is your best estimate? I realize it would be an estimate. What time will it take for any other nation to get into operation?

Dr. BUSH. Well, I would like to qualify my answer, in order to be clear, because conditions determine the answer to such an extent.

To take an example, Great Britain could, if it wished to throw its industrial effort into it, if they went into the thing on an all-out basis, there is no doubt that they could build and put a plant into operation in, say, 3 years.

On the other hand, I think it is highly questionable that Great Britain would wish to do it on such an accelerated basis. They might be able to do it in a year if they put wartime efforts into it—priorities and all sorts of measures taken in wartime.

I think, rather, that they would wish and choose to do it on a longer time scale, and hence more economically.

The CHAIRMAN. Of course, Great Britain would have no fear of any stock pile of atomic bombs which we might have.

Dr. BUSH. I agree with you, I do not think they would have any fear, any more than they would be afraid of our Navy and Army.

The CHAIRMAN. How about other nations?

Dr. BUSH. Well, take a nation like Russia. I think she, if she threw her full weight into it and if she imported freely those things which she does not herself manufacture adequately at the present time, then I think in 4 or 5 years she could have a plant in operation. On the other hand, if she did it relying entirely on her own resources and building those up as she proceeded, meaning by that that she would have to build plants to make the parts before she could use those parts, I think it would take them somewhat longer, it might take as long as 20 years, if she did the entire process that way.

Now again, if she wishes to accelerate the process by making it very important, all-important, in her economy and if she makes the sacrifices in her standards of living in order to accomplish it at a maximum rate, it might shorten the time somewhat. I do not think she would choose to do it that way because it would be uneconomic.

Senator TYDINGS. May I ask a question?

The CHAIRMAN. Yes.

Senator TYDINGS. Dr. Bush, have you any doubt—first, preliminary to my question, let me say this: I don't believe that it has been shown that this new government which has come into being in Russia has ever been guilty of bluffing. It has had the merit of saying it would do something and then doing it, and it has taken a very realistic approach to things. It was realistic with respect to Hitler and the German crisis.

You will remember that they did reduce the standard of living of the Russian people so far as was possible to prepare for this war, over a long period of years. It was their own program.

Now, keeping that in mind, and in view of a statement of Mr. Molotov that they would have atomic bombs "and more," is there any room for doubt that the Russians are now proceeding with all their might and main, so far as they know how? Can there be any doubt of that?

Dr. BUSH. I think it would be very doubtful, sir.

Senator TYDINGS. Why?

Dr. BUSH. At the time when Russia had her 5-year plan and when she made her sacrifices which you mentioned, she was threatened by Hitler and by the military development of Germany and she knew that she would have war.

But now, it is different. I do not believe that they feel that way now.

Senator TYDINGS. But how do you know that the Russians do not still consider themselves threatened?

Dr. BUSH. I am quite sure that the Russians do not feel that we are a threat. We do not have interests which conflict seriously. They know that we are not warlike; they know that for a fact.

If I believed that Russia feels threatened by the United States, I would despair of their realism. I think they are very realistic.

Senator TYDINGS. Do you think Molotov was just simply making conversation?

Dr. BUSH. All he said was that they were going to have atomic energy.

Senator TYDINGS. He said they would have the atomic bomb "and more."

Dr. BUSH. What are, do you think, "and more"?

Senator TYDINGS. The discovery of new weapons.

Dr. BUSH. All he said, as I got it, was, "We are going into the development of this field." That is what Russia is going to do, and I feel quite sure that they will do it well. He did not say that they were going to develop it at the maximum possible speed. I would be quite surprised if it was made a matter of such urgency, under the present circumstances.

Senator TYDINGS. You don't think it will be made a matter of urgency under the present circumstances?

Dr. BUSH. I say there is no reason whatever why they should make it such a matter of urgency, why they should sacrifice all of their other interests.

They have a great interest in restoring their economy after this war; they will be busy.

Senator TYDINGS. That is true. They also have an interest in survival, as we have.

Dr. BUSH. Let me say once more that there is a great difference between Hitler and the Germans and this country, and the Russians know it.

Senator TYDINGS. Well, if I were a Russian, I would want to proceed with all possible speed right now. I don't mean what I am saying as criticism, but I do say that if they had a bomb I would want my government to proceed.

I think they are just as human in their feeling toward their own country. They love their country, and they want to protect it.

Furthermore, I think it would be contrary to all recent Russian history if they did not try to keep abreast with all the others.

Dr. BUSH. We have to think of it as a whole. If we limit it to one factor alone, we might distort the whole picture.

For instance, there is the matter of delivery of the bomb, whether it be by airplane, guided missile, rocket, or other means, we have the problem of delivery of——

Senator TYDINGS. And the suitcase.

Dr. BUSH. Yes, although when you mention that, that brings up something I would like to comment upon.

You have the elements of war. You have the Army, the Navy, submarines—the whole power of war. The atomic bomb is one element only, a very important element and the deciding element at the end of this war, and in the future, when bombs are plentiful, if they ever are, I think it will be controlling.

Today, however, in thinking of our national defense, we don't think of atomic bombs alone, and we should not think of them alone. We think of a great many elements.

So does Russia. I believe that Russia, like ourselves, will maintain such armed forces as she will determine will be needed for her national security in a reasonable manner as to——

Senator TYDINGS. And also maintain its plant?

Dr. BUSH. Yes, as a part of that system, that is quite right.

Senator TYDINGS. And, therefore, you think that they are approaching this in a rather leisurely way?

Dr. BUSH. Not leisurely, but in the same way we are, with a determination of reasonableness.

Senator TYDINGS. I cannot imagine anything more important in the national defense, so far as Russia would be concerned, right now, than the production of atomic bombs in Russia. I say that in no spirit of criticism. If I were running Russia, knowing that one nation had this great weapon and that we did not have it, it seems to me that I would be getting on the job right away to get it. I would get it so that I could be in as strong a position as any other nation for the business of war.

To show you what I mean, I would not want to sit down in a poker game where one fellow had a royal flush and I had two deuces, three treys and a five spot——

Senator BYRD. I would ask for a another deal. You would be holding six cards.

The CHAIRMAN. Do you want to amend your hand, Senator?

Senator TYDINGS. Well, let it go.

Dr. BUSH. My point is that I don't think they will sacrifice their national economy.

Senator TYDINGS. You don't?

The CHAIRMAN. Dr. Bush, you spoke of atomic bombs as being capable of control, that they could be controlled when they came into existence and after they came into existence.

Now, we had here last week some testimony, and I believe it was Senator Tydings who brought up the example of 40 of these bombs being planted in 40 of our major cities and activated at the same time, and there was discussion of the consequent tremendous loss of lives, maybe 40,000,000 people.

Do you believe that the country could wage any war after such an event?

Dr. BUSH. I don't believe the event would occur.

The CHAIRMAN. Well, I don't think so either.

I didn't think Pearl Harbor was going to occur, but it did.

Dr. BUSH. Yes, but we don't have to believe in miracles. I can say this, that this situation is serious enough without going back into Jules Verne and Buck Rogers. I have been annoyed in recent weeks in reading some of the discussion about these possibilities. We have realistic things enough to think about, without going into the realm of fantasy.

The CHAIRMAN. I am interested in the realistic, too. What is unrealistic about carrying in an atomic bomb in sections and planting it in one city, if not in 40 cities?

Dr. BUSH. Well, thinking realistically about it, I would say that at the present time there are no atomic bombs in the world except the ones we have got, and we certainly don't intend to do it.

Now, what are you asking?

Are you asking about now or 10 years from now? I will have to know that. I want to know the conditions, the conditions of international understanding, and approach the question from that standpoint.

I think the question is without meaning at the present time because it is in regard to the future. We do not know the nature of war as it might be then, and until we do know I don't have any answer to the question, I can make no comment as to such a fantastic way of using bombs, whether it would be feasible or not.

Senator AUSTIN. But you have heard about that, about suitcases?

Dr. BUSH. I have heard about suitcases until I am tired of hearing about them.

Senator TYDINGS. Doctor, you do know that there were plenty of plans for sabotage during the war—of course, with such things as dynamite, and so on, not atomic bombs. Most of the plans were frustrated during the war because we captured the saboteurs when they landed from a submarine.

We also know about Pearl Harbor; we also know about Poland, and we also know about many similar cases throughout history.

We have got to prepare not only for this hour and this minute and the next 6 months, we have got to enlarge, imagine, and comprehend this thing not only as to what it is but as to what it will be 5, 10, or 20 years from now. We have got to lay a foundation.

Dr. BUSH. That is quite right, Senator.

Senator TYDINGS. The only thing I am interested in is this: Is it possible, in your opinion, in 5, 10, 15, or 20 years from now, assuming that a foreign nation or a group of nations intended to make war, that foreign agents, undetected, could come into this city with atomic bombs and plant those bombs and explode them simultaneously?

Dr. BUSH. You mean simply from the standpoint of not being interfered with?

Senator TYDINGS. Yes.

Dr. BUSH. Such as driving a truck across the border?

Senator TYDINGS. Yes.

Dr. BUSH. The answer is "Yes," of course.

Senator TYDINGS. Also, for instance, they could drive a submarine up the river here and carry it in on a truck into Washington?

Dr. BUSH. I think that is a little complicated; it sounds that way to me. Without going into details, however, the answer is "Yes, from a technical standpoint."

Senator TYDINGS. The point is that it could be done?

Dr. BUSH. Yes. But by the same token, it is technically possible to drive 10,000 trucks across the border, each with 10-ton bombs, and do in the same way. That is a technological thing only. It is an entirely different question, whether any nation would do such a thing—quite different.

Senator TYDINGS. Well, as the world is constituted today, perhaps it wouldn't be. I saw Germany rise again after the last war, and I am not certain that she will not rise again after this war, in spite of its disasters, and I am not certain that, in another 20 years, there will not be another Hitler to bring the world into war again.

We don't know what will happen. Maybe the stock market will be as high as it was in the 1920's and people will be more interested in gambling than in national defense.

We have to look into the future, 10, 15, or 20 years ahead. I see no reason in the world to assume that we might not have another Hitler and that he might not send his agents over here to blow us up.

Dr. BUSH. Senator, I would not want you not to look into the future, and I would not urge you not to use your imagination.

My point is simply that we have plenty enough to think about that is very definite and very realistic—enough so that we don't need to step out into some of these borderlines which seem to be, to me, more or less fantastic.

Let me say this: There has been a great deal said about a 3,000-mile high-angle rocket. In my opinion, such a thing is impossible today and will be impossible for many years.

Senator TYDINGS. But not ultimately impossible?

Dr. BUSH. I say nothing is ultimately impossible, because I do not know. But I can say with confidence that I would not know how to do it today, and I do not think that any man in the world, today, would. I am speaking about a 3,000-mile rocket.

Senator TYDINGS. What would you have said, 10 years ago, about the 100-mile buzz-bomb?

Dr. BUSH. I would have said, 10 years ago, if anybody wanted me to design a 100-mile buzz-bomb, that I could readily get people to do it.

Senator TYDINGS. What do you think will be the limit, 10 years from today, as to range?

Dr. BUSH. Buzz-bomb?

Senator TYDINGS. Yes.

Dr. BUSH. 2,000 miles.

Senator TYDINGS. 2,000. Then, what is there to stop you from putting on that rocket or buzz-bomb with a 2,000-mile range an atomic bomb?

Dr. BUSH. A buzz-bomb flies in the air; an airplane flies in the air. You can leave the crew out and you can control it by remote control. The buzz bomb can fly just as far as an airplane and carry the same load, and it is subject to all the antiaircraft interception that an airplane is subject to.

Senator TYDINGS. But there is no reason why the atomic bomb could not be put in that device?

Dr. BUSH. No, there is no reason why you could not put an atomic bomb in such a device. It could be delivered in an airplane, say, over Japan, without a crew, if somebody wanted to do that.

But the people who have been writing these things that annoy me haven't been talking about that. They have been talking about a 3,000-mile high-angle rocket, shot from one continent to another, carrying an atomic bomb and so directed as to be a precise weapon which would land exactly on a certain target, such as a city.

I say, technically, I don't think anybody in the world knows how to do such a thing, and I feel confident it will not be done for a very long period of time to come.

Senator TYDINGS. Of course, it would not take much brain power to use an aircraft carrier or some modification of an aircraft carrier and equip it with rocket-firing guns and get within 100 miles of the shore and use the atomic bomb from there, from 100 miles?

Dr. BUSH. That is what I mean when I say that we have got enough troubles, enough serious practical problems to deal with now, without letting our imagination roam.

The CHAIRMAN. Well, Dr. Bush, I read in this week's Collier's magazine an article by General Carl Spaatz of the Air Forces. I would like to have you read that article.

Dr. BUSH. That would not worry me in the slightest degree. I have just been criticizing the report of General Arnold of the Army Air Forces.

The CHAIRMAN. I wish that you would, sometime later on, comment on that article.

Senator TYDINGS. What does it say, Mr. Chairman?

The CHAIRMAN. What it says, Senator, is that the Germans, the year preceding the end of the war, were designing a rocket, and were pretty well along on it, that could carry from that continent to this continent and that would contain a warhead. They did not, of course, at that time have in mind an atomic warhead. That is my understanding of the article, at least.

Of course, I do not qualify General Spaatz as an engineer, but he has written this article in Collier's.

Dr. BUSH. If you were talking about 400 miles or 500 miles, I would say by all means. That is what the Germans did with their V–2. I would say yes, even with 2,500 miles.

But 3,000 miles? That is not just a little step beyond, it is a vastly different thing, gentlemen. I think we can leave that out of our thinking. I wish the American public would leave that out of their thinking.

Senator TYDINGS. If you were Secretary of the Navy or Chief of Staff, as Admiral King is, and had the responsibility for keeping our fleet up to par and ready for all emergencies, and you had Congress in back of you, what would there be from hindering you from taking one or more aircraft carriers and modifying them or adapting them so that they could have an equipment of guns that would fire an atomic bomb 200 or 150 or 100 miles?

Dr. BUSH. I would like to say not a gun, a rocket.

Senator TYDINGS. Whatever it might be. You could then stand off the coast out of sight and level the cities along the coast, could you not?

Dr. BUSH. Provided the country you are trying to level doesn't do anything about it.

Senator TYDINGS. But they would not know about it. We did not know about Pearl Harbor until too late.

Dr. BUSH. If I were the Secretary of the Navy, I would be sure to see that the best possible group of people, both Congress, military men, scientists, engineers, industrialists, study every angle of the armament of the Navy to see what the relative emphasis ought to be on the developments of today.

More than that, I wish that that could be done effectively and rationally and not merely service by service, because we need a national program of research and development on weapons and we have not got it at the present time.

However, whether your particular scheme would fit in that, Senator, I do not want to say.

Senator TYDINGS. Pearl Harbor made a profound impression on me, and so did the development of the atomic bomb. I don't want to be caught napping twice at the same open switch.

Senator JOHNSON. Dr. Bush, you are just about the most reassuring witness we have had. You are different from the other scientists which the committee has had; they were all gloomy scientists, and they have made these hearings virtually a chamber of horrors.

Dr. BUSH. On the other hand, please don't misunderstand me. This is a tough problem and it is going to be a long time before we have a solution to it, but I am not pessimistic.

Gentlemen, I believe the advent of the atomic bomb means the end of great wars, world wars. I hope that I am right. But it is going to take a long time and a lot of hard work to get to that consummation.

Senator JOHNSON. I possess the same kind of optimism that you have, and I believe that this new creation will stop wars.

Dr. BUSH. As General Eisenhower said, it might blackmail the world into peace.

Senator JOHNSON. I hope you are right. But, using your illustration of a few minutes ago, you said that when gunpowder came out, and the crossbow, and other weapons of war, they tried to outlaw them. On the other hand, there was the statement made with each of those weapons, as it came out, that it would be so bad that it would stop war. Well, they did not.

Dr. BUSH. There is a lot of difference, Senator. I think this is the first time we have had a new element come into it of this type.

I cannot imagine two nations, each of which had atomic bombs in quantities and in each of which the people knew all the facts and knew the world situation and in each of which the government was responsible to the people, I cannot imagine two such nations ever going to war.

Senator TYDINGS. Your imagination outstrips mine. To me it seems as if you have laid down a premise of two great nations that have all the things that go into the making of a war.

I think that we have even a longer road before us to travel than you have indicated in the control of the atomic bomb. I hope it is not so. I am really in sympathy with your objective and my only reason for asking questions is that I want to make sure that our use and consideration of this new weapon does not tie us to a state of unpreparedness.

Dr. BUSH. Right. Right. But let me repeat, as I said before, that meanwhile this Nation has got to be strong.

SENATOR TYDINGS. That is right.

Dr. BUSH. We ought to be so strong as not to threaten anyone else's security but so strong that there will be no question about our own security.

Senator HART. I do not want to ask Dr. Bush a question. I want simply to say something about him.

I learned of his wartime activities some time ago. Naturally, what I learned primarily was his activities as a scientist. I followed them somewhat and I was particularly struck all the time by the doctor's balance and his innate and continuous common sense throughout this difficult time, these difficult years which we and he have been going through.

This statement which he has produced this morning is very representative of those qualities in him. It is, as we might expect, a brief statement and I sincerely hope that it will be published in full all over the country. I have not seen anything which would be so effective as this statement, in my judgment, much more effective than this article in Collier's Weekly, the article which you referred to, Mr. Chairman.

The CHAIRMAN. I hope you understand, Senator, that I do not vouch for what General Spaatz said, but since 5,000,000 or 10,000,000 people are going to read it, it probably would be well if we could have some comment on it from Dr. Bush.

Now, Dr. Bush, General Groves in his testimony before this committee mentioned a figure of $500,000,000 a year for the operation of these plants. Have you given that matter any thought at all?

Dr. BUSH. No, sir; I haven't been into those estimates.

The CHAIRMAN. If, to take it hypothetically, if such were the figure, what part, what proportionate part do you think we should devote to further peacetime uses and what part to military uses?

Dr. BUSH. It is very hard to separate them, Senator, of course. In fact, you might say that every part of material produced would be capable ultimately of being put to commercial purposes, peaceful purposes, if the commercial development is successful, as I feel quite sure it will be.

Senator HICKENLOOPER. Mr. Chairman, may I ask a question?

The CHAIRMANS Go ahead, Senator.

Senator HICKENLOOPER. I just want to revert to a statement you made a moment ago, I believe to Senator Johnson, in which you said you could not imagine two nations where the people of the countries knew, that you could not imagine those nations going to war with each other.

With regard to your approach there, the point he was trying to raise a while ago, I think, that ultimately we would reach our final production of this bomb and there would be a time when we could relax.

Do you feel that there might come a time when the people of the country might realize the enormity of this thing and realize the potential destruction, and do you think that then, in turn, they will police their officials, if you please, to keep the heads of the governments from using this power to the destruction of people?

Dr. BUSH. Quite right.

The CHAIRMAN. Dr. Bush, do you believe that a scientifically feasible control system can be worked out?

Dr. BUSH. Scientifically, such a system could be worked out. I would go more than that. I think a practical system, a system practical and feasible, can be worked out in time, after we have gained a knowledge sufficient for the purposes of control; yes, in time.

The CHAIRMAN. In time. Well, now, if the principal nations or the United Nations were to meet in session and agree to a scientific system of control, would you not be in favor of putting it in immediately?

Dr. BUSH. I don't think I know quite what you mean.

The CHAIRMAN. Let us assume that they meet in the United Nations Organization and that they set up a commission. The commission reports with a recommendation for scientific inspection, inspection of all the countries of the world.

Dr. BUSH. For what?

The CHAIRMAN. To see whether or not there is fissionable material made and, if so, by what process and whether or not any military use was going to be made of that material. Would you not be in favor of putting it into working order immediately?

Dr. BUSH. I think that would be going rather far for a first step.

The CHAIRMAN. Well, if it could be accomplished, it would be highly desirable, would it not?

Dr. BUSH. Yes; but I imagine that there will have to be several steps. The first one might well be an agreement among the nations through the United Nations Organization to make known all the situation in regard to resources in war materials and the extent to which they are being moved, and so on.

The CHAIRMAN. To that extent you would be in favor of an agreement?

Dr. BUSH. To that step, certainly.

The CHAIRMAN. Or to all steps to a scientifically feasible inspection system?

Dr. BUSH. But an inspection system, Senator, has got to be for a purpose. There is no use talking about an inspection system in the abstract. What is the inspection system supposed to do?

I have given you one example and in that example, that case, the inspection system would be to find out the facts in regard to the distribution of the resources and raw materials and their shipments. As I say, I believe such a system could be set up and it would work effectively.

Now, if we could find another step, the next step——

The CHAIRMAN. What would be the next step?

Dr. BUSH. Specifically, it does not need an immediate setting up under the United Nations Organization of an inspection system with vague and general commitments. Rather, it means that we set up first an agreement among the nations to make certain facts known and then an inspection system to produce explicit effects—which is a very different thing.

The CHAIRMAN. Well, do you think a demonstration of the power of this thing to statesmen of this world might hasten their agreement to a completely implemented inspection system?

Dr. BUSH. No. There has been sufficient demonstration in Japan.

Senator HICKENLOOPER. In other words, the statesmen of the world know what this thing can do now.

Dr. BUSH. Of course, and so does everybody.

Senator HICKENLOOPER. We have got to the point where we have rubbed the lamp and the genie has come out and we cannot get him back into the lamp.

Dr. BUSH. That is right.

The CHAIRMAN. My point is, Doctor, whether or not you agree that we should take a lot of steps, fast, Doctor, which might be for the betterment of the future health and safety and security of the world.

Dr. BUSH. Right, but not too fast, Senator. We must adjust the burden to the means that can be employed and we should proceed with such deliberation that we can be assured that the agency we set up is successful from the outset and will continue to be successful and shall not be overburdened.

The CHAIRMAN. Dr. Bush, I want to thank you on behalf of the committee for your statement. It may be that we might ask you to come back here later.

Dr. BUSH. I would be very glad to come back any time.

The CHAIRMAN. Thank you.

There will be no session of the committee tomorrow. We will resume on Wednesday at 10 o'clock.

The hearing for today is adjourned.

(Whereupon, at 12:30 p. m., the committee adjourned until Wednesday, December 5, 1945, at 10 a. m.)

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2d Session
79TH CONGRESS

SENATE

COMMITTEE
MONOGRAPH NO. 1

ESSENTIAL INFORMATION ON ATOMIC ENERGY

(Including a Glossary and Bibliography)

SPECIAL COMMITTEE ON ATOMIC ENERGY
UNITED STATES SENATE

PURSUANT TO

S. Res. 179

A RESOLUTION CREATING A SPECIAL COMMITTEE TO INVESTIGATE PROBLEMS RELATING TO THE DEVELOPMENT, USE, AND CONTROL OF ATOMIC ENERGY

p. 32 abe

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CONTENTS

ESSENTIAL INFORMATION ON ATOMIC ENERGY

PART I. INTRODUCTION

This booklet has been compiled and published by the Senate Special Committee on Atomic Energy under the authority of Senate Resolution 179. It is intended to provide essential information about atomic energy and to furnish a factual basis for public discussions on this subject. It is printed to serve as a supplement to the committee's hearings, which are now available at small cost from the Government Printing Office.

The joint declaration made by President Truman and Prime Ministers Attlee and Mackenzie King on November 15, 1945, is included here because it is the basis of our international policy on atomic energy. In addition to this, there are presented here two scientific articles that explain in simple terms the physical theory behind the atomic bomb. The first of these articles deals also with some of the engineering problems in the atomic bomb project in the United States. It is intended principally as a condensation of the official report on this project prepared by H. D. Smyth, which is available from the Government Printing Office. The second of the articles is the official British statement, which has not been widely circulated in this country. Along with a brief history of the developments in scientific theory, this statement includes an account of an atomic bomb project which was carried on by the British Government from 1940 to 1943, when it was merged with the American project.

For reference purposes, this publication contains a glossary of scientific terms, a chronological table of important developments in nuclear physics and in the atomic bomb project, and a bibliography. For the chronology and bibliography the committee is indebted to Mr. Morris Leikind, Associate Fellow in Medicine and Biology, and a member of the staff of the General Reference and Bibliography Division of the Library of Congress. We are grateful to the Librarian of Congress, Dr. Luther H. Evans, for lending the services of Mr. Leikind.

BRIEN MCMAHON,
Chairman, Special Committee on Atomic Energy.

Following is the text of Senate Resolution 179 (79th Cong., 1st sess.), referred to above. Senate Resolution 179, creating a special committee to investigate problems relating to the development, use, and control of atomic energy, was agreed to on October 22, 1945.

Resolved, That a special committee on atomic energy to be composed of eleven Members of the Senate appointed by the President pro tempore of the Senate, of whom one shall be designated as chairman by the President pro tempore, is authorized and directed to make a full, complete, and continuing study and investigation with respect to problems relating to the development, use, and control of atomic energy. All bills and resolutions introduced in the Senate, and all bills and resolutions from the House of Representatives, proposing legislation relating to the development, use, and control of atomic energy shall be referred to the special committee. The special committee is authorized to report to the Senate at the earliest practicable date by bill or otherwise with recommendations upon any matters covered by this resolution. The existence of this committee shall terminate at the end of the Seventy-ninth Congress.

For the purposes of this resolution the committee, or any duly authorized subcommittee thereof, is authorized to hold such hearings, to sit and act at such times and places during the sessions, recesses, and adjourned periods of the Senate in the Seventy-ninth Congress, to employ such experts, and such clerical, stenographic, and other assistants, to require by subpena or otherwise the attendance of such witnesses and the production of such correspondence, books, papers, and documents, to administer such oaths, to take such testimony, and to make such expenditures, as it deems advisable. The cost of stenographic services to report such hearings shall not be in excess of 25 cents per hundred words. The expenses of the committee, which shall not exceed $25,000, shall be paid from the contingent fund of the Senate upon vouchers approved by the chairman.

PART II. TEXT OF THE AGREED DECLARATION ON ATOMIC ENERGY BY THE PRESIDENT OF THE UNITED STATES, THE PRIME MINISTER OF THE UNITED KINGDOM, AND THE PRIME MINISTER OF CANADA, ISSUED NOVEMBER 15, 1945

THE PRESIDENT OF THE UNITED STATES, THE PRIME MINISTER OF THE UNITED KINGDOM, AND THE PRIME MINISTER OF CANADA have issued the following statement:

1. We recognize that the application of recent scientific discoveries to the methods and practice of war has placed at the disposal of mankind means of destruction hitherto unknown, against which there can be no adequate military defense, and in the employment of which no single nation can in fact have a monopoly.

2. We desire to emphasize that the responsibility for devising means to insure that the new discoveries shall be used for the benefit of mankind, instead of as a means of destruction, rests not on our nations alone, but upon the whole civilized world. Nevertheless, the progress that we have made in the development and use of atomic energy demands that we take an initiative in the matter, and we have accordingly met together to consider the possibility of international action—

(*a*) to prevent the use of atomic energy for destructive purposes;

(*b*) to promote the use of recent and future advances in scientific knowledge, particularly in the utilization of atomic energy, for peaceful and humanitarian ends.

3. We are aware that the only complete protection for the civilized world from the destructive use of scientific knowledge lies in the prevention of war. No system of safeguards that can be devised will of itself provide an effective guaranty against production of atomic weapons by a nation bent on aggression. Nor can we ignore the possibility of the development of other weapons or of new methods of warfare which may constitute as great a threat to civilization as the military use of atomic energy.

4. Representing, as we do, the three countries which possess the knowledge essential to the use of atomic energy, we declare at the outset our willingness, as a first contribution, to proceed with the exchange of fundamental scientific information and the interchange of scientists and scientific literature for peaceful ends with any nation that will fully reciprocate.

5. We believe that the fruits of scientific research should be made available to all nations, and that freedom of investigation and free interchange of ideas are essential to the progress of knowledge. In pursuance of this policy, the basic scientific information essential to the development of atomic energy for peaceful purposes has already been made available to the world. It is our intention that all further information of this character that may become available from time to time shall be similarly treated. We trust that other nations will adopt the same policy, thereby creating an atmosphere of reciprocal confidence in which political agreement and cooperation will flourish.

6. We have considered the question of the disclosure of detailed information concerning the practical industrial application of atomic energy. The military exploitation of atomic energy depends, in large part, upon the same methods and processes as would be required for industrial uses.

We are not convinced that the spreading of the specialized information regarding the practical application of atomic energy, before it is possible to devise effective, reciprocal, and enforceable safeguards acceptable to all nations, would contribute to a constructive solution of the problem of the atomic bomb. On the contrary, we think it might have the opposite effect. We are, however, prepared to share, on a reciprocal basis with others of the United Nations, detailed information concerning the practical industrial application of atomic energy just as soon as effective enforceable safeguards against its use for destructive purposes can be devised.

7. In order to attain the most effective means of entirely eliminating the use of atomic energy for destructive purposes and promoting its widest use for industrial and humanitarian purposes, we are of the opinion that at the earliest practicable date a commission should be set up under the United Nations Organization to prepare recommendations for submission to the Organization.

The Commission should be instructed to proceed with the utmost dispatch and should be authorized to submit recommendations from time to time dealing with separate phases of its work.

In particular the Commission should make specific proposals—

(*a*) for extending between all nations the exchange of basic scientific information for peaceful ends;

(*b*) for control of atomic energy to the extent necessary to insure its use only for peaceful purposes;

(*c*) for the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction;

(*d*) for effective safeguards by way of inspection and other means to protect complying States against the hazards of violations and evasions.

8. The work of the Commission should proceed by separate stages, the successful completion of each one of which will develop the necessary confidence of the world before the next stage is undertaken. Specifically it is considered that the Commission might well devote its attention first to the wide exchange of scientists and scientific information, and as a second stage to the development of full knowledge concerning natural resources of raw materials.

9. Faced with the terrible realities of the application of science to destruction, every nation will realize more urgently than before the overwhelming need to maintain the rule of law among nations and to banish the scourge of war from the earth. This can only be brought about by giving wholehearted support to the United Nations Organization, and by consolidating and extending its authority, thus creating conditions of mutual trust in which all peoples will be free to devote themselves to the arts of peace. It is our firm resolve to work without reservation to achieve these ends.

HARRY S. TRUMAN,
President of the United States.

C. R. ATTLEE,
Prime Minister of the United Kingdom.

W. L. MACKENZIE KING,
Prime Minister of Canada.

THE WHITE HOUSE, THE CITY OF WASHINGTON,
November 15, 1945.

PART III. ATOMIC ENERGY: DEVELOPMENT AND APPLICATION[1]

To the familiar fields of civil, mechanical, electrical, electronic, and chemical engineering, a new one has been added by the physicists—nuclear engineering. Before the war, nuclear physics had provided practical engineers with a host of new things having peaceful uses—neutrons for cancer therapy, artificial radioactive materials for treatment of leukemia and cancer and for use in fundamental chemical studies, both in biology and in chemical industry. So important was this field of work just before the war that several large companies were considering the manufacture and sale of radioactive materials. The war interrupted this activity and placed over all nuclear research a tight secrecy restriction, but it enormously accelerated the research that resulted so dramatically in the atomic bomb.

With the war ended, we can devote our energies to active cultivation of the applications of nuclear engineering to peaceful purposes—to better ways of producing neutrons and high-energy electrons for therapy and artificial radioactive materials for all kinds of uses. Moreover, we are standing on the threshold of the era in which atomic power will be developed.

All sorts of prophecies are being made about atomic power. Some say it will come only in the very distant future and may not then be practical; others are rashly predicting automotive power from U–235 in a very few years. The wide variance in predictions comes about largely, of course, from the fact that most of the prophets have little more than a crystal ball to guide them. Whatever the prophets say, atomic energy will surely offer some of the most important engineering possibilities of the next generation.

Let us get the main points of the story in terms of answers to some simple questions.

What is atomic energy?—All energy used industrially comes either from the work done by falling water or from the combustion of fuels—coal and petroleum products, principally. In combustion of coal the atoms of carbon (C) in the coal combine with the oxygen (O) of the air to form carbon dioxide (CO_2). At the same time, energy is released in the form of heat. The facts to remember are these:

(1) The atoms involved in the process are not changed intrinsically: the carbon atom of the coal is still a carbon atom in the CO_2 of the flue gas; the oxygen atoms, likewise, are unaffected.

(2) The energy made available does not come from perceptible changes in the carbon and oxygen atoms that combine.

Now a combination of the elements of two substances without change in the elements themselves is known as a *chemical reaction,* and the energy released, as *chemical energy. Atomic energy,* on the other hand, is that associated with changes in the basic *physical*

[1] By Dr. E. U. Condon, Director of the National Bureau of Standards and Scientific Adviser to the Senate Special Committee on Atomic Energy. This article was first published in slightly different form in the Westinghouse Engineer for November 1945.

nature of the atoms. The atoms are not merely recombined, but lose their individuality. In a chemical reaction, atoms of the same kind are present before and after, as in the combustion process referred to above:

$$C+O_2 \longrightarrow CO_2$$

But in nuclear reactions, atoms are made to react in such a fundamental way that at the end of the process the atoms are not the same as those we start with. The atoms of hydrogen, for example, can be made to react with those of lithium to produce a different kind of atom; in other words a *different element*, helium: [2]

$$H^1+Li^7 \longrightarrow 2\ He^4$$

This reaction was an English discovery made in 1932. It is a process which actually occurs in the laboratory, and constitutes an atomic transformation of the kind the alchemists sought fruitlessly to achieve for centuries. It lies quite outside the scope of the classical ideas of chemistry.

The amount of energy released in the nuclear reaction of hydrogen and lithium is enormous. When by ordinary chemical reaction a molecule of CO_2 is formed, the energy released, measured in units used by the physicists, is 4.1 electron-volts. In the nuclear reaction by which hydrogen and lithium give helium, the energy released is *17,000,000 electron-volts per atom of lithium consumed*—millions of times greater, weight for weight, than the chemical energy released in the burning of coal. And so, generally, in nuclear reactions, for the weights of fuel involved, the energy released is millions of times greater than that released in chemical reactions.

Why is not atomic energy obtainable practically by "nuclear burning" of hydrogen and lithium to form helium?—The answer is furnished by comparison with coal. Coal (or any other chemical fuel) is valuable not only because of the energy release, but also because a self-maintaining fire can be made in which carbon and oxygen continue to burn. Of what use would coal be if a thousand dollars' worth of matches were needed to burn a ton of coal? That was essentially the situation with all nuclear reactions prior to discovery of the phenomenon of uranium fission in 1939.

To make hydrogen atoms react with lithium it was necessary to ionize them and accelerate them in some kind of high-voltage apparatus. Of the many atoms accelerated thus to act as "bullets," only a few struck the target, i. e., the lithium atoms, in such a way as to react. The energy used to accelerate the atoms which did not strike the target was wasted. The net result was that more energy was put into the experiment than was released. The over-all output-input ratio was less than one.

Hence from 1932 to 1939, while we knew that large energy releases were possible from many different nuclear reactions, these could be produced only in laboratory apparatus that required more energy for operation than was liberated by the nuclear reactions.

How did uranium fission change this picture?—However, as soon as the word of discovery of uranium fission reached this country from Germany in January 1939, it was at once realized by physicists that

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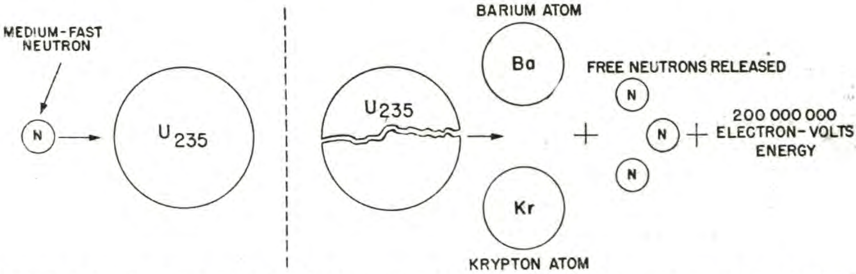
[2] In equations such as that given here the letter denotes one atom of the kind indicated by the chemical symbol and the superscript gives the rough atomic weight of the atom. This equation indicates the transformation of 1 atom of hydrogen and 1 atom of lithium into 2 atoms of helium.

the possibility of getting atomic power in useful form was within reach. But first let us say what uranium fission is. The uranium atom is the heaviest atom occurring in nature. The nucleus of a uranium atom contains 92 protons, and this nucleus is surrounded by 92 electrons. One kind of uranium nucleus, U–235, contains, in addition to the 92 protons, 143 neutrons, giving a total weight (i. e., atomic weight) of 235. (For explanations of these terms—neutron, proton, atomic weight, etc.—see the glossary). Another kind, U–238, contains 146 neutrons, raising the weight to 238. These two kinds of atoms, as well as a third rare type, U–234, are closely intermingled in ordinary uranium, with the U–238 atoms greatly predominating. When a neutron strikes the nucleus of a uranium atom in just the right way, the nucleus breaks up into two approximately equal fragments, each of which is the atom of a different element. This fission is accompanied by the release of about 200,000,000 electron-volts per atom split. Great as this is, it is no better, weight for weight, than the reaction that forms helium from hydrogen and lithium; in fact, it is only about half as great a release of energy.

The essential thing about uranium fission is that the uranium atom, as it falls apart into two more or less equal fragments, *liberates several*



Release of atomic energy depends on the phenomenon known as fission. A neutron moving with the right velocity strikes a uranium-235 atom (or plutonium atom) which breaks into two middle-size atoms whose total masses are very slightly less than the mass of the disintegrating atom. The difference appears as an enormous amount of energy, according to the Einstein law of mass and energy equivalence.

more free neutrons. Since the neutrons act as bullets hitting the uranium atom nucleus as a target, and the target itself liberates more neutrons, a self-maintaining process ensues. The splitting, in other words, requires a neutron to make it go, and the splitting process itself acts as a source of neutrons which causes more uranium atoms to split. Here we have the basis of a self-maintaining process, technically known as a *chain reaction*. A chain reaction is to nuclear reactions what ordinary combustion is to chemical reactions.

Why, then, does not ordinary uranium explode spontaneously, or at least "burn nuclearly"?—There are complications. Theoretically, when several neutrons are released at every fission, a chain reaction is possible. But to make it an actuality, one of the several neutrons released must actually produce another fission to keep the process going. Otherwise, the nuclear "fire" goes out. If all the neutrons released produced more fission, the material would explode violently. But neutrons move rather freely through matter (like X-rays) and are thus lost by escaping through the surface. The remedy is to use a big enough lump of uranium so as to get a smaller surface-to-volume ratio. If the lump is large enough to sustain an automatic chain reaction, it is said to be of the "*critical size.*" In a mass of fissionable material (pure U–235 or plutonium) of the critical size, there is a high probability that the neutrons traveling through it will smash the nuclei of other uranium atoms before escaping, thus making possible the chain reaction.

Another complication is that impurities in the uranium tend strongly to absorb neutrons. This is very difficult to remedy, for appreciable losses result from the presence of only one part per million of some materials, and it is no easy matter to manufacture anything of that purity on an industrial scale.

The worst complication of all is that uranium itself absorbs neutrons in other ways than those that produce fission. It turns out that the over-all effect of this nonfission absorption of neutrons by uranium is sufficiently great to prevent the explosion of perfectly pure uranium, even in so large a lump that escape of neutrons through the surface is negligible.

To understand this clearly, some facts about neutrons are in order. Neutrons given out in the fission process are "fast," i. e., have speeds corresponding to several million electron-volts of kinetic energy. Now fast neutrons colliding with uranium atoms are likely, because of their speed, to pass through them, losing energy in the process without being captured and without producing fission. Gradually such neutrons are slowed down to intermediate speeds, at which point they are unable to produce fission in the U–238 atoms, which constitute the overwhelming bulk of ordinary uranium. At intermediate speeds, they may produce fission in U–235 atoms, but since these make up only one one-hundred-and-fortieth part of natural uranium, it is easy to see that the neutrons released by this small group would not sustain a chain reaction amidst a large group of nonreacting atoms.

If a neutron moves about, uncaptured, until it reaches a very low energy level (about 10 electron-volts), it is likely to be captured by a U–238 atom; in this case it will not cause fission, but will change the U–238 to U–239. Two important facts stem from this phenomenon: (1) It explains the production of plutonium. More of this later. (2) It explains why a chain reaction cannot be maintained in ordinary uranium, for so many neutrons are used up in this way that an insufficient number remains to produce fission.

The clue to *possibly* setting up a chain reaction in ordinary pure metallic uranium, which contains all kinds of uranium atoms but is predominantly U–238, was to arrange the uranium in a lattice. At various regular points throughout the lattice were placed lumps of uranium; the area between was filled up with some material designed to slow up the neutrons as they came shooting out of the uranium at high speeds. Thus slowed, the neutrons would pass back into the uranium. The same process might be repeated for a given neutron over and over again. The idea was that most neutrons would thus escape being caught by U–238 until they had lost so much energy that capture by U–238 was unlikely. Ultimately, they would return to the uranium lumps and be of sufficiently reduced speed to cause fission in U–235.

In the technical vocabulary of nuclear engineering, this other material that keeps neutrons escaping from the uranium in custody and helps them lose energy until they are safe from capture by U–238 is called the *moderator*. Evidently the moderator material must not absorb too many neutrons, for if it does the reaction will be stopped. Besides the quality of not absorbing neutrons, the moderator material should have a low atomic weight. This is because the neutrons to be slowed collide elastically with the nuclei of the atoms of the moderator material, and so give up more energy at each impact if the two participants of this collision have approximately the same mass. The lower the atomic weight of a material, the closer do its nuclei come to fulfilling this condition. The nucleus of hydrogen, the element of lowest atomic weight, is a single proton which has very nearly the same mass as a neutron. From this viewpoint, ordinary water, because of its hydrogen content, would be ideal for a moderator material. Unfortunately, however, it absorbs too many neutrons. Heavy water (see glossary) does not absorb too many neutrons, but previously it was not available in sufficient quantity. Metallic beryllium is a possibility, but proved too expensive. Finally, as explained below, graphite was adopted as a moderator for the production of plutonium in the atom bomb project, although not until processes were developed for manufacturing it to much higher standards of purity than is usual in ordinary industrial practice.

As this knowledge about the qualities of uranium and the various moderators was developed, up to January 1942 the question of whether a chain reaction would really take place remained unanswered because of lack of exact measurements of the various absorptions involved. But as knowledge accumulated, it became more and more probable that such a lattice, or "pile," of uranium lumps and moderator would work, i. e., a chain reaction continuously releasing atomic energy by fission of the U–235 in it would be self-maintaining.

How can the pile be kept from blowing up?—If a pile is so arranged that, on the average, more than one fission results from the neutrons produced by each fission, then clearly the number of neutrons present and the amount of heat generated increase by the compound-interest law. If a great multiplication happens rapidly—say in a small fraction of a second—then the phenomenon becomes an explosion. In short, we have an atomic bomb. Even if the reaction occurs slowly the pile would soon be destroyed by melting if the multiplication were allowed to proceed.

One way to control the pile is to provide passageways through it into which rods of material that strongly absorb neutrons can be placed. When these rods are in, they absorb so many neutrons that the chain reaction is stopped. As these are slowly withdrawn, a point is reached at which the reaction is just able to proceed. If pulled out farther the neutrons are able to multiply more rapidly and the pile operates at a higher power level. To stop the pile the absorbing rods are simply pushed back in further. Cadmium and boron-containing steel are suitable materials for the control rods.

The language of the preceding paragraph implies that the time-scale is slow enough for an operator to maintain control by manual operation of the rods or by use of a similar slow-acting control mechanism. That is in fact the case owing to another phenomenon in the fundamental physics of fission—delayed neutrons.

It was discovered, in May 1942, that most but *not all* neutrons emitted in the fission process come out instantly. The uranium nucleus, in splitting apart, spills out some neutrons immediately, but the fragments of the split nucleus are in a highly unstable condition and some of them throw out additional neutrons after a short delay, amounting on the average to half a minute. It is the delayed neutrons that set the time scale on which the neutron multiplication in the pile builds up, and set it at such a rate that slow-acting controls are easily able to regulate the activity of the pile.

The first pile was built on the University of Chicago campus during the fall of 1942. It contained 12,400 pounds of uranium, together with a graphite moderator. The original intention was to have it spherical in shape, but as the critical dimensions proved to be smaller than the original calculations indicated, the sphere was left incomplete, giving the actual pile the shape of a large inverted doorknob.

It was first operated on December 2, 1942, at a power level of one-half watt, and on December 12 the power level was stepped up to 200 watts, but it was not allowed to go higher because of inadequate provision for shielding personnel from dangerous radiations. Further studies on piles were made by the construction of one in Tennessee designed for 1,000-kilowatt level of operation. Later a pile using heavy water instead of graphite as moderator was built.

In summary, it should be remembered that although a pile is built with ordinary uranium, it is only the 0.7 percent of the metal, that is, U–235, that is active. The U–238 which constitutes most of the metal actually tends to stop the process. Only by ingenious lattice arrangement for slowing neutrons in a moderator is the pile able to operate in spite of the presence of the more prevalent U–238.

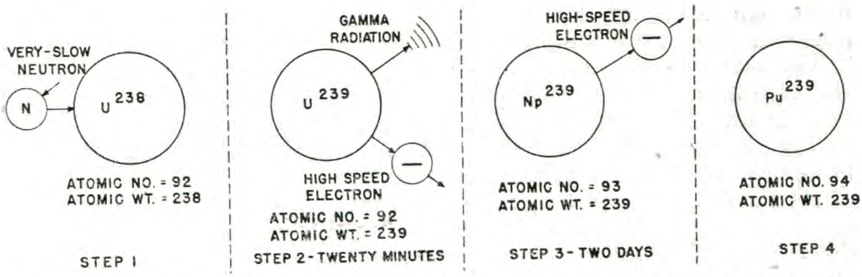
This means that, regarded as a fuel, only one one-hundred-fortieth of the total weight of uranium is being directly used; the rest is an inert material that remains largely untransformed by the pile.

How does the bomb chain reaction differ from that in the pile?—The atomic bomb explodes, whereas the reaction in the pile proceeds in a slow way easily controlled by manual operation of absorbing rods. The fundamental difference is that the bomb (one type) is made of essentially pure U–235 without the use of a moderator. The chain reaction in such a bomb is carried on by fast neutrons directly released by fission. As already remarked, this cannot happen with ordinary uranium because the U–238 slows the neutrons to a very low energy level, at which point they cannot produce fission in U–235 but are absorbed by the U–238 without producing fission. With essentially pure U–235 these competing absorption processes do not occur and the reaction is carried by the fast neutrons directly emitted from a U–235 fission. These are utilized at once to produce fission in other U–235 atoms. Here the main factors tending to stop the reaction are the loss of neutrons through the surface (which sets a minimum size to the bomb) and losses by absorption by impurities, including any remaining U–238.

What is plutonium?—This is a newly discovered chemical element made from uranium by atomic transmutation. It exists in nature, if at all, only in the minutest quantities. Plutonium is important because, like U–235, it is a material from which atomic bombs can be made.

That U–238 can capture neutrons has already been mentioned as a phenomenon detrimental to the operation of a pile. This very detriment, however, is turned to constructive purpose in the production of plutonium. When U–238 captures a neutron, it becomes U–239 and emits gamma radiations as does radium. U–239 atoms are not stable, having a mean life of only about 20 minutes, and emit high-speed electrons by a process of spontaneous radioactivity. By this activity they are transformed into atoms of essentially the same mass, but with one greater positive charge, 93, on the nucleus. Thus a new chemical element called neptunium is formed. Its symbol is Np–239.

Neptunium is also highly unstable with a mean life of only 2 days. Its atoms are spontaneously radioactive. Each atom emits a high-speed electron and by this process is transformed into an atom of a new element, plutonium, which has 94 positive charges on the nucleus, but retains the atomic weight 239. The physicist's symbol for plutonium is Pu–239.



Plutonium is made by a four-step process in which a U–238 atom absorbs a slow-moving electron. The product emits two electrons successively, resulting in a new man-made element of higher atomic number and mass than occurs in nature. Plutonium, like U–235, can break down in a chain reaction and be made to explode.

The piles erected by the Manhattan District project at Oak Ridge and Hanford were not intended to develop atomic power, but to produce the new element, *plutonium*, which provides a second material suitable for bombs. It is, in short, a competitor to U–235. The process by which plutonium is formed—capture of neutrons by U–238—tends, as previously emphasized, to stop the chain reaction in a pile. Nevertheless, the uranium lumps in the pile are exposed to a dense atmosphere of neutrons, and so the means is at hand for changing a part of the U–238 into Pu–239.

The several large piles put in operation generated heat equivalent to many hundreds of thousands of kilowatts. To utilize the heat would have required additional engineering in order to operate the pile at a high temperature, but in the atomic-bomb project there was not time for that.

A pile, when run at a high power level, also generates an enormous amount of radioactive material, far more potent than all the radium that was ever mined. To safeguard workers against the radiations from these materials, many operations must be performed by remote control. Since high standards of reliability and accuracy are essential throughout, the production of plutonium by this method becomes extremely complicated.

The plutonium is formed within the blocks of uranium inserted in the pile. These must be removed from the pile and the plutonium can then be extracted from the uranium by fairly simple chemical methods, since the two are entirely dissimilar elements.

How is U–235 separated from ordinary uranium?—In view of all the uncertainties involved in this separation, it was felt desirable to develop several methods for extracting in almost pure form the 0.7 percent of U–235 contained in ordinary uranium.

The almost complete identity of all physical and chemical properties of two isotopes of the same element—in this case U–235 and U–238—makes this a particularly difficult problem. Several methods were tried, some of which, for a variety of reasons, were abandoned. The three methods carried from the research stage into actual production were (*a*) *the mass-spectrographic method;* (*b*) *the gaseous-diffusion method; and* (*c*) *the thermal-diffusion method.*

In addition to these three, a fourth, that of separating gaseous uranium compounds in large, high-speed centrifuges, was used, but only in the original model, or pilot, plant in Tennessee. The centrifuges operated on the same principle as cream separators on a dairy farm, depending for their results on the very slight difference in the masses of the two uranium isotopes.

The *mass-spectrographic method* was developed by the physicists of the radiation laboratory at the University of California during the year 1942. By January 1943 certain industrial firms were called in to design and manufacture the essential process equipment for the large production plant at Oak Ridge, Tenn. In this method the poles of an electromagnet are enclosed in a large vacuum chamber. Uranium is introduced in the form of a volatile compound into an arc discharge which breaks the compound down and ionizes the uranium atoms.

A large potential difference between the ion source and the tank pulls these ions through a slit in the source. Instead of moving straight across the tank, the ions are caused by the ordinary electrodynamic action of a magnetic field with a current (the current being moving charged ions) to move in circular paths. But the light ions move in a path of slightly smaller radius than the heavy ions. Therefore, separate receiver boxes can be placed at the appropriate places to catch the material of each kind.

Naturally, it is not as simple as this idealized description implies. The magnetic field must be exceedingly well regulated and the ripple in the high-voltage supplies must be exceedingly small, otherwise the ions will wander and either fail to be collected or get into the wrong receiver.

An interesting sidelight of this plant is that the many tons of conductor in the exciting coils of the electromagnets were made of silver—since the Federal Government had plenty of idle silver in its monetary reserves whereas copper was a critically short material during the war.

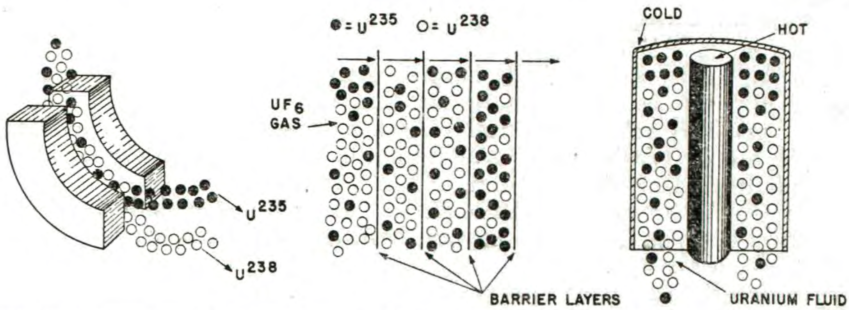
One of the most important features of the device is that the ion beam, in moving through the vacuum, ionizes some of the residual gas, providing free electrons that neutralize the space charge of the positive ion beam. This permits the use of beam currents which, although small, are nevertheless vastly greater than they would be if space charge were not neutralized. Without this feature the yield would be so low that this method in its present form would not be feasible.

The *gaseous-diffusion method* requires the use of the uranium in the form of a volatile compound, UF_6, the hexafluoride. When any mixed gas diffuses through a porous material, separation occurs because at a given temperature light molecules move more rapidly than heavy molecules. However, there is only a very slight effect at a single passage through one sheet, or "barrier," of the porous material. Therefore, it is necessary to arrange for many successive fractionations, as in fractional distillation, at each of which only a small separating effect is obtained.

The impelling force causing the gas to flow through the barrier is, of course, a pressure drop that has to be made up by recompressing the gas in preparation for leakage through the next barrier. Because of the corrosive nature of the gas, and its great value after going partly through the plant, the design of these pumps presented many difficult engineering problems.

The problem of the barriers was itself of the utmost difficulty. This called for the mass production of many acres of barrier having microscopic passages of a kind that would resist corrosion and clogging up by the process gas.

The *thermal-diffusion method* is based on application of a curious and little understood physical phenomenon occurring in liquids as well as gases. In its barest essentials, thermal diffusion is this. Suppose we have either a mixture of gases or a mixture of two mutually



The small proportion of U-235 can be separated from the predominating U-238 in several ways, none of them easy. Three have been used on a large scale, and a fourth (mechanical centrifuge) successfully passed pilot-plant tests. By the mass-spectrometer method (left) the atoms are charged and passed through a magnetic field, causing them to take separate paths. In the gaseous-diffusion method (center) the light masses pass through a little more readily than the heavy ones. In the thermal-diffusion method (right) the lighter atoms tend to separate from the heavy ones under thermal action.

soluble liquids and put them in a container that is hot in one part and cold in another—arranging matters so the material is not stirred up by convection currents. Then, after a long time, it will be found that the material in the colder part is denser than that in the warm part. A gradual variation in composition will have arisen between the cold and the hot parts of the material to accompany the range in its temperature. An equilibrium is established in which a composition gradient accompanies the temperature gradient.

This, too, is a small effect and is useful only when an arrangement is made for achieving many successive fractionations so as to build up a large resultant separation. In this method the process gas or liquid is placed in a vertical tube, within which is placed another tube kept hot by any means while the outer tube is kept cool. Thus, a radial temperature gradient exists in the process fluid. This provides a means for separation, which is enhanced by the countercurrent action due to convection as the hot fluid near the inner tube rises and the cold fluid near the outer tube descends.

By the spring of 1943, it was proved that this method could separate U–235 with an initial cost in time and money less than that of the other methods. The heat was provided by steam and the chief drawback was the enormous consumption of steam, so the thermal-diffusion plant, though relatively inexpensive to build, was rather expensive to operate.

As matters stand now, separation of U–235 from natural uranium is being done by production plants based on the three entirely different methods at the Government's reservation at Oak Ridge, Tenn.

And now the bomb!—Very little of this part of the story can be told as yet. Preliminary studies on this problem were made in 1941 and early 1942. At the end of the summer it was decided to concentrate all this work on a greatly expanded scale at a specially constructed laboratory at Los Alamos, N. Mex., about 40 miles northwest of Santa Fe. The first group of laboratory buildings, administrative buildings, homes for the personnel, and barracks for the soldier guards were built during the winter of 1942–43 and the scientific staff began to arrive and start work in April 1943. What these people achieved, starting with empty buildings on a remote mesa with only an old Diesel-driven mine generator as the laboratory power supply, thousands of miles from major industrial facilities and supplies, is an epic in the annals of science.

Although discussion of the bomb's details is not permitted, these essential points can be enumerated:

(*a*) The active material is either Pu–239 from the piles at Hanford, Wash., or U–235 from the three different separation plants at Oak Ridge, Tenn.

(*b*) A bomb less than the critical size will not explode at all, so it is not possible to experiment with little ones to learn how to make a big one.

(*c*) Before firing, the active material must be kept separated into two or more lumps, each of subcritical size. The act of firing consists of assembling these rapidly into a mass that is above critical size.

(*d*) This must be done with great rapidity, using a firing mechanism, itself a difficult problem. The need for rapidity arises from the fact that if the parts come together slowly an explosive reaction begins before the parts are completely together. This would blow them apart again and stop the fission chain reaction with only an insignificant release of the atomic energy.

(*e*) Even with the best design possible, the stopping of the reaction due to the bomb's blowing itself apart was expected to prevent the effective conversion by fission of all the material in the bomb. Some estimates placed this conversion efficiency as low as a few percent. What was actually attained at the Alamogordo, N. Mex., tests has not been disclosed to date.

(*f*) The fission products are extremely radioactive and if all of them were to remain in a relatively small area (say a square mile) the radiations would be too intense to permit the existence of any living matter in the region for probably several weeks after the explosion.

(*g*) To get maximum destructive effect from the blast the bomb is fired while at a considerable height above ground, which also favors the dispersal over a wide area of the radioactive products, so that the contamination of the area is not thought to be an important attribute of the weapon.

What of the future?—While no reputable scientist ever makes definite promises about anything that lies in the future, still it is possible to venture an opinion that the following significant developments are highly likely to be made within the coming decade:

(*a*) More effective ways of producing U–235 and Pu–239 will be developed, permitting greater production at lower cost.

(*b*) These materials, in combination with ordinary uranium, will make possible power-producing piles of smaller size than those thus far developed.

(*c*) Piles will have important peacetime uses as special-purpose energy sources, and as sources of neutrons and radioactive materials for medical and other scientific work.

(*d*) Piles will probably not be developed into small power units for automobiles or airplanes because of their over-all weight, including that of the material needed to shield the passengers from the dangerous radiations. Also, because of shielding difficulties, piles will probably not provide the driving power for railroad locomotives. However, it is reasonable to suppose that within a decade some ships may derive their power from piles.

(*e*) Although atomic energy may seem strange and mysterious, it will find its application in the power field as a source of heat. The fission chain reaction makes the pile get hot. Some heat exchanger fluid must go through the pile to get out the heat. The hot fluid will then be directly used as the working fluid in a standard heat engine; e. g., a steam turbine, possibly of special design. In other words, the pile is a new kind of boiler, and however mysterious it may seem now, it will not require a revolution in the well-known engineering practice by which heat is converted into mechanical effort and thence into electrical power.

It is known that fission may also be produced in thorium, which is much more abundant in nature than uranium, and, therefore, may be the fuel used in piles of the future. Whether release of atomic energy from other materials can be achieved is a question which can be decided only by research. At present, no means of doing this are in sight, but it should be remembered that the atomic bomb would have seemed fantastic to the best nuclear physicists in 1938. In the meantime, the most urgent problem is that of international arrangements which will assure that atomic power will be used for peaceful purposes only.

It was felt by those at Alamogordo that there was brought into being something big and something new that will prove to be immeasurably more important than the discovery of electricity or any of the other great discoveries which have so affected our existence.[3]

NOTE ON URANIUM ORES

Although uranium is contained in over 100 minerals, only two—pitchblende and carnotite—are of importance. It is estimated that uranium is present in the earth's crust in the proportion of about four parts per million. Early rough estimates were that the nuclear energy

[3] From the Smyth report.

available in known world deposits of uranium is adequate to supply the total power needs of this country for 200 years (assuming utilization of U–238 as well as U–235).

Pitchblende occurs in metalliferous veins, found in Bohemia and Saxony. More recently, deposits have been found in the Belgian Congo and the Great Bear Lake region of northern Canada. Most of the importations to this country during 1942 and 1943, the last years for which data are available, were from Canada and the Belgian Congo.

Pitchblende of good quality contains as much as 80 percent of uranoso-uranic oxide (U_3O_8). It is a brown to black ore with pitch-like luster in the form of crystallized uraninite. Madame Curie was among the first to recognize this material as a source of radium.

Carnotite, the second main source of uranium, has been discovered in Arizona, Colorado, and Utah. It is found as a canary yellow impregnation in sandstone. Production of this ore climbed steadily during the middle thirties from a low of 254 short tons in 1934 to a high of 6,256 in 1939. The actual pounds of uranium extracted from the ore produced in 1939 were 59,269. The actual extent of deposits has not been divulged.

Until recently, the only use for uranium was as a coloring agent for ceramics and glass. It was used in amber signal lenses and in glass with a special coefficient of expansion for glass-to-metal contacts in radio tubes.

PART IV. BRITISH STATEMENTS RELATING TO THE ATOMIC BOMB [1]

STATEMENTS BY PRIME MINISTER ATTLEE AND WINSTON CHURCHILL, ISSUED AUGUST 6, 1945

STATEMENT BY THE PRIME MINISTER

1. Everybody will have seen the important statements which have been made by President Truman and by Mr. Stimson, the United States Secretary for War, about the atomic bomb. The problems of the release of energy by atomic fission have been solved and an atomic bomb has been dropped on Japan by the United States Army Air Force.

2. President Truman and Mr. Stimson have described in their statements the nature and vast implications of this new discovery. Some account is now required of the part which this country has played in the remarkable scientific advances which have now come to fruition. Before the change of government Mr. Churchill had prepared the statement which follows, and I am now issuing it in the form in which he wrote it.

STATEMENT BY MR. CHURCHILL

3. By the year 1939 it had become widely recognized among scientists of many nations that the release of energy by atomic fission was a possibility. The problems which remained to be solved before this possibility could be turned into practical achievement were, however, manifold and immense, and few scientists would at that time have ventured to predict that an atomic bomb could be ready for use by 1945. Nevertheless, the potentialities of the project were so great that His Majesty's Government thought it right that research should be carried on in spite of the many competing claims on our scientific manpower. At this stage the research was carried out mainly in our universities, principally Oxford, Cambridge, London (Imperial College), Liverpool, and Birmingham. At the time of the formation of the coalition government, responsibility for coordinating the work and pressing it forward lay in the Ministry of Aircraft Production, advised by a committee of leading scientists presided over by Sir George Thomson.

4. At the same time, under the general arrangements then in force for the pooling of scientific information, there was a full interchange of ideas between the scientists carrying out this work in the United Kingdom and those in the United States.

5. Such progress was made that by the summer of 1941 Sir George Thomson's committee was able to report that, in their view, there was a reasonable chance that an atomic bomb could be produced

[1] This chapter is a reprint of a pamphlet entitled "Statements Relating to the Atomic Bomb," published by the British Government, His Majesty's Stationery Office, London, 1945. Price 4d.

before the end of the war. At the end of August 1941 Lord Cherwell, whose duty it was to keep me informed on all these and other technical developments, reported the substantial progress which was being made. The general responsibility for the scientific research carried on under the various technical committees lay with the then Lord President of the Council, Sir John Anderson. In these circumstances (having in mind also the effect of ordinary high explosive which we had recently experienced), I referred the matter on August 30, 1941, to the Chiefs of Staff Committee in the following minute:

General Ismay for Chiefs of Staff Committee.

Although personally I am quite content with the existing explosives, I feel we must not stand in the path of improvement, and I therefore think that action should be taken in the sense proposed by Lord Cherwell, and that the Cabinet Minister responsible should be Sir John Anderson.

I shall be glad to know what the Chiefs of Staff Committee think.

The Chiefs of Staff recommended immediate action with the maximum priority.

6. It was then decided to set up within the Department of Scientific and Industrial Research a special division to direct the work, and Imperial Chemical Industries, Ltd., agreed to release Mr. W. A. Akers to take charge of this Directorate, which we called, for purposes of secrecy, the Directorate of Tube Alloys. After Sir John Anderson had ceased to be Lord President and became Chancellor of the Exchequer, I asked him to continue to supervise this work, for which he has special qualifications. To advise him, there was set up under his chairmanship a consultative council composed of the president of the Royal Society, the chairman of the Scientific Advisory Committee of the Cabinet, the Secretary of the Department of Scientific and Industrial Research, and Lord Cherwell. The Minister of Aircraft Production, at that time Lord Brabazon, also served on this committee. Under the chairmanship of Mr. Akers there was also a technical committee on which sat the scientists who were directing the different sections of the work, and some others. This committee was originally composed of Sir James Chadwick, Professor Peierls, and Drs. Halban, Simon, and Slade. Later it was joined by Sir Charles Darwin and Professors Cockcroft, Oliphant, and Feather. Full use was also made of university and industrial laboratories.

7. On October 11, 1941, President Roosevelt sent me a letter suggesting that any extended efforts on this important matter might usefully be coordinated or even jointly conducted. Accordingly, all British and American efforts were joined and a number of British scientists concerned proceeded to the United States. Apart from these contacts, complete secrecy guarded all these activities and no single person was informed whose work was not indispensable to progress.

8. By the summer of 1942 this expanded program of research had confirmed with surer and broader foundations the promising forecasts which had been made a year earlier, and the time had come when a decision must be made whether or not to proceed with the construction of large-scale production plants. Meanwhile, it had become apparent from the preliminary experiments that these plants would have to be on something like the vast scale described in the American statements which have been published today.

9. Great Britain at this period was fully extended in war production and we could not afford such grave interference with the current

munitions programs on which our warlike operations depended. Moreover, Great Britain was within easy range of German bombers, and the risk of raiders from the sea or air could not be ignored. The United States, however, where parallel or similar progress had been made, was free from these dangers. The decision was therefore taken to build the full-scale production plants in America.

10. In the United States the erection of the immense plants was placed under the responsibility of Mr. Stimson, United States Secretary of War, and the American Army administration, whose wonderful work and marvelous secrecy cannot be sufficiently admired. The main practical effort and virtually the whole of its prodigious cost now fell upon the United States authorities, who were assisted by a number of British scientists. The relationship of the British and American contributions was regulated by discussion between the late President Roosevelt and myself, and a Combined Policy Committee was set up.

11. The Canadian Government, whose contribution was most valuable, provided both indispensable raw material for the project as a whole, and also necessary facilities for the work of one section of the project which has been carried out in Canada by the three Governments in partnership.

12. The smoothness with which the arrangements for cooperation which were made in 1943 have been carried into effect is a happy augury for our future relations and reflects great credit on all concerned—on the members of the Combined Policy Committee which we set up; on the enthusiasm with which our scientists and technicians gave of their best—particularly Sir James Chadwick, who gave up his work at Liverpool to serve as technical adviser to the United Kingdom members of the Policy Committee and spared no effort, and not least, on the generous spirit with which the whole United States organization welcomed our men and made it possible for them to make their contribution.

13. By God's mercy, British and American science outpaced all German efforts. These were on a considerable scale, but far behind. The possession of these powers by the Germans at any time might have altered the result of the war, and profound anxiety was felt by those who were informed. Every effort was made by our intelligence service and by the Royal Air Force to locate in Germany anything resembling the plants which were being created in the United States. In the winter of 1942–43 most gallant attacks were made in Norway on two occasions by small parties of volunteers from the British Commandos and Norwegian forces, at very heavy loss of life, upon stores of what is called heavy water, an element in one of the possible processes. The second of these two attacks was completely successful.

14. The whole burden of execution, including the setting up of the plants and many technical processes connected therewith in the practical sphere, constitutes one of the greatest triumphs of American—or indeed human—genius of which there is record. Moreover, the decision to make these enormous expenditures upon a project which, however hopefully established by American and British research, remained nevertheless a heartshaking risk, stands to the everlasting honor of President Roosevelt and his advisers.

15. It is now for Japan to realize, in the glare of the first atomic bomb which has smitten her, what the consequences will be of an

indefinite continuance of this terrible means of maintaining a rule of law in the world.

16. This revelation of the secrets of nature, long mercifully withheld from man, should arouse the most solemn reflections in the mind and conscience of every human being capable of comprehension. We must indeed pray that these awful agencies will be made to conduce to peace among the nations, and that instead of wreaking measureless havoc upon the entire globe, they may become a perennial fountain of world prosperity.

Statement by the Department of Scientific and Industrial Research, Issued August 12, 1945

I. INTRODUCTION

1. The Prime Minister has issued a statement describing the events leading up to the production, in the United States, of atomic bombs and the dropping, by the United States Army Air Force, of the first of these on Japan. Statements have also been made by President Truman and Mr. Howe. Further statements have been issued by the United States and Canadian Governments giving an account of the work carried out in their respective countries which led up to or was associated with this remarkable achievement. These supplementary statements also give an outline of the scientific background without which it is impossible to appreciate the great advance which has been made.

2. The following official statement has been prepared to fulfill a similar purpose in this country. It begins with a very brief account of the outstanding discoveries in that branch of physics known as nuclear physics, which by the year 1939 had led scientists to the belief that it should be possible to find a way of releasing atomic energy on a significant scale and under controlled conditions. It will be seen that scientists of many countries shared in this development and that the contribution of British laboratories was outstanding.

3. There follows an account of the examination of the problem in this country from the beginning of 1940 to the middle of 1941, when a scientific committee reported that there was a good chance that atomic bombs could be produced in time for use in the war. The next section of the statement deals with the organization of the work in this country and with the scope of the research programs undertaken. Reference is made to the interchange of information with the corresponding United States organization and to the decision, already referred to in the Prime Minister's statement, that full-scale plants for the production of atomic bombs should be built not in this country but in the United States of America. There is a short reference to the decision to transfer to Canada one section of the work. This was at first a joint Anglo-Canadian project, but became later, with the cooperation of the United States Government, a tripartite enterprise.

4. In the Prime Minister's statement there is a reference to the setting up in Washington, after discussions between President Roosevelt and Mr. Churchill, of a Combined Policy Committee. This committee accepted certain recommendations from its scientific advisers for a closer integration of the scientific work, which involved the transfer to United States of America and Canada of many of the

scientists working on this project in the United Kingdom. The present statement ends with a note on the effect of this on the British programs.

5. This statement is intended to be read in conjunction with the American and Canadian statements. It is, therefore, confined as far as possible to work in the United Kingdom and to the share taken by British scientists in the American and Canadian projects. Consequently no reference is made to the gigantic scale of the American scientific and technical effort, the successful outcome of which constitutes, as Mr. Churchill has already said, one of the greatest triumphs of human genius of which there is record.

II. HISTORICAL SURVEY

6. The discovery of the fission of uranium and its application in the atomic bomb is no isolated event, but follows a series of discoveries which since the end of last century have been the basis of the modern science of physics. This work has been done in many countries and is the result of full and free collaboration between scientists, among whom those working in Britain have played a most important part.

7. Classical ideas on the nature and properties of matter culminated in the atomic theory of the nineteenth century. It was accepted that all matter was made up of discrete, indestructible particles, or atoms, which were classified into 92 different species or elements. From the atoms of one or more of these elements all the different chemical compounds that exist in nature are built up. But it was regarded as a cardinal point that the atoms of any one element could in no way be changed or converted into those of another.

(*a*) *Radioactivity*

8. The fundamental break with this theory occurred when the French physicist, H. Becquerel, in 1896, discovered that one of the elements—uranium—was continuously emitting radiation of an unknown type which could penetrate matter and affected a photographic plate. Further study of this new-found property of uranium led to the isolation of another element—radium—from the uranium deposits in Joachimstal by Pierre and Marie Curie in 1898. Radium showed, to a much greater degree, this same property of emitting radiation and it was clear that the phenomenon of radioactivity, as it was called, was altogether different from those associated with normal chemical reactions between atoms. In 1902 Rutherford and Soddy, who were then working at McGill University, Montreal, suggested that it could only be explained by the assumption that the atoms of uranium, radium, and other radioactive elements which had by then been discovered, were unstable and were continuously breaking up at rates which were characteristic for each element.

9. This suggestion was conclusively proved by detailed experimental work, in the course of which the nature and properties of the radiation from radioactive elements were discovered. Part of this radiation, the so-called alpha rays, consists of helium atoms, carrying a positive charge of electricity, and these were found to be of the greatest value as a tool for further exploration of the structure of atoms.

10. It was, in fact, research on the penetration of matter by alpha rays which led Rutherford, at Manchester University in 1911, to the

fundamental discovery that the whole mass of each atom was concentrated in a minute central nucleus which carried a positive electric charge. Round this nucleus, but at relatively very great distances, revolved elementary negative electric charges—the electrons—in numbers sufficient to neutralize exactly the positive charge of the nucleus. The mass of these electrons was negligible compared with that of the nucleus. In terms of classical electromagnetic theory, however, such a system would be unstable and the energy of the revolving electrons would in a very short time be lost as radiation. Niels Bohr, of Copenhagen, put forward a theory in 1913, which combined Rutherford's model of the nuclear atom with the quantum theory of energy which had been enunciated by Planck, to explain limitations of the classical electromagnetic theory.

11. The resulting Rutherford-Bohr model of the atom proved to be of the greatest value in explaining the results of experimental work in every branch of physics and, in particular, the relationship between the different elements as regards their ordinary physical and chemical properties. These are determined entirely by the electrons revolving round the nucleus and are therefore practically independent of the mass of the nucleus. It was, therefore, immediately understood that any element, with a given charge on the nucleus, could exist in more than one modification with different atomic masses but almost identical physical and chemical properties.

12. The existence of such modifications of any element, which were known as isotopes, had first been suggested by Soddy in 1910 as a result of studies of the decay products of the natural radioactive elements. Aston, at Cambridge, followed up work, which had been started by J. J. Thomson and developed the so-called mass-spectrograph, which subjected a stream of electrically charged atoms, or ions, to a crossed electric and magnetic field and brought those of different mass to a focus at different points. It was proved, with the help of this instrument, that the great majority of elements consisted of a mixture of two or more isotopes, and that the relative weight of the atom of any given isotope of any element was very nearly a simple multiple of the weight of a hydrogen nucleus, or proton.

13. Because the isotopes of an element have almost identical chemical properties it is in general extremely difficult to separate them or even to change appreciably their relative concentration. We must take recourse to processes which depend on the nuclear mass of the atoms, making use of the difference in mass between isotopes. This difference is usually only a small fraction of the total mass. Moreover, while some of these methods, such as that used in the mass-spectrograph, are not difficult to apply, they can ordinarily deal only with very small quantities of material too small to be of much practical use. In 1932 Urey and Brickwedde of Columbia University, New York, showed that hydrogen itself is not a simple element but contains a small amount (about one five-thousandths) of an isotope known as heavy hydrogen, or deuterium, which has almost double the mass of a proton. Because, in this case, the ratio of the masses of the isotopes is as 2 to 1, the physical and chemical properties of hydrogen and deuterium are sensibly different and it was found possible to separate them, in a pure state, in large amounts by normal technical methods.

14. The atoms of nearly all the elements are stable and it is only in the case of the radioactive elements that spontaneous disintegration of the nucleus takes place. Although it was known that when this occurred energy was released, atom for atom, on a scale incomparably greater than that connected with any known chemical reaction, it was recognized to be of no practical use because the rate of decay can in no way be influenced and it was obvious that any hope of understanding the conditions which might make such influence possible would depend on an understanding of the structure of the atomic nucleus.

(*b*) *Artificial disintegration of atoms*

15. The first decisive step in the solution of this problem was taken by Rutherford who in 1919 showed experimentally that the charged alpha particles from radium–C could, in rare instances, collide with the nucleus of an atom of the common element nitrogen in such a way that it broke up and, as a result of the collision, the nuclei of two other atomic species or elements (oxygen and hydrogen) were formed.

16. While the discovery of radioactivity had shown that some of the elements could, spontaneously, break up to form other elements, Rutherford had now shown that the particles emitted in this process could be used to break up, or transmute, the atoms of other elements which were normally stable.

17. This development was pursued in the following years by Rutherford and Chadwick, who found that many other light elements could be transmuted in a similar way. In each case a proton was ejected, and generally the process of transmutation was accompanied by the release of a considerable amount of energy. It thus appeared that the proton was a common constituent of atomic nuclei and one of the fundamental particles of which matter is built up. Moreover, the release of energy in these processes was a further indication of the store of energy resident in atomic nuclei.

18. In parallel with this development, Rutherford, with Chadwick and other colleagues and students of the Cavendish Laboratory, attacked many other questions concerning the properties of atomic nuclei and their structure, laying the experimental foundations of a whole new branch of physics, now known as nuclear physics, arising from Rutherford's discoveries, first of the nature of the phenomenon of natural radioactivity; secondly, of the existence of the atomic nucleus; and thirdly, that some nuclei could be transmuted by bombardment with alpha particles.

19. A further very important step was taken here in 1932 when Cockroft and Walton carried out an experiment in which hydrogen nuclei, produced artificially in an electric discharge and accelerated to a high velocity by means of an applied voltage, were used to bombard another stable element, lithium. The atoms of this element were found to disintegrate and transmutation, the dream of the alchemists, had been achieved in a completely controlled laboratory experiment.

20. In this transmutation, and in others which followed this new discovery, the release of energy was enormous for such a minute event as a reaction involving a single nucleus. Nevertheless, the number of nuclear reactions was so small that the amount of energy generated by the reaction was extremely small compared with the total input of energy used to produce the bombarding particles. The practical value

of these nuclear reactions as a source of energy was still completely negligible.

21. The reason is not far to seek; not only are these nuclear reactions very rare events, but the reactions are not self-propagating. This is quite different from the chemical reactions with which we are familiar in our daily life, such as the combustion of coal or oil. Once started, these propagate themselves and the reactions develop and spread, involving the whole bulk of material: thus the lighting of a fire releases enough heat to ignite the neighbouring fuel, which in turn releases more heat to ignite more fuel, and so on. This is not the case for the nuclear reactions which have so far been mentioned; the particles which are formed in them are insufficient to affect neighbouring nuclei so as to maintain the reaction and propagate it. It is clear that if we wish to tap the hidden reserves of energy in atomic nuclei and put them to practical use we must find a reaction which can propagate itself; for example, a reaction in which particles are emitted of the same kind that initiated it and in sufficient numbers to affect neighbouring nuclei, which in their turn emit new particles to react with other nuclei, thus beginning a chain reaction which spreads through the whole mass.

22. It is convenient at this point to consider the form of this reserve of energy in atomic nuclei. As long ago as 1905 Einstein showed that, according to the theory of relativity, there is no essential difference between mass and energy, but that energy has mass and mass represents energy. For many years the proof that energy and mass were equivalent depended on indirect, although conclusive, evidence. The reason for this lack of immediate evidence is the extreme size of the ratio between mass and energy. A very small mass corresponds to a very large amount of energy. For example, a mass of one ounce transformed entirely into heat energy would be sufficient to convert nearly a million tons of water into steam. The fantastic size of the figure for conversion of mass to energy explains why a loss of mass has never been observed in ordinary chemical processes; the heat given off in combustion has, we believe, mass associated with it, but its amount is so small that it cannot be detected by the most sensitive balance.

23. Very striking and direct evidence for the equivalence of mass and energy was furnished by the experiments on the artificial transmutation of atoms. It was shown that in these nuclear reactions a release of energy was always accompanied by a decrease of mass and that the equivalence between mass and energy was exactly as predicted by Einstein. It thus appears that in these nuclear reactions matter is being partially converted into energy and that the reserve of energy of the atomic nucleus is hidden in the most obvious place, its own mass. There is, therefore, a store of energy resident in matter which is enormously greater than that available to us from any known chemical process. It is clear that since no such extraordinary sources are known on this earth there can be no appreciable conversion of matter into energy. On the other hand, it is now generally accepted that it is this store of energy in matter itself which maintains the heat of the sun and of other stars through a cycle of nuclear charges in which matter is converted into energy.

24. In the newly discovered reactions involving atomic nuclei rather than the outer screen of electrons, there was an enormous release of

energy of this type for each atom that was successfully bombarded. The scientific importance of the results was immense but the apparent practical value was still negligible because only one successful collision could be obtained in many thousands and the total input of energy in producing the bombarding particles was far greater than the energy release from the very few successful collisions.

25. This low efficiency is, in part, due to the very small size of the nucleus compared with that of the atom as a whole. The massive central nucleus of an atom, with its surrounding cloud of electrons, has often been compared with the sun in the planetary system and a direct collision between the bombarding particle and the nucleus, which would be needed to break up the latter, is an inherently improbable event. But when both the nucleus and the bombarding particle are positively charged there will be a force of repulsion between them which will greatly lessen the chance of a direct collision. Only particles of very high energy can overcome this force and nearly all the bombarding particles will lose their energy in collisions with the electrons surrounding the atomic nuclei before they have a chance of reaching the nucleus itself.

(c) *Discovery of the neutron*

26. In 1932 Chadwick, working in the Cavendish laboratory, made a discovery of fundamental importance. The observation was first made by Bothe and Becker in Germany that, when the element beryllium was bombarded with the alpha particles emitted by polonium—a natural radioactive element—a very penetrating radiation was emitted. Joliot and his wife, Irene Curie-Joliot, in Paris, carried these observations further and finally, as a result of detailed measurements of the masses and energies of recoil particles, Chadwick was able to prove that this apparent radiation consisted of fundamental particles which had a mass almost the same as that of a proton, but had no electric charge. These new-found particles were called neutrons, and it was at once realized that they, together with protons, were likely to be the ultimate constituents of the nuclei of atoms of all elements. The nucleus of any atom could be built up from the number of protons required to give the observed positive electric charge, together with the additional number of neutrons to bring the nuclear mass up to the observed value.

27. The discovery of the neutron was, however, of even greater practical importance in that its lack of electric charge made it an ideal projectile for carrying out nuclear transformations. The use of neutrons as a means of exploring the structure and reactions of atomic nuclei was taken up vigorously in physics laboratories throughout the world. Neutron sources could be made either by mixing radium or polonium with beryllium so as to take advantage of the nuclear reaction already mentioned or by the use of an instrument known as the cyclotron, which had been developed by E. O. Lawrence, of the University of California, Berkeley. This instrument has been of very great value in the production of high-energy beams of charged atoms or nuclei and many nuclear reactions which could be carried out with such beams were found to produce neutrons.

28. In the meantime an important contribution to the rapid advance in the new science of nuclear physics was made by Joliot and Mme. Irene Curie-Joliot, who, in 1933, showed that certain elements, which

are normally stable, undergo nuclear reactions when bombarded by alpha rays and yield new atomic nuclei which are isotopes of known elements but which are not stable and decay in the way characteristic of the natural radioactive elements. This decay was associated with the emission of beta rays, which, since the early work on radioactivity, had been recognized as being negatively charged electrons whose mass is negligible compared with those of either the proton or the neutron. In any radioactive series the emission of an electron, while leaving the atomic mass number unchanged, results in the increase, by one unit, in the net positive charge of the nucleus.

29. In 1934 E. Fermi and the school of physicists then working with him at Rome began an intensive study of the reactions produced when the nuclei of all atomic species were subjected to neutron bombardment. In the course of this work the heaviest known elements were examined and, in particular, uranium—with the atomic number 92—was subjected to neutron bombardment. The results of this work showed that new isotopes were formed which were unstable and were subject to radioactive decay. It therefore seemed that, by bombardment of the heaviest known atom with neutrons, it was possible to produce in the laboratory atoms of higher atomic number, 93 and upward, than were found in nature.

30. Further experimental work, however, led to certain difficulties in this explanation and it was found to be impossible to account for the existence, in the normal arrangement of atomic species, of the very large number of so-called transuranium elements that were discovered. At this time it was generally accepted that these new elements were all, in fact, of higher atomic number than uranium, and elaborate chemical tests had proved that they certainly could not be identified with any of the elements immediately below uranium in atomic number or weight.

(*d*) *Discovery of fission*

31. Professor O. Hahn and Dr. Strassmann, in Berlin, became interested in this problem at the end of 1938 and, from the particular point of view of their chemical nature, carefully reexamined the new elements. In January 1939 they published a most important paper in which they reported positive chemical evidence to show that one, at least, of the new isotopes which were believed to be of higher atomic number and mass than uranium was, in fact, an isotope of the element barium which has an atomic number and mass not very different from half that of uranium.

32. Immediately afterward Dr. O. Frisch and Prof. Lise Meitner pointed out that this discovery could only mean that when uranium was bombarded by neutrons a nuclear reaction took place of a kind utterly different from any so far studied and that the uranium nucleus split into two parts of roughly equal mass. This phenomenon, for which they proposed the name "nuclear fission," could be explained in terms of the theory of nuclear reactions which had been developed by Professor Bohr in the preceding years. They also pointed out that the fragments of the uranium nucleus would fly apart with great energy and this prediction was given a direct proof by experiments carried out by Dr. Frisch in Copenhagen. Confirmation of the reality of the fission process with uranium, and of the great energy release which accompanied it, was obtained by Professor Joliot in

Paris independently (and at nearly the same time) and by other physicists throughout the world as soon as the original work was known to them.

33. Very shortly afterward, in the spring of 1939, Professor Joliot and his collaborators, Drs. Halban and Kowarski, gave an experimental proof of the additional fact, which was expected on theoretical grounds, that when the fission of uranium takes place a number of free neutrons is also produced. Their first experiments showed this number to be about 3. Experiments of the same types were carried out by Drs. Anderson, Fermi, Hanstein, Szilard, and Zinn in the United States of America, and independent confirmation was obtained of the fact that more than one free neutron is produced for each fission of a uranium nucleus.

34. It was immediately recognized that this discovery was of the very greatest significance and that, for the first time, there was an experimental basis for the hope that the useful realization of the enormous store of atomic energy in matter could be achieved. Not only did the fission reaction provide the large amount of energy that was calculated from the difference in mass of the reactants and products, but the liberation of more than one new neutron each time that a uranium nucleus underwent fission made possible the continuation of the reaction by the development of a chain process, once the initial step had been taken. Such a chain process would enable the reaction, in a suitable mass of uranium, to take place at an ever-increasing rate and would involve so many atoms that there would be a sensible and, indeed, possibly an overwhelming liberation of energy. The whole process could, furthermore, be started by the application of only a minute fraction of the energy that would be liberated and the difficulty hitherto encountered in nuclear reactions of obtaining an over-all gain in energy would be eliminated.

35. It was therefore only natural that there should be an outburst of activity in most of the physics laboratories of the world with a spate of publications in the scientific press. This continued until the outbreak of war, when an increasing sense of the great potential value of this work imposed restrictions.

36. Certain important facts emerged from the work that was published during this period, and theoretical conclusions and expectations were announced, but it is hardly possible to give any strictly chronological account of them. The work was done in so many laboratories and the results, sometimes in a very preliminary form, were communicated to so many journals and published at such varying intervals after communication that details of priority cannot be clearly settled. But reference should be made to the visit which Professor Bohr paid to the United States of America from January till May 1939. He was able to report directly to American physicists the experiments carried out by Hahn, Frisch, and Meitner, and their suggested interpretation of the results. In addition, while in the United States of America, Bohr developed and published, in collaboration with Prof. J. A. Wheeler, of Princeton University, New Jersey, a theory of the fission process.

37. One important prediction which was made from this theory related to the different behavior of the various isotopes of uranium. This element consists, for much the greater part (99.3 percent), of atoms of mass number 238, but there is also an isotope (0.7 percent)

of mass 235, and a very small proportion (0.008 percent) of an isotope of mass 234. The first two, which are conveniently designated by the symbols U–238 and U–235, respectively, are the most important in connection with the uranium fission project. Bohr predicted, in February 1939, that the common isotope, U–238, would be expected to undergo fission only when the bombarding neutrons had a high energy, but that the rarer U–235 isotope would behave differently in that it would not only show this reaction with high-energy neutrons but in addition would be particularly liable to undergo fission when the energy, and therefore the velocity, of the bombarding neutrons was very low. This prediction was, in fact, confirmed in March 1940 by experiments carried out by Nier, of Minnesota, and Booth, Dunning, and Grosse of Columbia University, New York. They used a sample of uranium in which the content of U–235 had been increased above the normal value by means of Nier's mass-spectrograph.

38. It is relevant, at this point, to refer to a different phenomenon shown by the U–238 isotope when bombarded by neutrons of one rather narrowly defined energy value which is intermediate between the very high energy required to cause fission of this isotope and the very low energy which is most effective in causing fission of U–235. Neutrons which have this so-called resonance energy are very strongly absorbed by the U–238 nucleus, but fission does not follow. Instead, the new nucleus, which now has a mass number 239, emits two electrons in successive steps and is thereby converted first to an isotope of an element with atomic number 93 (for which the name, "neptunium," has been suggested) and then to one of an element with atomic number 94. This latter has provisionally been named "plutonium," and the isotope formed from U–238 after resonance capture of a neutron may be represented by the symbol Pu–239. Neptunium and plutonium are true transuranium elements of the type suggested by Fermi, and are not found in nature. Of the two, Pu–239 is of particular interest in connection with the general problem of fission and the release of atomic energy because it could be expected, from the Bohr-Wheeler theory, to show the same sort of properties as U–235 and to be capable of undergoing fission with the greatest ease when bombarded by neutrons of very low energy.

39. Reference must also be made to the fact that the three nuclear species U–235, U–238, and Pu–239 are not the only ones that can undergo fission. The two elements next below uranium in the atomic series were also shown to have this same property. Thorium, with atomic number 90 and consisting of one isotope only of atomic mass 232, behaves in the same way as U–238, and fission can only be brought about when the bombarding neutrons have very high energy. The very rare radioactive element protactinium, with atomic number 91 and atomic mass 231, behaves, as regards fission, in a manner intermediate between U–235 and U–238. These facts, again, are all explicable in terms of the Bohr-Wheeler theory, which enumerates certain general rules covering the behavior to be expected with regard to fission of any heavy nucleus, known or unknown.

(e) *Chain reaction and the atomic bomb*

40. The foregoing survey of the development of atomic and nuclear physics, though necessarily brief and incomplete, has traced the growth of the idea that there are enormous reserves of energy in all

matter; that these are of a nature quite different from those involved in chemical processes, such as the burning of coal or oil or the detonation of TNT or other explosives; and that the nuclear reactions by which they are released are more comparable to those occurring in the sun or stars or in the natural radioactive elements found on the earth.

41. While this idea has been formed and steadily strengthened since the discovery of the phenomenon of radioactivity at the end of last century, it is only since the discovery, reported at the beginning of 1939, of the special phenomenon of fission that a way has been clearly seen by which this atomic or nuclear energy in matter could be released, controlled, and put to use by man.

42. In recent years the enormous effort expended on the solution of this problem, practically all of which has been borne by the United States of America, has been concentrated on the development of an atomic bomb. Considerations of security make it impossible to disclose many of the details of this work, but in what follows some indication is given of the share in it which has been carried out in Britain. Before doing this, however, it may be worth summarizing the nature of the problems relating to the use of fission, either to produce a violent explosion or to liberate atomic energy under controlled conditions, as they appeared when the work was organized, with a new sense of its urgency and importance, at the beginning of the war.

43. It was generally accepted that a chain reaction might be obtained in uranium which would yield enormous amounts of energy. This, on a basis of equal weights, would be millions of times greater than that produced by the combustion of coal or oil. But it was realized that, if this chain reaction was to be divergent and self-sustaining, certain critical conditions must be satisfied. In the first place, the system as a whole must be of such a size that there was not too great a probability that neutrons produced in the fission process would escape from the system and so be unable to take any further part in the chain process. Secondly, the system must not contain more than a limited amount of material that would absorb neutrons and in this way, again, remove their chance of contributing to the divergent fission chain reaction. Thirdly, the fact was appreciated that, if the reaction was not to "run away," it was essential to make use of neutrons of very low energy in the individual steps of the chain process. Only then would it be possible to introduce methods which would allow the rate of development of the process to be controlled. The neutrons produced when fission occurs have very high energies, but this is dissipated as a result of elastic collisions with the nuclei of other atoms that may be present. Professor Joliot and his coworkers in Paris, Professor Fermi and other physicists in the United States of America, and Prof. Sir George Thomson and his colleagues in London, were giving thought to the possibility of using a mixture of uranium and some suitable slowing-down medium arranged in such a way that the fast neutrons produced by fission would lose their energy by elastic collisions before initiating further fission in the uranium. A suitable slowing-down medium must, above all, not have any large probability of capturing a neutron, and its atoms should be of as small mass as possible in order to get the maximum rate of loss of energy in the neutrons through elastic col-

lisions. The most suitable materials to fulfill both these conditions were heavy hydrogen or its compound, heavy water, helium, beryllium, and carbon.

44. At the beginning of 1940, Dr. Frisch and Professor Peierls, of Birmingham University, and Prof. Sir James Chadwick, of Liverpool University, independently called attention to the possibility of producing a military weapon of unprecedented power. They pointed out that the slow neutron chain reaction would not produce explosive effects much greater than those obtained with ordinary explosive, but that if a chain reaction with fast neutrons could be realized the explosive effects might be enormous. It was realized that ordinary uranium would not be suitable, for even if a fast chain reaction could be realized with it a very large quantity of metal would be required. On the other hand, the isotope U–235, if it could be separated, offered great possibilities. It seemed that the amount required to make a bomb would not be very large, certainly between 1 and 100 kilograms, and rough calculations of the energy released showed that the explosion of such a bomb might be equivalent to many thousands of tons of TNT.

45. The explosion of an atomic bomb is very different in its mechanism from the ordinary chemical explosion, for it can occur only if the quantity of U–235 is greater than a certain critical amount. This is because the reaction depends on the conservation of the neutrons produced in the fissions. In a block of pure, or nearly pure, U–235 the neutrons will either be absorbed in the mass of metal, producing new fissions, or they will escape into the outer air, thus being wasted and useless for propagating the reaction. The proportion of neutrons which escape can be reduced by increasing the size of the block of metal, since the production of neutrons is a volume effect and will, therefore, increase more rapidly with size than the loss by escape, which is a surface effect. It follows that if the explosion is possible it will require a certain minimum amount of material, which is called the critical size. The chain reaction will develop so fully that an explosion occurs only if the quantity of U–235 is greater than this critical amount. Quantities less than this are quite stable and perfectly safe. On the other hand, if the amount of material exceeds the critical size it is unstable and a reaction will develop and multiply itself with enormous rapidity, resulting in an explosion of unprecedented violence. Thus all that is necessary to detonate a bomb of U–235 is to bring together two pieces each less than the critical size, but which when in contact form an amount exceeding it.

46. If an appreciable fraction of the atoms in a mass of U–235 undergo fission within a very short time the amount of energy liberated will be so great that the mass will attain a temperature of many million degrees and a pressure of many millions of atmospheres. It will consequently expand with very great rapidity. As the density of the mass decreases the neutrons can escape more easily from it, and the chain reaction will come to an end. In order to release an appreciable fraction of the available energy, it is therefore necessary that the reaction should develop so rapidly that a substantial part of the material can react before the system has time to fly apart. The neutrons produced in the fission process are fast enough to fulfill this condition (but not if they are slowed down by artificial means as mentioned in the paragraphs above).

47. The interval of time between the beginning and the end of the nuclear reaction is exceedingly brief. In this interval the mass will have expanded so much that the nuclear reaction breaks off, owing to the escape of neutrons. During this interval a substantial part of the mass of U–235 should undergo fission, releasing a large amount of energy. If only 1 pound of U–235 is affected this release of energy will be as much as from 8,000 tons of TNT.

III. THE REALIZATION OF THE ATOMIC BOMB. BRITISH ACTIVITIES AND ORGANIZATION

(*a*) *Prof. Sir George Thomson's committee*

48. A committee of scientists, with Prof. Sir George Thomson as chairman, was set up in April 1940, originally under the Air Ministry and later under the Ministry of Aircraft Production. This committee was instructed to examine the whole problem, to coordinate work in progress, and to report, as soon as possible, whether the possibilities of producing atomic bombs during this war, and their military effect, were sufficient to justify the necessary diversion of effort for this purpose.

49. The first step to be taken was to establish the nuclear data on which depended the possibility of an atomic bomb and which determined its size. This work had already begun at Liverpool early in 1940 under Prof. Sir James Chadwick, and it was now pushed on more rapidly with Drs. Frisch and Rotblat as his senior collaborators. As the work developed and further problems appeared, it was extended to the Cavendish Laboratory, Cambridge, under Drs. Feather and Bretscher. This also had the advantage of providing an insurance against possible interruption from the effects of enemy bombing, to which the Liverpool laboratory was somewhat exposed. The many theoretical aspects of the problem were investigated by Professor Peierls, assisted by Dr. Fuchs and others. They used the experimental data provided by Liverpool and Cambridge to calculate the critical size of the bomb, they examined the mechanics of the reaction, and calculated the amount of energy likely to be released in an atomic explosion, studying the conditions for increasing the amount.

50. This was clearly only one side of the problem, for it would not have been of immediate practical use to show that an atomic bomb was feasible, provided that a certain quantity of U–235 were available, unless it could also be shown that there was a reasonable possibility of separating such a quantity of U–235 from ordinary uranium, and in a reasonable time. This aspect of the problem was also considered by the committee. In the early stages of the work not much actual experiment could be done owing to the scarcity of men and of facilities, but one method of separation was examined at Liverpool and shown to be unpromising. There are, of course, several methods available for separating isotopes on a laboratory scale. These were examined very carefully by the committee, having in mind that it was essential to select and concentrate on what was likely to be the most economical method, owing to the fact that the manpower and industrial resources of Britain were already wholly engaged on production for immediate war needs. The committee came to the conclusion that the gaseous-diffusion method was by far the most promising for large-scale production. It is based on physical principles which

have long been fully understood and which are easily amenable to calculation, and it seemed likely to make fewer demands for highly skilled precision work.

51. Research on this method of separation was taken up by a team of workers under the direction of Dr. F. E. Simon in the Clarendon Laboratory, Oxford. They were aided on the theoretical aspects by Professor Peierls and his group, and on the chemical side by Prof. W. N. Haworth and a group of men under his direction in the chemistry department, Birmingham University. The Metropolitan-Vickers Electrical Co. and Imperial Chemical Industries, Ltd., were consulted on the many technical questions which were involved. Some experimental work on the diffusion method was also started at Imperial College, London University.

52. By the early summer of 1941 the committee decided that the feasibility of a military weapon based on atomic energy was definitely established and that this weapon had unprecedented powers of destruction; that a method of producing the amounts of material required was in view; and that a fair estimate of the industrial effort needed to accomplish the project could be given. Accordingly, the committee drew up a report dated July 15, 1941, which summarized its findings and which made recommendations for the prosecution of the project on a large scale. By agreement between the Minister of Aircraft Production and the Lord President of the Council, this report was referred to the Scientific Advisory Committee of the War Cabinet, of which Lord Hankey was the chairman.

53. It is proper at this point to consider in general terms what had been done and what remained to be done. The experiments on the nuclear properties of uranium had confirmed that ordinary uranium itself would be useless for the purpose of an atomic bomb and that it would be necessary to use the isotope U–235 which is present in ordinary uranium only to the extent of 0.7 percent. They had further shown that if pure or nearly pure U–235 were available in sufficient bulk a chain reaction could develop which would result in an explosion of extreme violence. The data which had been obtained were sufficient to give an estimate of the amount of U–235 required, but this estimate was very rough and the critical size was known only to a factor of three. The theoretical work had confirmed the early result that the amount of energy released in an atomic explosion would be very large compared with the effect of ordinary bombs. Calculations had been made on the effect of "tampers" and on the best size of bomb. The method of assembly of the material for use as a weapon and the method of fuzing had been considered, but no experiments had been made. On the problem of production of this material, U–235, it had been decided to concentrate on the gaseous-diffusion method, and research and development on some aspects had shown considerable promise. A scheme had been put forward by Dr. Simon and Professor Peierls which had proceeded to the first stage of design. Leading experts of industrial firms had been consulted who had agreed that it should be possible to build a satisfactory plant, although difficulties were to be anticipated. Estimates were given for the cost of a plant to provide adequate quantities of U–235 and for the time required to build it.

54. In short, the committee was completely convinced that an atomic bomb depending on the fission of U–235 was feasible and that

its effect would be comparable with that of some thousands of tons of TNT, and that a method of separation of U–235 from ordinary uranium could be realized on a large scale so that sufficient quantities of the material could be obtained. Admittedly, a great deal of work remained to be done on all aspects of the project. More precise nuclear data were required so that, for example, the critical size could be estimated with better precision; some points needed confirmation; methods of assembly and of fuzing of the material had to be thoroughly examined. The main problem, however, was the design and construction of a plant for the production of the material, and this most essential part of the project was only in its early stages.

55. A different but important aspect of the application of the fission of uranium was also reviewed by the committee. This was the possibility, mentioned in a previous section of this statement, of finding conditions under which a mixture of uranium and some suitable slowing-down medium might give a neutron chain reaction in which the release of energy was obtained in a controlled way. This work was being carried out at Cambridge by Drs. Halban and Kowarski.

These two French pyhsicists had been sent by Professor Joliot to this country at the time of the fall of France in June 1940. They brought with them the 165 liters of heavy water—practically the whole world stock of this material—which the French Government had bought from the Norsk Hydro Co. just before the invasion of Norway. Drs. Halban and Kowarski were instructed by Professor Joliot to make every effort to get in England the necessary facilities to enable them to carry out, with the cooperation of the British Government, and in the joint interest of the Allies, a crucial experiment which had been planned in Paris and for which the heavy water had been acquired. Facilities were provided at the Cavendish Laboratory, Cambridge, and by December 1940 they produced strong evidence that in a system composed of uranium oxide (as actually used) or uranium metal with heavy water as the slowing-down medium, a divergent slow neutron fission chain reaction would be realized if the system were of sufficient size. It seemed likely that, if uranium metal were used, this critical size would involve not more than a few tons of heavy water.

56. The committee concluded that this work had great potential interest for power production but that this particular application was not likely to be developed in time for use in the war. It was, however, recognized that the slow neutron work had a bearing on the military project, for the plutonium which would be produced in such a system could be extracted chemically and might be capable of use in an atomic bomb instead of U–235. The difficulties in the way of building a slow neutron system seemed to be prohibitive at that time. In order to produce the quantities of plutonium which it was guessed, from analogy with U–235, might be required for a bomb, many tons of uranium and many tons of heavy water would have been necessary. The latter particularly would have demanded a major industrial effort.

57. During this period, April 1940 to July 1941, similar problems were occupying the minds of American scientists. Contact was maintained partly by the transmission of reports through the normal scientific liaison machine and partly by visits in both directions by scientists on general scientific missions. Professor Bainbridge, of the

National Defense Research Committee of America (NDRC), was in England in April 1941, and Professor Lauritsen (NDRC) was in England in July of the same year on general scientific matters. Both were invited to attend meetings of Sir George Thomson's committee.

(b) Directorate of Tube Alloys, DSIR

58. The Scientific Advisory Committee of the War Cabinet, of which Lord Hankey was the chairman, endorsed the view of Sir George Thomson's committee on the importance of the atomic bomb, with the result that Mr. Churchill, who had been kept informed on the developments by Lord Cherwell, asked Sir John Anderson, in September 1941, to undertake personal responsibility for the supervision of this project as one of great urgency and secrecy. To advise him he set up, under his chairmanship, a consultative council, of which the members were the chairman of the Scientific Advisory Committee of the War Cabinet (Lord Hankey and, later, Mr. R. A. Butler), the president of the Royal Society (Sir Henry Dale), the Secretary of the Department of Scientific and Industrial Research (Sir Edward Appleton), and Lord Cherwell. To insure continuity the Minister of Aircraft Production, Lord Brabazon of Tara, served on this council at the beginning.

59. The direction of the work was entrusted to a new division of the Department of Scientific and Industrial Research and thus fell under the general administrative charge of Sir Edward Appleton as Secretary of the Department. It was known, for reasons of security, as the Directorate of Tube Alloys. Mr. W. A. Akers was, at Sir John Anderson's request, released by the Board of Imperial Chemical Industries, Ltd., to act as Director, with direct access to the Minister on all questions of policy. Mr. Akers had as his deputy and principal assistant, Mr. M. W. Perrin, who was also lent by ICI. Mr. Akers was advised by a technical committee, under his chairmanship, composed of the scientists who were directing the different sections of the work and some others. The original members were Prof. Sir James Chadwick, Professor Peierls, and Drs. Halban, Simon, and Slade, with Mr. Perrin as secretary. Later it was joined by Sir Charles Darwin and Professors Cockcroft, Oliphant, and Feather.

(c) Visit of United States Mission to Britain, November 1941

60. In November 1941, at the time when the new TA (Tube Alloys) organization was set up, an American mission, composed of Professors Pegram and Urey, of Columbia University, came to this country to study the experimental and theoretical work which had been done on the TA project, to learn our ideas for future work, and to agree on arrangements for complete and rapid interchange of information. They visited all the establishments where TA work was in progress and took part in a meeting of the new TA Technical Committee at which progress was reviewed and new programs discussed.

(d) Visit of British TA Mission to United States of America, February-April 1942

61. Under the new organization a great extension of the scale of work, both in university and industrial laboratories, was started. In the United States of America, also, a greatly intensified TA effort had followed the return of Professors Pegram and Urey from England. A mission composed of Mr. Akers, Dr. Halban, Professor Peierls, and

Dr. Simon visited America at the beginning of 1942 to ensure that the programs planned for the United Kingdom were coordinated as efficiently as possible with the American work.

62. Every section of the American program was examined in detail and it was already clear that the new American TA organization intended to make the fullest use of the enormous resources available in the universities and in industry.

(*e*) *British TA program*

63. It was clear in 1942 that, even though granted very high priority, the scale upon which TA research and development could be undertaken in the United Kingdom must be far smaller than in America. A large proportion of the qualified physicists was occupied in other urgent war work and the industrial resources of Britain were engaged, at that time, in war production to a much greater extent than was the case in the United States of America.

64. Consequently it was necessary to limit the field of TA investigation. Broadly the programs chosen were:

Determination of essential nuclear physical data.

Theoretical investigations into the chain reaction in an atomic bomb, the dimensions and design of a bomb, and its blast effect.

The gaseous-diffusion U–235 separation process. This included theoretical and experimental research on the process, the design, and construction of prototype machines, the manufacture of materials needed, studies on materials of construction, etc.

Investigation of slow neutron divergent systems, especially with heavy water as the slowing-down medium.

The manufacture of uranium metal for the slow neutron systems or piles.

The manufacture of heavy water.

(*i*) *Location of work*

65. Experimental determination of nuclear physical data: The research teams at Liverpool and Cambridge Universities were considerably strengthened and small programs were started at Bristol and Manchester Universities.

Prof. Sir James Chadwick exercised general supervision over all this work.

Slow neutron systems: This work continued at Cambridge under Drs. Halban and Kowarski, with the collaboration of Dr. Bretscher.

Theoretical investigations into chain reaction, etc.: Professor Peierls and his team continued their studies at Birmingham, with collaboration on special problems with Professor Dirac, of Cambridge.

Later, when Professor Peierls moved to United States of America, Dr. A. H. Wilson led this group.

66. The gaseous-diffusion process—University research: The experimental work was under the general direction of Dr. Simon. His extended team at the Clarendon Laboratory had, as leaders, Mr. Arms and Drs. Kurti and Kuhn. The theoretical study of the process remained in the hands of Professor Peierls and his group at Birmingham. Also at Birmingham University Professor Haworth, who had been very active in TA from the days of the Thomson committee, had a group working on a number of chemical problems connected with the diffusion project.

67. Research and development in industrial establishments: The Metropolitan-Vickers Electrical Co., Ltd., accepted a contract for the design and construction of certain prototype machines embodying the principles worked out by Dr. Simon and Professor Peierls. The successful construction of these machines was a considerable technical achievement in view of the novel features contained in them. They were later abandoned in favor of a simpler design which offered certain advantages in operation.

68. Imperial Chemical Industries, Ltd. (ICI), were entrusted with the contract for the development of the diffusion plant as a whole, and the work was carried out by the Billingham division of that company. This program was a very extensive one as it covered everything involved in the design of a complete plant, including the working out of flow sheets, research on materials of construction, and the development of new types of valves, instruments, etc., to meet novel conditions.

69. In this work they were assisted by the metals division of ICI, which studied various manufacturing processes. ICI Metals, Ltd., had as subcontractors Percy Lund Humphries and Co., Ltd., and the Sun Engraving Co., Ltd., coordinated by Dr. Banks, whose services were made available by the Printing and Allied Trades Research Association. Metallization, Ltd., also made a valuable contribution to this section of the work. Processes for the manufacture of the many special chemicals required were worked out by the general chemicals division of ICI, assisted by the dyestuffs division. The Mond Nickel Co., Ltd., under a separate contract, made a very successful investigation of certain metallurgical problems.

70. Although some of these research programs will be carried on a little longer, largely in order to establish optimum conditions, ICI Billingham division has been able to close down the main program after producing flow sheets and designs for diffusion plants operating over a fairly wide range of conditions. In broad outline the plant is, of course, similar to the American diffusion plant now in operation, but it embodies certain novel features.

71. The manufacture of uranium metal: ICI (General Chemicals), Ltd., undertook the manufacture of uranium metal and succeeded in developing a satisfactory method. The conversion of the metal into rods, as required for a pile, was tackled by ICI metals division. It soon became apparent that many problems required study in connection with the physical, metallurgical, and chemical properties of the metal. Research on these points was undertaken by the National Physical Laboratory, Dr. Simon at Oxford with a subgroup at Birmingham, the British Non-Ferrous Metals Research Association, Dr. Orowan at Cambridge, and the Alkali Division of ICI.

72. Heavy water: ICI Billingham division, which had some experience in the separation of heavy water on a laboratory scale, was asked to prepare a scheme for the production of this material on a large scale. After examining various methods they reported that the most suitable process to adopt in this country, if speed of construction and certainty of operation were paramount, was the electrolytic process incorporating the vapor phase catalytic exchange principle introduced by Professor Taylor of Princeton University, United States of America. Flow sheets and designs were prepared for a plant in which the exchange system was of a novel design believed

to be simpler and more efficient than any of those hitherto used or suggested.

73. Electromagnetic method: Through the interchange of information we were aware of the remarkable development work which was being carried on at the University of California under Prof. E. O. Lawrence, with the object of converting the mass-spectrograph, used for the separation of isotopes in minute quantities, into a large-scale production apparatus, but it was decided not to start any corresponding research in this country as the physicist most suitable for this work, Professor Oliphant, of Birmingham, was engaged in other urgent war work.

74. In July 1943 it was possible to release him from that work so that it was decided to start a research program at Birmingham on this method. Before work had really started Professor Oliphant visited America in connection with discussions on a closer integration of British and American TA efforts, in which it was agreed, as described below, that the most efficient course to follow in the joint interest was for Professor Oliphant and most of his team to move to United States of America. The British electromagnetic program was therefore abandoned.

75. After Professor Oliphant's return to this country in March 1945 it was decided to arrange for research to be started on some of the electrical engineering problems involved in this type of plant. With this object research contracts have been placed with the British Thomson-Houston Co., the General Electric Co., and Metropolitan-Vickers Electrical Co. In addition, the first and last of these companies had already given considerable assistance by lending to the British TA organization the services of Dr. K. J. R. Wilkinson, Dr. T. E. Allibone, and other physicists and engineers.

(*ii*) *Coordination of programs*

76. It will be seen from the account of the diffusion plant research project that many university and industrial teams were concerned, so that proper coordination of the work became an important matter. The same applied to the work on the production of uranium metal and its metallurgy. It was also evident that some of the chemical research carried out for one project would be of interest in connection with another. To insure satisfactory coordination of the work certain committees and panels were set up.

77. The diffusion work was dealt with by the Diffusion Project Committee reporting to the TA Technical Committee. The members of this Diffusion Committee were:

Mr. W. A. Akers, Director, TA (DSIR), chairman.
Maj. K. Gordon (later Dr. G. I. Higson), ICI Billingham division. deputy chairman.
Dr. F. E. Simon, Oxford University.
Mr. H. S. Arms, Oxford University.
Prof. R. Peierls (later Dr. A. H. Wilson), Birmingham University.
Mr. J. D. Brown, ICI Billingham division.
Dr. J. B. Harding, ICI Billingham division.
Mr. C. F. Kearton, ICI Billingham division.
Mr. S. Labrow, ICI Billingham division.
Mr. J. R. Park, ICI Billingham division.
Mr. N. Elce, Metropolitan-Vickers Electrical Co.

Mr. H. Smethurst, Metropolitan-Vickers Electrical Co.
Mr. M. J. S. Clapham, ICI metals division.
Mr. S. S. Smith, ICI metals division.
Mr. M. W. Perrin, TA Directorate (DSIR), secretary.

78. The chemical research was coordinated by a panel reporting to the TA Technical Committee. The constitution of this panel was:

Prof. W. N. Haworth, Birmingham University, chairman.
Dr. R. E. Slade, ICI vice chairman.
Dr. F. E. Simon, Oxford University.
Dr. J. P. Baxter, ICI general chemical division.
Dr. J. Ferguson, ICI alkali division.
Mr. J. R. Park, ICI Billingham division.
Mr. M. W. Perrin, TA Directorate (DSIR), secretary.

79. Uranium metal production and metallurgical matters were handled by a Metal Panel, whose members were:

Mr. E. Colbeck, ICI alkali division, chairman.
Dr. W. O. Alexander, ICI metals division.
Dr. N. P. Allen, National Physical Laboratory.
Mr. G. L. Bailey, British Non-Ferrous Metals Research Association.
Dr. A. M. Roberts, ICI general chemicals division.
Dr. F. E. Simon, Oxford University.
Mr. D. C. G. Gattiker, TA Directorate (DSIR), secretary.

(*iii*) *Research Contracts. Patents.*

80. The contracts under which research is carried on in university laboratories contain clauses reserving exclusively to the Government all discoveries, inventions, and other results arising from the work. In the case of researches carried on by industrial firms all results, inventions, and developments in detail applicable within the TA field become exclusively the property of the Government. Where an invention is also usable outside the TA field provision has been made whereby its use outside the field can be made available to industry. It is within the discretion of the Government to decide whether or not a particular use is within or without the field. Questions relating to inventions and patents are dealt with by a small Patents Committee composed of:

Mr. A. Blok, DSIR, chairman.
Mr. W. A. Akers, Director TA (DSIR).
Mr. M. W. Perrin, TA Directorate (DSIR).

(*f*) *Joint British-Canadian-American slow neutron project in Canada*

81. Toward the end of 1942 it was decided that the slow neutron research in progress at Cambridge would proceed more quickly and efficiently if it were transferred to a place geographically nearer to Chicago where the corresponding American work was being carried out.

82. A proposal was made to the Canadian Government that a joint British-Canadian research establishment should be set up in Canada to work in close touch with the American group. The Canadian Government welcomed the suggestion, with the result that at the beginning of 1943 a large research establishment was set up in Montreal under the general direction of the National Research Council of Canada.

83. Practically the whole of the Cambridge group, under Dr. Halban, was moved to Montreal where the research staff was rapidly

augmented by many Canadian scientists, several new recruits from the United Kingdom, and a certain number from the United States. The laboratory was at first directed by Dr. Halban. He resigned this position early in 1944 and Prof. J. D. Cockcroft was appointed to succeed him.

84. During the spring of 1944 the Americans joined actively in that project which now became a joint British-Canadian-American enterprise. Its scope was enlarged and in 1944 a site was selected on the Ottawa River, near Petawawa, Ontario, for the construction of a pilot scale pile using heavy water supplied by the United States Government as the slowing-down medium.

85. This joint enterprise in Canada has been described more fully in statements issued by the Canadian Government. It represents a great contribution, both in men and money, by that Government to the development of this new branch of science and its application.

(g) Transfer of British TA research groups to United States of America

86. In August 1943 Sir John Anderson visited America and discussed with the United States authorities the means by which the cooperation between the two countries might best be placed upon a more formal basis. Further discussions took place subsequently between President Roosevelt and Mr. Churchill which led to the setting up of a Combined Policy Committee in Washington.

87. Prof. Sir James Chadwick, who was appointed scientific adviser to the British members of this committee, examined, with those responsible for the scientific and technical direction of the American project, the question whether there were any further steps which could be taken in the pooling of scientific and technical effort which would accelerate the production of atomic bombs in the United States of America.

88. As a result of these discussions it was decided to move to America a large number of the scientists working in England on TA in order that they might work in the appropriate American groups.

89. At this time Professor Bohr escaped from Denmark and the British Government appointed him as an adviser on scientific matters. His scientific advice on the TA project has been available both in this country and in the United States to the two Governments.

90. Professor Oliphant and his team from Birmingham University were moved to Berkeley to work with Professor Lawrence's group engaged in research on the electromagnetic isotope separation project. They were joined by other physicists from Britain, including Professor Massey of University College, London; Dr. T. E. Allibone, and Dr. K. J. R. Wilkinson, who worked partly at Berkeley and partly at the electromagnetic separation plant itself. Dr. Emeleus of Imperial College, London; Dr. J. P. Baxter, and others were transferred to the electromagnetic plant. Dr. Frisch, from the Liverpool nuclear physics group, and Dr. Bretscher, from the corresponding Cambridge section, together with some members of their teams, were moved into the great American TA research establishment at Los Alamos, which is described in American statements on the project. They were joined, at that time or later, by a number of other British scientists including Professor Peierls and Dr. Penney, of Imperial College, London University. Prof. Sir Geoffrey Taylor also paid several visits to this establishment.

91. The effect of these transfers and others which were made to the Montreal project was to close down entirely all work in the United Kingdom on the electromagnetic process and to reduce almost to nothing the nuclear physical research. Nevertheless, there is no doubt that this was the proper course to follow, in the light of the decision which had been taken to give the highest priority to the production in the shortest possible time of an atomic bomb for use in this war.

PART V. CHRONOLOGICAL TABLE: DEVELOPMENTS IN NUCLEAR PHYSICS AND IN THE ATOMIC BOMB PROJECT

Ca. 400 B. C. Democritus, a Greek philosopher, one of the first to propose an atomic theory.

79 B. C. Lucretius, Roman philosopher, expounds an atomic theory in De Rerum Natura, the greatest philosophical poem of all times.

The atomic theory persisted in the writings of speculative philosophers for many centuries until the time of John Dalton (British), when it first appeared in a form useful to the growing science of experimental chemistry.

1789. M. H. Klaproth (German) isolates from pitchblende a "half-metallic substance" which he named uranium after the planet Uranus, which had recently (1781) been discovered.

1803. Dalton expresses theory that all chemical elements are made of atoms.

1811. Avogadro (Italian) distinguishes between atoms and molecules.

1816. Prout (British) voices hypothesis that all elements are simply various combinations of hydrogen atoms.

1859. Bunsen and Kirchhoff (German) develop spectroscope as an instrument for analyzing light and for studying the chemical composition of incandescent gases.

1871. Mendeleeff (Russian) and Meyer (German) independently develop the periodic table of the elements.

1891. G. J. Stoney (Irish) coins name, "electron," for the elementary particles of electricity.

1895. W. C. Röntgen (German) discovers X-rays.

1896. H. Becquerel (French) discovers phenomenon of radioactivity in uranium ores.

1896. J. J. Thomson (British) studies deflection of cathode rays by a magnet and concludes these rays are actually streams of discrete particles of negative electricity, thus giving evidence for the physical reality of Stoney's electrons.

1897. Rutherford (British) studies radiations from uranium after Becquerel's discovery of radioactivity and designates three types of rays—*alpha*, *beta*, and *gamma* rays.

1898. Marie and Pierre Curie (Polish-French) discover radium and polonium.

1900. Planck (German) announces the quantum theory that energy manifests itself in discrete amounts called quanta.

Elster, Geitel (German), and Wilson (British) show that a closed ionization chamber demonstrates weak but persistent conductivity. Wilson suggests ionization might be due to radiation coming from outside the earth's atmosphere.

1905. Einstein (German) publishes his "special theory of relativity" which includes the famous equation $E=Mc^2$ for the equivalence of energy and mass.

1906. Rutherford and Geiger develop the first electrical instrument for counting alpha particles. This became, through successive refinements, the Geiger counter for detecting atomic particles of various kinds. It is one of the most powerful observing and measuring instruments in the physical sciences.

1910. Millikan (American) begins his classical experiments to measure the exact charge of the electron.

The possibility of isotopes, atoms with different weights but identical chemical properties, is suggested by Soddy.

1911. Rutherford proposes theory of the nuclear atom with its mass and positive charge at its center.

Barkla (British) finds number of electrons on outside of atom by studies on scattering of X-rays.

1912. C. T. R. Wilson (British) devises the modern form of cloud expansion chamber for the visible study of ionized particles. This is another fundamental tool of the nuclear physicist.

Laue, Friedrich, and Knipping (German) demonstrate X-ray diffraction by crystals.

W. H. and W. L. Bragg (father and son, British) develop X-ray spectrometer using crystals as diffraction gratings.

1913. F. Soddy, K. Fajans, and A. S. Russell independently explain laws of radioactive disintegration.

Niels Bohr (Danish) devises model of atom with central nucleus and electrons rotating in orbits about it.

Moseley (British) establishes atomic numbers of the elements through studies of their X-ray spectra.

1915. Einstein announces his general theory of relativity.

1919. Rutherford changes nitrogen into oxygen by bombarding atomic nuclei with alpha particles. This was the first artificial transmutation of an element in history.

1919–32. F. W. Aston (British) devises the mass-spectograph and uses it to measure the atomic weights of the isotopes of most chemical elements.

1920. Aston measures the atomic weight of hydrogen with the mass-spectrograph and Harkins (American) suggests the existence of an atomic particle with zero electric charge. He uses the name "neutron" for it.

1922. Boron, fluorine, sodium, aluminum, and phosphorus are artificially disintegrated by Rutherford and Chadwick.

Millikan and his collaborators begin their studies on cosmic rays.

1924. DeBroglie (French) starts quantum mechanics by suggesting existence of waves associated with particles.

1927. Davisson and Germer (American) show that beams of electrons can behave as if they were waves. Their experimental results were in good agreement with DeBroglie's equations.

1929. G. Gamow (Russian), R. W. Gurney (British), and E. U. Condon (American) show that the laws of radioactivity are explained in terms of quantum mechanical behavior of particles in the nucleus.

1930. The positron, a particle of positive electricity, is predicted from theoretical consideration by P. A. M. Dirac.

1931. W. M. Latimer, H. C. Urey, H. L. Johnson, R. T. Birge, and D. H. Menzel (American) construct table of isotopes and predict existence of unknown isotopes. Many of these have already been discovered.

E. O. Lawrence (American) invents the cyclotron.

1932. H. C. Urey, F. Brickwedde, and Murphy (American) discover heavy hydrogen (deuterium).

J. Chadwick (British) discovers the neutron.

C. D. Anderson (American) discovers positron resulting from passage of cosmic rays through matter.

J. D. Cockcroft and E. T. S. Walton (British) find mass converted to energy when the lithium nucleus is bombarded with artificially accelerated protons.

1933. Chadwick, Blackett, and Occhialini demonstrate production of positrons through bombardment of matter with gamma rays.

Van de Graff (American) designs electrostatic generator to produce up to 10,000,000 volts.

C. C. Lauritsen uses million-volt X-ray tube for atomic studies.

1934. E. Fermi (Italian) bombards uranium with slow neutrons and creates new element with atomic number 93.

Irene Curie and F. Joliot (French) produce artificial radioactivity.

1935. Dempster (American) discovers uranium-235.

1939. O. Hahn and F. Strassmann (German) bombard uranium with neutrons and find barium and krypton among the fragments of the uranium nuclei.

Lise Meitner and O. Frisch (German) propose theory that this splitting of the uranium atom, to which they gave the name "fission," is accompanied by the release of enormous quantities of energy.

Frisch and Joliot independently and almost simultaneously demonstrate experimentally that large amounts of energy are actually released as a result of uranium fission.

Bohr and Wheeler present early comprehensive theory of nuclear fission. Bohr suggests that uranium-235 undergoes fission.

Meitner studies fission in thorium.

Several American laboratories (Columbia, Johns Hopkins, Carnegie Institution, and California) confirm fission experiments.

Possibility of military uses of energy released by fissionable materials envisaged by L. Szilard, E. Fermi, E. Wigner, and others.

In fall of 1939, Alexander Sachs transmits a letter from Einstein to President Roosevelt suggesting that work on fission be encouraged.

President Roosevelt appoints Advisory Committee on Uranium.

1940. National Defense Research Committee organizes and takes over uranium research project.

Two new elements, neptunium and plutonium, are created and quantity production becomes a definite possibility.

Nier, of Minnesota, and Dunning, of Columbia, independently confirm Bohr's prediction of the fissionability of uranium-235.

1941. Possibilities of using plutonium for a bomb were investigated.

Office of Scientific Research and Development takes over uranium project.

1942. August 13. The Manhattan District of United States Army, Corps of Engineers, is established for the production of atomic bombs.

December 2. The first self-maintaining nuclear chain reaction is put into operation on the campus of the University of Chicago.

1943. April. Laboratory for bomb research opened at Los Alamos, N. Mex.

1945. July 16. The first experimental atomic bomb is successfully exploded in New Mexico.

August 6. The first military atomic bomb is dropped on Hiroshima in Japan.

August 6. President Truman issues first announcement on the use of the bomb.

August 8. Second atomic bomb dropped on Nagasaki.

August 11–12. Official report, "Atomic Energy for Military Purposes," by H. D. Smyth, is released to the public.

October 3. President Truman sends message to Congress recommending legislation for domestic control of atomic energy.

November 15. Declaration on atomic energy issued by President Truman and Prime Minister Attlee and Mackenzie King.

December 27. Moscow Agreement announced.

1946. January 24. United Nations Atomic Energy Commission is created.

PART VI. GLOSSARY: SCIENTIFIC TERMS RELATING TO ATOMIC ENERGY

Alpha-particle, a positively charged particle emitted by certain naturally radioactive substances like uranium and radium. The alpha-particle has been found to be identical with the helium atom nucleus, which consists of two protons and two neutrons.

Atom, the smallest unit of which a chemical element is built. The simplest atoms are those of hydrogen; the most complex, those of uranium. The word is derived from the Greek and means "an uncuttable thing," which makes the name rather ill adapted to an age of atom smashing and reflects the older view that atoms are fundamental, indestructible things in nature.

History.—Some suggestions that matter is made of atoms occur in the writings of the ancient Greeks and Romans, especially Democritus and Lucretius. A scientific approach waited upon the work of John Dalton, British chemist, about 150 years ago. He developed an atomic theory on the basis of known facts about the composition of chemical compounds and first arrived at an understanding of the relative weights of the better-known elements.

In the middle of the nineteenth century, a Russian chemist, Mendeleeff, discovered that when the elements are arranged in a scale ordered according to their atomic weights, elements with similar characteristics appear at regular intervals in the scale. This arrangement of the elements is known as the periodic system of the elements. It first led men to the realization that an atom of any element must be built on a pattern which partially repeats itself in other elements of similar chemical properties.

Toward the end of the nineteenth century, especially as a result of the work of Faraday (British) and Arrhenius (Swedish), it was learned from an examination of the facts of electrochemistry (the science behind the art of silverplating) that atoms are made of particles of electricity. At the end of the century the discovery of electrons by J. J. Thomson (British) and of X-rays by Röntgen (German) made this fact of the electrical nature of matter even clearer. Men began to investigate how the properties of matter could be fully explained in terms of atoms made of electrified particles.

Modern view.—In 1912 Rutherford (British) developed from experiments on radioactivity the nuclear model of the atom. He learned that atoms have a central relatively heavy particle, the *nucleus,* which carries a positive electric charge. This nucleus is surrounded by electrons carrying a negative electric charge sufficient to neutralize the positive charge of the nucleus. Thus, though made up of electrified particles, the whole atom is electrically neutral.

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The full theoretical development of the nuclear atom model was initiated by Bohr (Danish), who, with others, was able to relate the theory to the principal facts of spectroscopy (study of light emitted by atoms). Indeed, a rich vein of information about the details of atomic structure was derived from the study of light itself. This occupied the central position in physical research in the period 1915 to 1935.

In 1926, the detailed knowledge was greatly advanced by discoveries made by L. DeBroglie (French), E. Schrödinger (Austrian), and C. J. Davisson (United States) concerning the nature of the electron. It was found that the particles within an atom do not, as was first supposed, move according to the same mechanical laws as those governing planets or baseballs. This discovery led to the development of a new branch of physics known as quantum mechanics, and has raised problems which have not yet been fully settled.

Atomic bomb. While the details of the atomic bomb are military secrets, certain facts of interest have been disclosed.

Atomic bombs cannot be made smaller than a certain critical size. A small lump of uranium will not explode because it loses too many neutrons through its surface for a chain reaction to maintain itself. Before it is fired, the bomb contains the active material in two or more separated lumps, too small to explode by themselves, and the act of firing consists in bringing these together, at a great velocity, into a single lump large enough to be explosive.

Enough energy is released during the first few millionths of a second after firing to bring the material to a temperature of many millions of degrees. Thus the uranium is completely vaporized, enormous pressures develop, and expansion begins. In consequence of this expansion, the material becomes less dense, the neutrons can leak out more readily, and the chain reaction is stopped well before all the uranium is utilized.

Atomic number (usually denoted by Z in formulas). This gives the number of protons (positively charged) inside the nucleus of the atom, and also the number of electrons (negatively charged) outside the nucleus. Each chemical element is distinguished by a different atomic number.

All the atoms of a particular element have the same atomic number, for the chemical properties which characterize an element are determined by the number of electrons in the atom, in other words, by its atomic number. But not all atoms of the same chemical element have the same atomic weight. (See *isotopes*, *atomic weight*, and *nucleus*.)

Atomic weight. This term is used to denote the weight of any atom as measured on an arbitrary scale based on the weight of an oxygen atom. On this scale the figure 16 is chosen as the weight of the oxygen atom. Adopting this convention, it is found that the weights of atoms of the other elements can be expressed very nearly as whole numbers. These whole numbers are called the *rough* atomic weights. The atomic weight of ordinary hydrogen is 1; that is, a hydrogen atom is roughly one-sixteenth as heavy as an oxygen atom. The atomic weight of heavy hydrogen is 2; helium, 4; lithium atoms occur in two varieties, with weights, 6 and 7. The figure giving the rough weight of an atom on this scale is also the total number of protons and neutrons contained in the nucleus of the atom.

The *precise* atomic weights differ somewhat from these whole numbers by approximately one-thousandth of the total weight. This difference, however, is of decisive importance for estimating the energy released on the formation of these atoms in accordance with the *mass-energy equivalence* relation.

In precise work it is important to realize that two different scales for atomic weights are in use. The "physicists' scale" is one in which the weight of the abundant isotopic form of oxygen is arbitrarily taken as exactly 16. The "chemists' scale" takes the average weight of the various kinds of oxygen atoms as they occur in nature as exactly 16. The form scale is more convenient for studies of atomic energy.

International table of atomic weights

	Symbol	Atomic number	Atomic weight		Symbol	Atomic number	Atomic weight
Aluminum	Al	13	26.97	Neodymium	Nd	60	144.27
Antimony	Sb	51	121.76	Neon	Ne	10	20.183
Argon	A	18	39.944	Neptunium	Np	93	239
Arsenic	As	33	74.91	Nickel	Ni	28	58.69
Barium	Ba	56	137.36	Nitrogen	N	7	14.008
Beryllium	Be	4	9.02	Osmium	Os	76	190.2
Bismuth	Bi	83	209.00	Oxygen	O	8	16.000
Boron	B	5	10.82	Palladium	Pd	46	106.7
Bromine	Br	35	79.916	Phosphorus	P	15	30.98
Cadmium	Cd	48	112.41	Platinum	Pt	78	195.23
Calcium	Ca	20	40.08	Plutonium	Pu	94	239
Carbon	C	6	12.010	Potassium	K	19	39.096
Cerium	Ce	58	140.13	Praseodymium	Pr	59	140.92
Cesium	Cs	55	132.91	Protactinium	Pa	91	231
Chlorine	Cl	17	35.457	Radium	Ra	88	226.05
Chromium	Cr	24	52.01	Radon	Rn	86	222
Cobalt	Co	27	58.94	Rhenium	Re	75	186.31
Columbium	Cb	41	92.91	Rhodium	Rh	45	102.91
Copper	Cu	29	63.57	Rubidium	Rb	37	85.48
Dysprosium	Dy	66	162.46	Ruthenium	Ru	44	101.7
Erbium	Er	68	167.2	Samarium	Sm	62	150.43
Europium	Eu	63	152.0	Scandium	Sc	21	45.10
Fluorine	F	9	19.00	Selenium	Se	34	78.96
Gadolinium	Gd	64	156.9	Silicon	Si	14	28.06
Gallium	Ga	31	69.72	Silver	Ag	47	107.880
Germanium	Ge	32	72.60	Sodium	Na	11	22.997
Gold	Au	79	197.2	Strontium	Sr	38	87.63
Hafnium	Hf	72	178.6	Sulfur	S	16	32.06
Helium	He	2	4.003	Tantalum	Ta	73	180.88
Holmium	Ho	67	164.94	Tellurium	Te	52	127.61
Hydrogen	H	1	1.008	Terbium	Tb	65	159.2
Indium	In	49	114.76	Thallium	Tl	81	204.39
Iodine	I	53	126.92	Thorium	Th	90	232.12
Iridium	Ir	77	193.1	Thulium	Tm	69	169.4
Iron	Fe	26	55.85	Tin	Sn	50	118.70
Krypton	Kr	36	83.7	Titanium	Ti	22	47.90
Lanthanum	La	57	138.92	Tungsten	W	74	183.92
Lead	Pb	82	207.21	Uranium	U	92	238.07
Lithium	Li	3	6.940	Vanadium	V	23	50.95
Lutecium	Lu	71	174.99	Xenon	Xe	54	131.3
Magnesium	Mg	12	24.32	Ytterbium	Yb	70	173.04
Manganese	Mn	25	54.93	Yttrium	Y	39	88.92
Mercury	Hg	80	200.61	Zinc	Zn	30	65.38
Molybdenum	Mo	42	95.95	Zirconium	Zr	40	91.22

Beta-particle, a negatively charged particle emitted by certain radioactive substances. The beta-particle, it has been discovered, is simply a high-speed electron having energies such as would be obtained by accelerating an electron by a potential of several million volts. While beta-particles are emitted by the nucleus, it is not thought that electrons are contained in the nucleus as such. It is believed, however, that they are created (and immediately emitted) by a transformation of some of the energy in the nucleus. The processes involved in beta-particle radioactivity are at present not well understood.

Capture—in particular, capture of a neutron by an atomic nucleus. In atomic physics this term refers to any process in which a neutron, on colliding with an atomic nucleus, sticks to it or is absorbed into it, or from which fission results. Depending on the nucleus which is struck and the speed of the neutron striking it, the capture may have one of several results. For example, if a neutron is captured by a nucleus of ordinary hydrogen, some energy is given off as gamma radiation and there results a stable compound which is a nucleus of heavy hydrogen, also called a deuteron. When a neutron of any energy is captured by a U–235 nucleus, the result is the splitting of the U–235 nucleus, i. e., fission. On the other hand only neutrons having energy of more than about 1,000,000 electron volts are able to produce fission when captured by U–238. Those of lower energy stick to the nucleus, that is, they are captured to form a nucleus of U–239 which later, through natural radioactivity, transforms itself into neptunium.

Chain reaction, a term applied to any chemical or nuclear transmutation process in which some of the products of a particular change assist the further development of that change.

Specifically, in the fission chain reaction used in the atomic bomb, or the power-producing uranium pile, the occurrence of fission is caused by the capture of a neutron by a uranium atom. Then, when fission occurs, more neutrons are released, which in turn produce fission in additional uranium atoms, and so on.

In practical devices constructed to produce chain reactions, not every neutron emitted in fission causes more fission. Indeed, except to cause an explosion, a perfect chain reaction, i. e., one in which every neutron causes fission, is not desirable. And in the atomic bomb, designed to produce the most efficient chain reaction, some of the neutrons leak out of the surface before they cause fission. In the uranium pile some of the neutrons are absorbed by impurities or by control rods deliberately introduced to regulate the rate at which fission occurs.

The possibility of obtaining a true self-maintaining chain reaction depends on the fact that more neutrons are emitted in a fission than are required to produce it. The attainment of an actual chain reaction in a practical arrangement depends on fulfilling the condition that, in spite of inevitable losses, on the average at least one of the neutrons set free by each fission is effectively utilized in producing another fission.

Cross-section, a term used in atomic physics in measuring the number of collisions of a given kind experienced by particles bombarding a given target. It tells the effective target area for the process in question and is thus usually expressed in square centimeters.

The cross-section in a bombardment of an atomic nucleus, i. e., the effective area exposed to a bombarding neutron of a certain speed, is, of course, an exceedingly small quantity, of the order of 10^{-25} sq. cm.

To give a familiar example, one may compare a bombardment process to shooting repeatedly at random into a large flock of ducks. The greater the average size of the ducks (the "cross-section") and the greater their number in a given area, the more of them will be hit. So, likewise, the number of neutrons going at a certain speed through a block of uranium which will be captured by uranium atoms varies with the capture *cross-section* of uranium and, also, with the number of uranium atoms in unit volume of the metal.

Cyclotron, a research instrument which is designed to provide a beam of high energy protons and deuterons. It was invented in 1930 by E. O. Lawrence (University of California) and has been of great importance as a tool for research in nuclear physics.

The cyclotron involves a large electromagnet having a vacuum chamber between its poles. In this chamber an electric arc is operated at the center to act as a source of protons or deutrons. Inside the chamber are two semicircular electrodes to which is applied a radiofrequency voltage. The protons are accelerated by the electrical field between these electrodes, they then move in a semicircular path as a result of the action of the magnetic field. During the time the protons are moving around in this semicircular path the voltage on the electrodes reverses so that the proton again is speeded up on traversing again the field between the electrodes. In this way the protons are given many successive increases in speed and acquire in the end energies of the order of several million electron-volts. (See *energy*.)

The beam of high energy particles so produced is allowed to impinge on various materials so as to produce nuclear transformations in the atoms of these targets.

Up to the beginning of the war there had been constructed about 20 large cyclotrons in various research laboratories in America, two or three in Russia and in England, one in Denmark, one in France, and three in Japan. They found extensive application in preparing artificial radioactive materials for use in medical research.

Deuterium, the special name given to heavy hydrogen, discovered in 1932 by Urey, then at Columbia University, and Brickwedde, of the National Bureau of Standards. Deuterium has almost the same chemical properties as the more abundant kind of hydrogen, although its atoms are twice as heavy. Heavy hydrogen makes up 1 part in 5,000 of ordinary hydrogen.

Deuteron, the special name given to the *nucleus* of heavy hydrogen. It is the simplest composite atomic nucleus and consists of one proton and one neutron.

Electron, the smallest known particle having a negative electric charge. The part of an atom outside the nucleus is made of electrons, the number of which, being equal to the protons in the nucleus, is the same as the *atomic number* of the atom. An electric current in a wire consists of the motion of electrons through the material of the wire. A current of 1 ampere corresponds to the passage of 6.24 billion billion electrons in one second. In radio tubes and in cathode ray (television) tubes, the current is carried by a stream of electrons. The *beta-particles* emitted by certain radioactive materials are high-speed electrons.

The mass of electrons at rest is so small that 5.02×10^{29} of them are needed to make a pound ($10^{29}=1$ followed by 29 zeros). The mass of all the electrons contained in a lump of matter is only about one three-thousand-six-hundredth of the total mass, most of the mass being contained, not in the electrons, but in the atomic nuclei. An electron in rapid motion has more mass than one at rest because of the *mass-equivalence* of its energy of motion. An electron accelerated through 512 kilovolts has twice as much mass as one at rest. Thus, the beta-particles as they are emitted by radioactive materials, and the electrons in high voltage X-ray tubes, may have several times their normal mass.

Electron-volt, a unit of energy; the amount of energy acquired by an electron when it falls through a potential difference of 1 volt. In terms of the basic unit of energy, the erg, the relation is

$$1 \text{ electron-volt} = 1.60 \times 10^{-12} \text{ erg.}$$ [1]

(See *energy*.)

Element, one of the basic kinds of matter—hydrogen, carbon, oxygen, uranium, etc.—from which all chemical compounds are formed. (See *atom*.) Each element is designated by a chemical symbol as shown in the table of elements and in the periodic chart.

Energy is defined in physics as the capacity for doing work. It appears in many forms, as energy of motion (kinetic energy), gravitational energy, heat energy, nuclear or atomic energy, chemical energy, and so on. But it is always measured by the work which it does. It is measured, in other words, as the product of the amount of force exerted multiplied by the distance through which the force acts.

$$\text{Energy} = \text{Force} \times \text{Distance}$$

For example, one unit of energy, the foot-pound, is the amount of energy necessary to lift a 1-pound weight a vertical distance of 1 foot.

In scientific work a great many other units are used to express quantities of energy, the fundamental unit of the metric system being 1 erg. The following table gives some of the commonly used energy units, arranged in order of size, and the number of ergs contained in each:

Energy unit	*Equivalent in ergs*
Electron-volt	1.60×10^{-12}
Erg	1.00
Foot-pound	13.56 million
Gram-calorie	41.86 million
British thermal unit (B. t. u.)	1.05×10^{10}
Horsepower-hour	2.68×10^{13}
Kilowatt-hour (1.341 horsepower-hours)	3.60×10^{13}

[1] $10^{-12}=1$ divided by 1,000,000,000,000 (i. e., 1 followed by 12 zeros). $10^{-4}=1$ divided by 10,000, etc.

The energy released on fission of a single uranium atom is 200 million electron volts$=3.2\times10^{-4}$ ergs. Therefore, to get one kilowatt-hour of energy it is necessary to bring about the fission of:

$$\frac{3.60\times10^{13}}{3.2\times10^{-4}}=1.12\times10^{17}\text{ atoms.}$$

Since there are 11.6×10^{23} uranium atoms in a pound, the fission of the uranium atoms in one pound of uranium brings about the release of 10.4 million kilowatt-hours of energy.

The total electrical energy developed in the United States in 1939 was 1.61×10^{10} kilowatt-hours, which is the amount of energy released by fission of:

$$\frac{1.61\times10^{10}}{1.04\times10^{7}}=1.55\times10^{3}\text{ pounds}$$
$$=7.75\text{ tons of uranium}$$

Fission, a particular kind of disintegration of an atomic nucleus. It is the release of energy in fission which makes the explosion in the atomic bomb. Fission was first realized in late 1938 by Otto Hahn and Strassmann (German). In the fall of 1945, Otto Hahn was awarded the Nobel Prize for this discovery.

In fission, the nucleus is stimulated by the capture of a neutron which strikes it. Immediately, or sometimes with a slight delay, the nucleus becomes unstable, breaks into two main fragments which are nuclei of elements of medium atomic weight, and spills out several neutrons.

The atomic nuclei produced as fragments and the several neutrons rush apart at high speed from the point where the fission occurred. The neutrons, being uncharged, move rather freely through solid matter, but the nuclear fragments are quickly brought to rest by colliding against other atoms of the material in which the fission occurred.

Of the elements occurring in nature, only uranium, thorium, and protoactinium are now known to be capable of undergoing fission.

Gamma ray, a nonmaterial short-wave radiation emitted by some radioactive atoms. It is of the same general nature as the X-rays produced by a high voltage X-ray tube. Gamma radiation resembles X-radiation and ordinary light in being related to electromagnetic waves, but differs from other atomic radiations in that it comes from the nucleus of the atom rather than from the electrons outside the nucleus which are the source of light and X-rays.

Heavy hydrogen.—See deuterium.

Heavy water, water in which all or nearly all of the hydrogen is of the heavy isotope called deuterium. In ordinary water only about one part in 5,000 of the hydrogen is deuterium. The preparation of heavy water from ordinary water is an expensive separation process, mostly based on electrolysis of water by a method originated in the United States by Washburn, of the National Bureau of Standards.

Since most of the weight in a water molecule is due to the oxygen, doubling the weight of the hydrogen only changes the molecular weight from 18 for ordinary water to 20 for heavy water. Since heavy water molecules are of practically the same size as ordinary water molecules, heavy water is about 10 percent more dense than ordinary water.

Heavy water is useful as a moderator in certain special forms of the uranium pile.

Ionization, the process by which an atom which is ordinarily electrically neutral acquires an electrical charge. For example, in electrical discharges, as in electric arcs, neon signs, and the like, some of the atoms lose one or more of the outer electrons and are left with a net positive electric charge. Atoms can be ionized by absorption of light or absorption of X-rays or as a result of being struck by an electron. An atom thus ionized is called an *ion*.

Isotope, a species of an element in which the atoms are of uniform atomic weight. Most chemical elements occur as a mixture of several isotopes, i. e., as a mixture of atoms which are alike in chemical properties but fall into several groups according to weight. For example, chlorine is a mixture of two kinds of chlorine atoms having rough atomic weights of 35 and 37. Uranium occurring in nature is a mixture of U–235, an isotope with weight 235, U–238, an isotope with weight 238, and a very minute amount of an isotope with weight 234. In the symbol designating a particular isotope, the rough atomic weight is usually written in the symbol thus: C–135, C–137, U–235, U–238. (See, also, *atom* and *nucleus*.)

Isotope separation methods (used in separating U–235 from U–238). Because *isotopes* of the same element have almost identical physical properties and identical chemical properties, the problem of separating them from one another is extremely difficult. Several methods developed in the laboratory before the war were extended to full-scale factory production to obtain uranium for the atomic bomb project. All of the plants so developed were constructed at Oak Ridge, Tenn.

(*a*) *Mass-spectrograph method.*—In this method the material, some volatile compound of uranium, is passed as a vapor into an electric arc in a vacuum tank. This *ionizes* the uranium atoms (leaves them positively charged by knocking off one or more of the neutralizing electrons outside the nucleus). The ionized atoms (called ions) are then accelerated by application of high voltage. The whole tank is placed between the poles of a large electromagnet which causes the ions to move in circular paths, the radii of which depend on the mass of the ions. The ions of two isotopes of uranium, U–235 and U–238, move in paths of slightly different radii and so can be collected in separate containers.

For the atomic bomb project this method was developed at the University of California.

(*b*) *Diffusion method* depends on the fact that when a mixture of gases is allowed to diffuse through a membrane, the molecules of lighter weight get through more rapidly than the heavy ones, resulting in a partial separation of the mixture. Actually, when the gases are as similar in weight, as volatile compounds containing the two *isotopes* of uranium, the degree of separation attained by one passage through a membrane is exceedingly minute. In order to achieve a useful degree of separation it is necessary to arrange for the gas to be diffused successively through many hundreds of membranes.

The research for this method was carried on in New York City at Columbia University.

(*c*) *Thermal diffusion method* depends on the fact that when a gaseous or liquid mixture is maintained under conditions where one part of it is hot and another cold, there is a partial separation of the mixture, with the differences in composition corresponding to the differences in temperature. This is also a very minute effect and arrangements must be made to augment the effect by repetition of the process.

The research for this method was conducted in Washington at the Naval Research Laboratory.

Mass-energy equivalence. This fundamental proposition, enunciated by Einstein in 1905 as one of the important practical consequences of the theory of relativity, states that when anything gives off energy it also loses weight or mass.

By the formula given by Einstein for this equivalence, the complete destruction of 1 pound of mass would be accompanied by the release of 10.66 billion kilowatt-hours of energy. (In the units used in pure physics, the destruction of 1 gram of mass is equivalent to the release of 9×10^{20} ergs of energy.) The size of this figure can be seen by comparison with the total electric power production in the United States which, in 1944, amounted to a little over 279 billion kilowatt-hours, the equivalent in mass, according to this formula, of 26 pounds.

This law is presumably true in all cases, but in the ordinary burning of a fuel the loss in mass is too small to be observed. In the releases of atomic energy produced thus far, which are millions of times greater for the mass of materials involved than in ordinary fuel combustion, it must be remembered that less than 1 percent of the total mass of material involved is actually consumed.

Mass number. This is another term for the *rough atomic weight.* It tells the total number of protons and neutrons in the nucleus. It should not be confused with atomic number, which gives at once the number of protons in the nucleus and the number of electrons outside the nucleus.

Moderator. This is the name given to any material used for the purpose of slowing down the average speed of a group of neutrons, by means of impacts of the neutrons with the atomic nuclei in the material of the moderator. It is essential that the nuclei of the atoms in the moderator do not absorb or capture the neutrons but merely act as buffers to slow them down and absorb part of their energy. The moderator is an important constituent of the energy- and plutonium-producing uranium pile. Thus far graphite has been used most frequently, although it must be specially manufactured to avoid contamination by certain elements, especially boron, which strongly absorb neutrons. Since the neutrons lose energy by elastic impacts with the nuclei in the moderator it is desirable to have a material of low atomic weight. Because ordinary hydrogen absorbs too many neutrons, ordinary water is ineffective. Heavy hydrogen (deuterium) in the form of heavy water is good, although its extraction from ordinary water is an expensive process. Metallic beryllium is also a suitable moderator.

Neptunium, a new chemical element not occurring in nature, whose atomic number is 93. It is produced in the uranium pile as an element intermediate in the process of making plutonium. When a U–238 atom in the pile captures a neutron, it becomes U–239 which is radioactive, emits a beta-particle, and is thus transformed into Np–239. This kind of neptunium is also radioactive and emits another beta-particle whereby it is transformed into Pu–239, plutonium, the fissionable material used in making atomic bombs.

Neptunium, like plutonium, was discovered by Segre, Seaborg, Kennedy, and Wahl, at Berkeley, Calif., in 1940.

Neutron, a particle with no electric charge, but with a mass approximately the same as that of the proton. In nature, neutrons are locked up in the nucleus of an atom, but they can be knocked out in various kinds of atom-smashing experiments. The number of neutrons in a particular nucleus is found by subtracting the atomic number from the rough atomic weight.

Neutrons were discovered in 1932 by Chadwick (British). He obtained them in a free state by bombarding beryllium atoms with alpha-particles from radium. This knocked the neutrons out of the beryllium nuclei and is still a useful laboratory way of producing streams of free neutrons of low intensity.

Neutrons play an especially important role in the practical utilization of atomic energy because when a uranium atom undergoes fission through the capture of a neutron, several more neutrons are produced which continue the process by the mechanism of a chain reaction.

Because they are electrically neutral, neutrons can move rather freely through most solid materials. They are, however, scattered by impact with the nuclei so that they move through matter by diffusion rather than by direct forward motion. Likewise, they are absorbed to some extent, the free neutrons being captured by nuclei to form new isotopic atoms which are in some cases radioactive.

The ability of nuclei thus to capture neutrons varies enormously from one atomic species to another and depends very greatly on the speed of the neutrons. Some substances are almost "transparent" to neutrons, others almost "opaque." There is no known substance which will act like a wall for neutrons and bounce back all the neutrons that strike it in the way that a steel boiler wall bounces back the molecules of steam that strike it.

Nucleus, the central part of the atom, which makes up most of the weight of the atom and is charged with positive electricity. Atomic nuclei are, it is now believed, made up of two kinds of fundamental particles, *protons* and *neutrons*.

The total number of particles of both kinds in the nucleus is given by the rough *atomic weight*. The number of protons is given by the *atomic number*. The number of neutrons can thus be found by subtracting the atomic number from the atomic weight. For example, in uranium-238, the total number of protons and neutrons is 238. The number of protons alone, given by the atomic number of uranium, is 92. Hence, by subtraction, the number of neutrons is $238-92=146$.

In the atoms of certain elements the nuclei, while all having the same number of protons, i. e., the same atomic number, differ as to atomic weight (see *isotopes*). For example, most hydrogen atoms have a single proton for a nucleus. Consequently, hydrogen is said to have an atomic weight of 1. But there are hydrogen atoms with a nucleus compounded of one proton and one neutron. These heavier atoms can be separated from the lighter, more normal hydrogen atoms to make heavy hydrogen (deuterium), a material with the same chemical properties as hydrogen, but with a rough atomic weight of 2. Some elements are represented by atoms of many different weights. Every atom of mercury, for instance, has 80 protons in its nucleus, but with respect to atomic weight, it may fall into any one of seven different varieties, having the rough weights: 196, 198, 199, 200, 201, 202, and 204.

At the time progress in fundamental science was interrupted by the war, the basic problem in physics was to learn the nature of the forces which hold together the particles in the nucleus. Evidently, forces of a new kind must play a role here for the neutrons, being neutral, are not affected by electrical charges, and the protons, being all positively charged, would fly apart if their mutual electrical repulsions were not overcome by some special nuclear attractions. The nature of these forces is as yet not fully known.

Periodic table, an arrangement of the chemical elements, first made by Mendeleeff (Russian), to show resemblances among them with respect to their chemical properties.

In this table the elements are arranged in rows by order of atomic number. When this arrangement is made, it is found that the elements in certain groups and in certain vertical columns of the table are those exhibiting similar chemical properties. For example, elements in right-hand column of the table—helium, neon, argon, etc.—are all inert gases.

The reason for this periodic recurrence of similar chemical properties in the elements arranged in this way is given by the theory of the electronic structure of the *atom* developed by Bohr (Danish) and perfected by Pauli (Austrian). For his contribution to this work, Pauli, now at the Institute for Advanced Study in Princeton, N. J., was awarded the Nobel Prize in physics in November 1945.

Pile. This term refers to the particular arrangement used to produce a chain reaction with uranium for the purpose of producing plutonium or for getting heat energy for generation of power.

The original pile was built on the campus of the University of Chicago and first operated on December 2, 1942. It consisted of blocks of graphite interspersed with lumps of metallic uranium, the whole being roughly in the shape of a sphere containing 12,400 pounds of uranium metal.

Subsequently several other piles were built for special purposes prior to the construction of the large plutonium production plant at Hanford, Wash.

The underlying idea of the pile may be explained simply. The neutrons released in fission have such high speeds that they are not very effectively captured again to produce further fissions and to carry on the chain reaction. Only neutrons at very low speeds will produce fission; those with high energy tend to pass right through the nuclear targets at which they are aimed without splitting them. To reduce the speed of the neutrons it is necessary for them to diffuse in some material of low atomic weight where they will lose energy by elastic impacts with the atoms of this material.

In the pile this moderator material is kept in layers or lumps separate from the uranium. This is necessary because uranium has a strong tendency to absorb neutrons of medium speed in a way that does not result in fission. The neutrons which become effective are those which are slowed below this speed in the moderator and diffuse back into the uranium to produce more fission.

Since their primary object was plutonium production and not heat, the piles that have been built thus far have been kept at relatively low temperatures either by dry-air cooling or by water cooling pipes. For power production it will be necessary to work out engineering designs which permit the piles to operate at a high temperature to generate steam for use in steam turbines driving electric generators.

The details of pile design will vary greatly, depending on the primary purpose of the pile, the moderator material which is chosen, and depending on whether natural uranium or uranium with enriched U–235 content is used. In operation a pile becomes enormously radioactive, so that all work connected with it must be done by remote control, behind very thick absorbing walls to avoid dangerous burns to the operating personnel. The whole future of the peacetime use of atomic energy depends on the success with which piles can be developed for various special purposes.

Plutonium, a new chemical element not occurring in nature, whose atomic number is 94. It was discovered by Segre, Seaborg, Kennedy, and Wahl working at Berkeley, Calif., in 1940. Plutonium (symbol: Pu–239) is used in making atomic bombs, the large plant at Hanford, Wash., having been designed solely for its production. This highly radioactive element is formed as a result of two successive beta-particle transformations from U–239 which itself is produced in the uranium pile (see *neptunium*).

Power.—A distinction should be made between *power* and *energy*. Power differs from *energy* in that it brings in the element of time. The faster a given amount of work is to be done, the more power is required. The amount of energy required is the same, regardless of the time in which the work is done.

The simplest direct unit of power is the foot-pound per second, which is the amount of power needed to lift a weight of 1 pound vertically at a speed of 1 foot per second. The most familiar electrical power unit is the kilowatt.

The relations between the common power units are as follows:

Unit:	*Number of foot-pounds per second*
Watt	0. 73756
Horse power	550.
Kilowatt (1,000 watts)	737. 56

It is important to recognize distinctly the difference between a *kilowatt of power* and a *kilowatt-hour of energy*. A kilowatt-hour measures the work done by a device delivering a kilowatt of power for 1 hour. To say that the installed capacity of a power generating station is 40,000 *kilowatts* is to say that it can deliver energy continuously at that rate, and does not give the total amount of energy delivered in any given period of time.

Since 1 pound of uranium undergoing fission releases 10.4 million kilowatt-hours of energy, it follows that the utilization of 10 tons per year of uranium would provide a steady output of power of:

$$\frac{10\times2000\times10.4\times10^6}{365\times24}=23.7 \text{ million kilowatts}$$

Protoactinium, a heavy element of atomic number 91, capable of undergoing fission on neutron capture. This element is extremely rare, and for this reason will probably not find practical application in atomic energy developments.

Proton, a small particle with a positive electric charge equal numerically to the negative electric charge of the electron. A single proton makes up the entire nucleus of the ordinary hydrogen atom. The nuclei of atoms of other substances contain a number of protons given by the atomic number of the element. The mass of the proton is so small that it takes 2.72×10^{26} of them to make 1 pound. The mass of the proton is, however, 1,820 times greater than that of the electron.

Radioactivity, a property of certain elements which causes their atomic nuclei spontaneously to disintegrate, gradually transmuting the original elements into others of different chemical properties. The radioactive atomic species occurring in nature include all elements whose atomic number is greater than that of lead. Since 1930, physicists have succeeded in transmuting nearly all of the chemical elements into radioactive forms by artificial bombardments. Many such materials are also produced as fission products.

The radiations emitted by radioactive materials have proved very useful in the study and treatment of cancer and other tumorous diseases, and in medical diagnosis and therapy generally. Rapid developments in this field may be expected now that abundant supplies of radioactive materials can be provided by uranium piles.

The rate at which radioactive materials transform is measured by time intervals, called the half-life; in the first half-life, the amount of material left unchanged is half the original amount; in the next half-life interval, half the remaining amount, or one-fourth the original amount, remains. The half-life of different materials varies widely: for uranium-238 it is 4.67 billion years; for radium it is 1,690 years; for polonium-210 it is 136 days, while for a special isotope of polonium (214) the half-life is only about a millionth of a second.

The radiations emitted by radioactive materials are of three types, *alpha-particles*, *beta-particles* and *gamma rays*. When an alpha-particle is emitted from the nucleus of an atom, the atomic weight is diminished by 4 and its atomic number by 2. For example, when U–238 emits an alpha-particle the remaining nucleus becomes an isotope of thorium, Th–234. When a beta-particle is emitted the atomic number is increased by 1, since the beta-particle carries away a negative electric charge, but the rough atomic weight is unchanged because the mass of an electron is so small. Thus, the thorium isotope Th–234 produced from U–238 is itself radioactive, emits a beta-particle and becomes Pa–234, an isotope of protoactinium. Emission of gamma radiation by an element does not change its atomic number or atomic weight but occurs in close association with the emission of alpha- or beta-particles.

Thorium, a heavy element of atomic number 90, which is capable of undergoing fission on capture of a fast neutron. Thorium has thus far not found application in atomic power production.

Uranium, the critical element that is used in the atomic bomb and in atomic power production because of the ability of its atoms to undergo fission when it absorbs neutrons.

Uranium has an *atomic number* of 92 and consists mostly of two *isotopes* of rough *atomic weights* 238 and 235. The U–238 makes up 99.3 percent and the U–235 about 0.7 percent of the natural metal. Minute amounts of U–234 are also found in natural uranium.

Uranium was discovered in the year 1789 as an element occurring in the mineral pitchblende. It was not prepared in metallic form until 1841. The discovery of its natural radioactivity was made in 1896 by Henri Becquerel and 2 years later the much more intense radioactivity of radium was discovered by Pierre and Marie Curie.

Since radium always occurs in nature in association with uranium-bearing minerals, most prospecting for uranium heretofore has been for the primary purpose of finding radium. Some uranium has been used in certain alloy steels; also, uranium compounds find application as pigments in the ceramic and glass industries. Prior to the discovery of fission, however, no very important uses for uranium had been discovered.

Natural deposits.—The most important uranium mineral deposits are in Jachymov, in Czechoslovakia, in Colorado, in the Belgian Congo, and at Great Bear Lake in Canada. There are also important deposits in Tjuja-Mujun, Ferghana, East Turkestan, a region belonging to the Union of Soviet Socialist Republics. In 1923, it was estimated that the uranium content of these deposits amounts to 60 tons. Other deposits, widely distributed throughout the world, are not rich enough to be worked at present in competition with the main deposits.

In most minerals there are 2.8 million grams of uranium for every gram of radium.

In the mines of Czechoslovakia and also of the Belgian Congo the average yield of radium is about 0.1 gram radium per (metric) ton of ore.

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"Sample list of reports": p. 182.

This report (now commonly known as the Smyth report) was made public for use by radio commentators after 9:00 P. M. E. W. T., Saturday, August 11, 1945, and for the press on Sunday, August 12, 1945. In its original form the report was issued as mimeographed material in a very limited edition. It was republished by the U. S. Govt. Printing Office (see above) and also by the Princeton University Press. This latter has the title: Atomic energy for military purposes; the official report on the development of the atomic bomb under the auspices of the United States government, 1940–1945. There are 264 pages and a number of illustrations. These photos are absent from the report printed in the Govt. Printing Office. In addition the Princeton version has some expanded sections dealing with health precautions.

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Davis, G. H. Splitting the mighty atom: New sources of world energy, diagrammatic drawings. Illustrated London news (London) Aug. 18, 1945, v. 207: 182–183. AP4.I3 v.207

Davis, Harry M. When can the atom be put to work. New York Times magazine, Dec. 1945, p. 10.

DeMent, Jack A. and H. C. Dake. Uranium and atomic power, with appendix on the atomic bomb. Brooklyn, N. Y. Chemical publ. co., inc., 1945. 343 p. QD181.U7D4

"A comprehensive, practical and theoretical exposition of the uranium minerals, based on the chemistry of uranium, and including the possibilities of atomic power." This book is essentially a reprint of the edition of 1941 with a brief appendix on the atomic bomb.

Dietz, David. Atomic energy in the coming era. New York, Dodd, Mead & co., 1945. 184 p. QC173.D5

A popular account by a well-known science reporter.

Evans, Robley. The medical uses of atomic energy. Atlantic monthly (Boston) v. 177, Jan. 1946: 68–73. AP2.A8 v.177

A general discussion of the possibilities of radioactive isotopes in medicine. Points out that there is an acute need for specialized personnel—especially hybrid Ph. D.'s to bridge gap between physics and related fields such as biology and medicine.

Failla, G. Biological effects of ionizing radiations. Journal of applied physics (Lancaster, Pa.) Apr. 1941. v. 12: 279–295.
QC1.J83 v.12

"Nuclear physics and cancer have been closely associated for about forty years. But the association now has more points of contact and it is already evident that cancer research, as well as therapy will greatly benefit from the new developments in nuclear physics."

5000 new products and procedures from atomic-bomb research. Electrical engineering (N. Y.) Oct. 1945, v. 64: 375–377.
TK1.A61 v.64

Forecast of benefits to American industry in new inventions, products and procedures resulting from Manhattan project.

Gamow, George. Atomic energy in cosmic and human life. New York, Macmillan co., 1946.

Announced for Mar. publication.

Goodman, Clark. The atomic competitor. American affairs (New York) Jan. 1946, v. 8: 59–60. HC101.N317 v.8

Author believes that atomic energy will replace oil as a source of energy and that remaining oil resources will be used for chemical production rather than burned up for its power content.

——— Petroleum vs. plutonium. Oil and gas journal (Tulsa) Nov. 17, 1945, v. 44: 227–248. TN860.04 v.44

A factual report to the petroleum industry which attempts to evaluate the present and future competition of atomic energy.

Hamilton, Joseph G. The application of radioactive tracers to biology and medicine. Journal of applied physics (Lancaster, Pa.) June 1941, v. 12: 440–460. QC1.J83 v.12

"This report has attempted to describe the experimental technique employed in the application of radioactive tracers to metabolic studies in biology and medicine." General in nature and well illustrated.

Harrison, George R. Atoms in action. The world of creative physics. Rev. ed. New York, Garden City publ. co., 1944. 401 p.
QC28.H37 1944

A popular introduction to what physics is about. Well illustrated and it concludes with a list of additional readings.

Hevesy, G. and F. A. Paneth. Radioelements as indicators in chemical and biological research. Science progress (London) July 1937, v. 32: 38–48. Q1.S79 v.32

An introductory essay by two British pioneers in this field.

How soon atomic energy? Scientific American (N. Y.) Nov. 1945, v. 173: 284–285. T1.S5 v.173

Survey based on Smyth report and discussions with leading physicists. Concludes that power possibilities may come within a decade or two. Applications to medicine and scientific research sooner.

Hyatt, Robert M. The power of the atom. Public utilities fortnightly (Baltimore) Sept. 27, 1945, v. 36: 424–430. Law Library

Author agrees with view that while applications of atomic energy will prove amazing they will supplement rather than supplant existing power systems for some time to come.

Isard, Walter and Vincent Whitney. Industrial uses of atomic power. New republic (N. Y.) Dec. 17, 1945, v. 113: 829–831.
AP2.N624 v.113

The authors examine possibilities for early use of atomic energy. They conclude that "The Atomic Age—if we live to see it—will be the outgrowth of orderly, evolutionary development in the direction of a more ample economy."

Kramer, Andrew W. Atomic energy is here. Power plant engineering (Chicago) Sept. 1945, v. 49: 74–77. TJ1.P77 v.49

Author warns: "Power plant engineers will do well not to ignore the possibility of atomic power."

——— Uranium and atomic energy. Power plant engineering (Chicago) Sept. 1945, v. 49: 78–84. TJ1.P77 v.49

"The treatment here has been, of necessity, somewhat sketchy but it will provide a background against which this development can be considered. Further disclosures regarding the atomic energy development will be presented in future articles."

Loofbourow, John R. Borderland problems in biology and physics. Reviews of modern physics (Lancaster, Pa.) Oct. 1940, v. 12: 267–358.
QC1.R4 v.12

Remarkably complete review: Includes sections on isotopes as biologic tracers with references to 306 articles in the bibliography. Valuable as an introduction to this field.

Low, A. M. What next with the atom? Popular science (N. Y.) Oct. 1945, v. 147: 65–67+ AP2.P8 v.147

The author, a well-known British scientist predicts an age of miracles when the atom is finally brought under control for peacetime use.

Low-Beer, Bertram V. A., John H. Lawrence and Robert S. Stone. The therapeutic use of artificially produced radioactive substances. Radiophosphorus, radiostrontium, radioiodine, with special reference to leukemia and allied diseases. Radiology (Syracuse, N. Y.) Nov. 1942, v. 39: 573–597. RC78.A3 v.39

A general review with an extensive bibliography.

McDermott, William F. Bringing the atom down to earth. Popular mechanics magazine (N. Y.) Nov. 1945, v. 84: 1–6+
T1.P77 v.84

Illustrated article on the possibilities of atomic power.

Roberts, R. B. and J. B. H. Kuper. Uranium and atomic power. Journal of applied physics (Lancaster, Pa.) Sept. 1939, v. 10: 612–614. QC1.J83 v.10

Can the energy which is locked up in the nuclei of atoms be made available for everyday use? The conclusions of the authors are still interesting today.

Shea, H. Gregory. Generation of atomic power from elements. Electronic industries (N. Y.) Oct. 1945. v. 4: 90–94.
TK161.E54 v.4

Discussion of the industrial possibilities of nuclear energy.

Sherman, Joseph V. Atomic age will dawn gradually. New industries may be created. However—Plan for federal control opposed. Barron's (N. Y.) v. 25, Oct. 8, 1945: 3. HG1.B3 v.25

Welch, Francis X. An "atomic era" for utilities? What steps can the public utilities take now or in the near future to put their house in order for the coming of the atomic age. Public utilities fortnightly (Baltimore) Sept. 13: 1945: v. 36: 349–361. Law Library.

Author makes seven general suggestions.

Williams, Clarke. Atomic power: next steps. 1. Bootlegging atomic-bomb materials. New republic (New York) Jan. 28, 1946, v. 114: 119–121. AP2.N624 v.114

A discussion of the feasibility of inspection by an atomic scientist.
"This is the first of a series of three articles on problems related to atomic power. The second article, by Dr. Alvin Weinberg, will discuss 'Peacetime Uses of Nuclear Power'."

D. Control of Atomic Energy

Angell, Norman. Human nature and the atomic age. Free world (N. Y.) Dec. 1945, v. 10: 74–76. D410.F78 v.10

Safety in the atomic age depends on the use of reason to control human nature.

——— Man and the atom. Free world (N. Y.) Sept. 1945, v. 10: 71–74. D410.F78 v.10

An exhortation to the use of reason in the atomic era.

The Association of Los Alamos scientists. Science (N. Y.) Dec. 14, 1945, v. 102: 608–609. Q1.S35 v.102

Announcement of an organization of scientists from the Los Alamos branch of the Manhattan District. Includes statement of aims.

The Association of Oak Ridge scientists; a letter to the Saturday review. Saturday review of literature (N. Y.) v. 28, Oct. 13, 1945: 24. Z1219.S25 v.28

Also in: Science news letter (Washington, D. C.) Oct. 20. 1945, v. 48: 250–252.
Atomic scientists speak out on the bomb.

Atom of discord. Editorial. The Economist (London) Nov. 24, 1945, v. 149: 737–738. HG11.E2 v.149

A discussion of the Truman-Atlee-King statement.

The atomic bomb—it's loaded. Editorial. American foreign service journal (Washington, D. C.) v. 22, Dec. 1945: 7–10+ JX1.A53 v.22

An analysis of the problems presented by atomic energy and its control. Discusses political and technical aspects.

Atomic energy and American policy. Official and unofficial pronouncements. International conciliation (N. Y.) Dec. 1945, no. 416: 749–823. JX1907.A8 no.416

Contents: Introduction by James T. Shotwell. I.—Official Statements. Statement on the atomic bomb, by President Harry S. Truman, August 6, 1945.—Statement on the atomic bomb, by Secretary of War Henry L.

Stimson, August 6, 1945.—President Truman's Message to Congress on the atomic bomb, October 3, 1945.—President Truman's foreign policy address, October 27, 1945. II.—Unofficial Statements. The atom and humanity, an address by Harold C. Urey, October 21, 1945.—From war to peace, an address by Harold E. Stassen, November 8, 1945.—Implementing and amending the charter, an address by James T. Shotwell, November 11, 1945.

Atomic energy in international and constitutional law. Lawyers guild review (Washington) Sept.–Oct., v. 5: 311–314. Law.

Report of the Committee on international law and relations, National Lawyers guild.

Atomic scientists of Chicago. The atomic bomb. Chicago, 1946. 62 p.

A compact but authoritative discussion of the atomic bomb and its implications. Includes illustrations, a glossary, and a brief reading list.

Baldwin, Hanson W. Atomic bomb responsibilities. Article introduced into the Record by Mr. Shipstead, Sept. 12, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4146–A4147.
J11.R5 v.91

Proposes: 1. Temporary retention of the atomic bomb secret; 2. Abolition of conscription; 3. Reduction of national armaments; 4. Rapid development of international police force; 5. Elimination of veto power; eventual outlawry of the atomic bomb.

Blackburn, Raymond. A British appeal on atomic energy. New republic (N. Y.) Nov. 19, 1945, v. 113: 663. AP2.N64 v.113

Pleads for concentration of effort on peacetime uses for atomic energy.

Bliven, Bruce. The bomb and the future. New republic (N. Y.) Aug. 20, 1945, v. 113: 210–212. AP2.N64 v.113

Bohr, Niels. A challenge to civilization. Science (N. Y.) Oct. 12, 1945, v. 102: 363–364. Q1.S35 v.102

"Let us hope that science, which through the ages has stood as a symbol of the progress to be obtained by common human striving, by its latest emphasis on the necessity of concord, may contribute decisively to a harmonious relationship between all nations."

Boothby, Robert J. G. Drama of man in the atomic age. From a speech in House of Commons. American affairs (N. Y.) Oct. 1945, v. 7: 217–219. HC101.N317 v.7

Argues for repeal of veto power in UN before we can have effective control of the atomic bomb.

Borst, Lyle B. Statement on atomic energy before an informal meeting of Members of Congress held on Thursday, November 8, 1945. Introduced into the Record by Mr. Voorhis, Nov. 15, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A5283–A5284.
J11.R5 v.91

Speaks as representative of the Association of Oak Ridge Scientists and the Federation of Atomic Scientists.

Brodie, Bernard. Absolute weapon: atomic power and world order. New York, Harcourt, Brace and co., 1946.

Announced for April publication.

Brodie, Bernard. The atomic bomb and American security. New Haven, Yale univ., 1945. 28 p. Mimeographed. (Yale Institute of international studies. Memorandum no. 18)

Contents: Atomic bombs and the conduct of war.—Possibilities of counter measures.—Military role of the traditional armed forces.—Is the atomic bomb a deterrent from war?—The economics of atomic bomb production and use.—How secret is the atomic bomb?—The problem of control.

Bryson, Lyman. The threat of the atoms. New York, Columbia broadcasting system, Aug. 12, 1945. 4 p. Mimeographed.

Transcript of radio broadcast in "Problems of the Peace" series.

Bulletin of the Atomic bomb scientists of Chicago (Chicago, Ill.) Dec. 10, 1945, v. 1, no. 1. 6 p.

This bulletin published bi-weekly provides information and news on the progress of current activities in connection with controlling the atomic bomb and atomic energy.

Byrnes, James F. The Moscow tripartite agreement; the reconciliation of differences. Vital speeches (New York) Jan. 15, 1946, v. 12: 197–200. PN6121.V52 v.12

Text of radio address by the Secretary of State, reporting on the Moscow Conference, delivered on Dec. 30, 1945.

Can the atomic bomb be controlled? Editorial. Christian century (Chicago) Oct. 24, 1945, v. 62: 1196–1197. BR1.A45 v.62

Argues for a world commission to control atomic energy.

Carnegie endowment for international peace. Committee on inspection of raw materials of the Committee on atomic energy. A conference report on international inspection of radioactive mineral production. New York, Carnegie endowment for international peace, The Geological society of America, American institute of mining and metallurgical engineers, Feb. 1946. 15 p.

The challenge of the atomic bomb. Nation (N. Y.) Dec. 22, 1945, v. 161: 701–720. AP2.N2 v.161

Special supplement (pt. 2) to the Nation containing addresses delivered at the Annual Nation's Associates' Forum held at Hotel Astor, December 1–3.

Childs, Marquis. Congress hears the atomic facts. Editorial from the Washington Post introduced into the Record by Mrs. Helen Gahagan Douglas, Oct. 19, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4757–A4758. J11.R5 v.91

Comments on the testimony of Dr. Oppenheimer before the Kilgore Committee.

——— Control of atomic energy. Editorial from the Washington Post, Oct. 6, 1945. Introduced into the Record by Mr. Downey, Oct. 29, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4886–A4887. J11.R5 v.91

Believes we should move in the direction of sharing the secret of atomic power under adequate controls.

Coffin, Tristram. Transcript of broadcast on atomic energy hearings over the Columbia broadcasting system, Oct. 21, 1945. Introduced into the Record Oct. 24, 1945 by Mr. Downey. Congressional record, 79th Cong., 1st sess., v. 91: A4812–A4813. J11.R5 v.91

Condon, Edward U. Atomic bombs and the future. Power plant engineering (Chicago, Ill.) Sept. 1945, v. 49: 84–85. TJ1.P77 v.49

Author pleads for a world order and continuation of unrestricted and fundamental scientific research.

——— Atomic energy and the future. Will the next conflict be "The War of Pushbuttons?" Army ordnance (Washington, D. C.) Nov. Dec. 1945, v. 29: 393–396. UF1.A6 v.29

Dr. Condon envisages possibility of a pushbutton war and destruction of our civilization if international controls of atomic energy are not forthcoming.

Coulborn, Rushton. Determinism and atomic force. Phylon, the Atlanta university review of race and culture (Atlanta, Ga.) Dec. 1945, v. 6: 305–309. E185.5.P5 v.6

An analysis of causality in human affairs in the light of atomic energy.

Cousins, Norman. Modern man is obsolete. New York, The Viking press, 1945. 59 p. JX1954.C68

An enlarged version of the famous editorial published in the Saturday review of literature, August 18, 1945.

——— Sovereignty in an atomic age. Saturday review of literature (N. Y.) v. 28, Oct. 13, 1945: 22–24 Z1219.S25 v.28

The author argues that national sovereignty must go if we are to survive in this atomic age.

Culbertson, Ely. How to control the atomic threat. New York, Total peace, inc., 1945. 14 p.

Advocates that the Quota force plan be amplified for the control of the atomic bomb.

Davis, Harry M. The atomic bomb: the facts and the issue. New York Times magazine (N. Y.) Nov. 11, 1945: 5, 41.
AP2.N6575 1945

A summary of the problems posed to statesmen by the atomic bomb.

Defense in the atomic age: plans for big U. S. forces. Absence of proof that large armies and navies are obsolete. United States news (Washington) Sept. 28, 1945: 22–23. JK1.U65 1945

Douglas, Helen Gahagan. Keep atomic energy free. New republic (N. Y.) Mar. 18, 1946, v. 114: 366.

Drake, Francis V. Let's be realistic about the atom bomb. Reader's digest (Pleasantville, N. Y.) Dec. 1945, v. 47: 108–112.
AP2.R255 v.47

Outlawry of the atom bomb will not necessarily outlaw war. A Department of scientific warfare to provide for adequate defense now is essential.

Einstein, Albert. Einstein on the atomic bomb, as told to Raymond Swing. Atlantic monthly (Boston) Nov. 1945, v. 176: 43–45.
AP2.A8 v. 176

Dr. Einstein suggests that secret of the atomic bomb be vested in a world government and that the United States, Gt. Britain and Russia proceed to form this government.

84144—46——7

Ellis, E. D. Atomic bomb, key to the international sanction. Current history (N. Y.) Oct. 1945, n.s. v. 9: 293–298.
D410.C82 n.s. v.9

Finletter, Thomas, and others. Problem of the year: control of the atom; a radio discussion. Chicago, University of Chicago press, 1946. 29 p. (University of Chicago round table Jan. 6, 1946. No. 407).
D410.U7 no.407

Speakers also included Grayson Kirk, Edward Levi, and Philip Morrison.

For peace by law—a communication. Article from the Washington Post, introduced into the Record by Mr. Voorhis, Oct. 16, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4671–A4672.
J11.R5 v.91

Statement signed by Justice Owen J. Roberts and others calling for a revision of the United Nations Charter.

Fosdick, Raymond B. The challenge: One world or *none*. We are in a race with our technologies; with our mounting capacities to destroy. New York Times magazine (N. Y.) Sept. 2, 1945: 8, 35–36.
AP2.N6575 1945

Fulbright, J. W. The effect of the atomic bomb on American foreign policy. Address delivered by Senator Fulbright at a meeting of the American foreign policy association in New York City on Oct. 20, 1945. Introduced into the Record by Mr. Fulbright, Oct. 29, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A5013–A5015.
J11.R5 v.91

The Senator believes that only by surrendering some of their sovereignty over armaments to the United Nations can the individual nations hope to survive in the world of the atomic bomb.

G, G. Science—before and after. American affairs (N. Y.) Oct. 1945, v. 7: 219–223. HC101.N317 v.7

A discussion of *Science, the endless frontier* in the light of the atomic bomb.

Gilfillan, S. C. The atomic bombshell. Survey graphic (N. Y.) Sept. 1945, v. 34: 357–358. HV1.S82 v.34

"New vistas of health and happiness stretch ahead of us—if mankind can learn to use for good, and not for destruction, the mind-numbing power we have unleashed."

Gordon, King. The bomb is a world affair. Nation (N. Y.) Nov. 24, 1945, v. 161: 541–543. AP2.N2 v.161

Supports Stassen's position for control by the United Nations.

Groves, L. R. The atomic age. Address delivered at Lafayette College, Easton, Pa., Oct. 26, 1945. Introduced into the Record by Mr. E. C. Gathings, Nov. 1, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4991–A4993. J11.R5 v.91

Atomic power must be developed as an instrumentality for human welfare or it will destroy us.

Gustavson, Reuben, Robert Hutchins and William Ogburn. Atomic force: its meaning for mankind. University of Chicago round table discussion no. 386. Chicago, Ill., Aug. 12, 1945. 17 p.
D410.U7 1945

Hass, H. B. The significance of atomic energy. School science and mathematics (Menasha, Wis.) Jan. 1946, v. 46: 1–6.
Q1.S28 v.46

International organization for peace is man's only hope author argues.

Hatch, Carl A. The atomic bomb. An address in the Senate, Nov. 2, 1945. Congressional record, 79th Cong., 1st sess., v. 91: 10486–10488. J11.R5 v.91

An address by Senator Hatch on what to do with the atomic bomb, with attendant debate.

Higinbotham, William. Suppose an atomic bomb exploded over Washington? The Washington post, Feb. 10, 1946.

Hill, David L., Dr. Rabinowitch and John A. Simpson. The atomic scientists speak up. Nuclear physicists say there is no secrecy in the atomic bomb and no defence against it. Life (Chicago) Oct. 29, 1945, v. 19: 45, 46, 48. AP2.L547 v.19

Statement by the Atomic scientists of Chicago.

Holloway, Vernon H. The atomic bomb, a world problem. New York, Congregational Christian churches, Council for social action, 1946. 16 p.

Hoyt, Palmer. Take the lid off the atom. Editorial in the Oregonian, Oct. 2, 1945. Introduced into the Record by Mrs. Helen Gahagan Douglas, Oct. 24, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4824–A4825. J11.R5 v.91

Objections to the May-Johnson bill.

Hutchins, Robert M. The atomic bomb versus civilization. Chicago, Human events, inc., 1945. 13 p. (Human events pamphlet no. 1).

A world community based on common understanding is our only hope for survival. Only education can bring about such understanding.

Huxley, Julian. Is war instinctive and inevitable? New York times magazine, Feb. 10, 1946: 7+ AP2.N6575

A biologist answers a fundamental question.

The Independent. Madison square garden crisis meeting [on atomic energy] Dec. 4, 1945. New York, Jan. 1946. 19 p. (Special issue of the Independent).

Includes extracts from addresses by Dr. Harold Urey; Professor Julian Huxley; R. J. Thomas; Secretary Henry Wallace; Senator C. W. Tobey and Colonel E. Carlson.

Jennings, John. The atomic bomb is the property of the American people, paid for by them, and it should be held for their protection, and not given away. Extension of remarks Oct. 17, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4692. J11.R5 v.91

Johnson, Alvin. Education in an atomic age. Saturday review of literature (N. Y.) v. 28, Sept. 15, 1945: 15. Z1219.S25 v.28

Jordan, Virgil. Frame of the future for America. American affairs (N. Y.) Oct. 1945, v. 7: 191–200. HC101.N317 v.7

Address on man's future in the Atomic era delivered at Rutgers university Sept. 13, 1945. To be published in book form by the Rutgers university press in January, 1946.

Kirchway, Freda. Russia and the bomb. Nation (N. Y.) Nov. 17, 1945, v. 161: 511–512. AP2.N2 v.17

Advocates giving bomb secret to Russia.

Knox, Ronald A. God and the atom. New York, Sheed and Ward, 1945. 166 p. BT1101.K73

Kraus, K. A. and M. E. Kraus. Fear in the atomic age. Saturday review of literature (New York) v. 29, Jan. 12, 1946: 13–15. Z1219.S25 v.29

Strengthening of UN is urged together with elimination of veto power.

LaFarge, John. Control of atomic energy. America (N. Y.) Nov. 17, 1945, v. 64: 174–176 BX801.A5 v.64

Recommends formation of a special agency as part of UN for the control of atomic energy.

Laski, Harold J. Atomic energy and free enterprise. Commercial and financial chronicle (N. Y.) Dec. 6, 1945, v. 162: 2699. HG1.C7 v.162

Society dominated by free enterprise cannot be trusted to keep the peace. Control of atomic energy by private interests would lead to further enslavement of mankind. Urges elimination of national sovereignty to end war.

Lindeman, E. C. Morality for the atomic age. Forum (N. Y.) Nov. 1945, v. 104: 231–233. AP2.F8 v.104

A peace based on fear of the bomb is not enough. A new dynamic morality is required for the atomic age.

Lindley, Ernest. Controlling the atom. Editorial from the Washington Post, Sept. 24, 1945. Introduced into the Record by Mr. Downey, Oct. 29, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4886–A4887. J11.R5 v.91

Discussion of some legislative proposals with special reference to that of Senator McMahon.

Ludlow, Louis. Remarks on the introduction of a resolution concerning the future of the atomic bomb, Sept. 5, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4054. J11.R5 v.91

Advocates that UN ban atomic bomb forever as an instrument of war.

Lundberg, George A. Can science save us? Harper's magazine (N. Y.) Dec. 1945, v. 191: 525–531. AP2.H3 v.191

"We must not expect physical science to solve social problems. We cannot expect atomic fission to reveal the nature of the social atom and the manner of its control. If we want results in improved human relations we must direct our research at these problems."

McKee, Frederick G. Control of atomic energy. Free world (New York) v. 11, Jan. 1946: 40–41. D410.F78 v.11

Proposes formation of an International Atomic Energy Corporation to control energy, its production and use.

McKellar, Kenneth. The atomic bomb. An address in the Senate, Nov. 1, 1945. Congressional record, 79th Cong., 1st sess., v. 91: 10414–10416. J11.R5 v.91

Advocates outlawing of the bomb. Cites protocol for the prohibition of the use of poison gas as a precedent.

McMahon, Brien. Controlling atomic energy. Address by Senator McMahon on Sept. 25, 1945 and introduced by him into the Record October 18, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4722–A4723. J11.R5 v.91

Masters, Dexter and K. Way, *eds.* One world or none. A report to the public on the full meaning of the atomic bomb. Prepared by 17 world authorities on the subject. New York, McGraw-Hill, 1946. 79 p.

Contents: Introduction by A. H. Compton.—Foreword: Science and civilization, by N. Bohr.—1. If the bomb gets out of hand, by P. Morrison.—2. It's an old story with the stars, by H. Shapley.—3. Roots of the atomic age, by E. P. Wigner.—4. The new power, by G. Young.—5. The new weapon: The turn of the screw, by J. R. Oppenheimer.—6. Air force in the atomic age, by H. H. Arnold.—7. There is no defense, by L. N. Ridenour.—8. The new technique of private war, by E. U. Condon.—9. How close is the danger, by F. Seitz and H. Bethe.—10. An atomic arms race and its alternatives, by I. Langmuir.—11. How does it all add up, by H. Urey.—12. Can we avert an arms race by an inspection system?, by L. Szilard.—13. International control of atomic energy, by W. Lippmann.—14. The way out, by A. Einstein.—15. Survival is at stake, by Federation of American (Atomic) Scientists.

The mind of science. American affairs (New York) Jan. 1946, v. 8: 29–34. HC101.N317 v.8

Extracts from the testimony of scientists before committees of Congress. "They represent the scientific mind working at the level of ordinary understanding."

Mowrer, Edgar A. Understanding the atomic bomb. Article introduced into the Record by Mr. Judd, Oct. 29, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A4909. J11.R5 v.91

Advocates joint Congressional committee to take testimony and resolve conflicting viewpoints on how serious a threat the atomic bomb really is.

Myer, Walter E. Political education for the atomic age. The Social studies (Philadelphia, Pa.) Feb. 1946, v. 37: 56–60.

The new age of atomics. London, The Social science association, Oct. 1945. 16 p. (No. 1)

Brief articles on some of the achievements of science written with the aim of explaining the part science can play in the social life of the community.

O'Connor, Tom. Atoms and you. New York, Pamphlet press, 1945. 21 p.

Ogburn, William F. Sociology and the atom; problem of changed methods of sociology to meet the future. American journal of sociology (Chicago) Jan. 1946, v. 51: 267–275. HM1.A7 v.51

"The use of atomic energy in machines will usher in the atomic age and more; the scientific revolution and its industrial uses may have even more extensive effects upon society than the industrial revolution ushered in by steam."

Oliphant, M. L. E. How the atom can be harnessed for peace: power production of nuclear methods; with diagrammatic drawings by G. H. Davis. Illustrated London news (London) Oct. 13, 1945, v. 207: 399–401. AP4.I3 v.207

Oppenheimer, J. Robert. Atomic weapons and the crisis in science. Saturday review of literature (N. Y.) v. 28, Nov. 24, 1945: 9–11. Z1219.S25 v.28

The former Director of the Los Alamos laboratory where the atomic bomb was constructed believes that man's fear of this terrible weapon may drive him into peace.

The Philadelphia resolution. Science (N. Y.) Dec. 14, 1945, v. 102: 608. Q1.S35 v.102

Text of a resolution (1) calling for a world authority to control the atomic bomb and (2) protesting the restrictive character of the May-Johnson bill for the domestic control of atomic energy. More than 1,200 scientists in the Philadelphia area endorsed the resolution.

Potter, Robert C. A B C of atomic energy. New York, Robert M. McBride and co., 1946.

Announced for May publication.

——— Atom comes of age. New York, Robert M. McBride and co., 1946.

Announced for May publication.

Present, Richard D. Scientists have no illusions. Free world (N. Y.) Dec. 1945, v. 10: 42–44. D410.F78 v.10

"The scientists are in agreement that the United States will forfeit its moral leadership if it does not take immediate steps to place atomic energy developments under international inspection and control."

The problem of atomic energy. The Antioch review. (Yellow Springs, Ohio) Winter, 1945–46. v. 5: 459–523. AP2. A562 v.5

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Should we share the secret of the atomic bomb with any other nation? Bulletin of America's town meeting (N. Y.) Oct. 25, 1945, v. 11: 3–21. H69.T6 v.11

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The use of the bomb was justified to end this war—the jurist believes. There must be no more wars, he concludes.

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West central industrial association. National safety and economy require inland plants to aid defense program. Statement introduced into the Record by Mr. Olin D. Johnston, Nov. 2, 1945. Congressional record, 79th Cong., 1st sess., v. 91: A5009–A5010.
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—— —— A bill to prohibit unauthorized disclosure of information concerning atomic bombs. Introduced into the House by Mr. Sumners, September 11, 1945 and referred to the Committee on the judiciary. 1 p. (79th Cong., 1st sess. H. R. 3997) GPRR

—— —— Concurrent resolution [to create a joint committee for the purpose of making a full and complete study and investigation with respect to the control of the atomic bomb]. Introduced into the House by Mr. Harris, September 11, 1945 and referred to the Committee on rules. 3 p. (79th Cong., 1st sess. H. Con. Res. 83) GPRR

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Letter from: Sec'y of War enclosing telegram; Dr. Arthur H. Compton; Dr. R. J. Oppenheimer; Hon. J. Voorhis, Memb. Congr. Calif.
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U. S. *Congress. Senate.* Joint resolution authorizing experiments with bombs or other weapons utilizing atomic energy to determine their effect on naval vessels. Introduced into the Senate by Mr. Hill, October 2, 1945 and referred to the Committee on military affairs. 2 p. (79th Cong., 1st sess. S. J. Res. 103) GPRR

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—— —— A bill for the development and control of atomic energy. Introduced into the Senate by Mr. Ball, Nov. 6, 1945 and referred to the Special Committee on atomic energy. 10 p. (79th Cong., 1st sess. S. 1557.) GPRR

—— —— Resolution [expressing the sense of the Senate (1) that the President enter into negotiations with other nations with a view to reaching an agreement which will prohibit the use of the atomic bomb as a weapon or instrument of war, and (2) that this country encourage the United Nations organization to use its powers effectively to prevent the use of the atomic bomb as a weapon or instrument of war]. Introduced into the Senate by Mr. McKellar, Nov. 8, 1945 and referred to the Special Committee on atomic energy. 2 p. (79th Cong., 1st sess. S. Res. 186.)

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—— —— A bill for the development and control of atomic energy. Introduced into the Senate by Mr. McMahon, Dec. 20, 1945 and referred to the Special Committee on atomic energy. 26 p. (79th Cong., 1st sess. S. 1717.) GPRR

—— —— A bill to provide temporarily for the development and control of atomic energy. Introduced into the Senate by Mr. Johnson, Feb. 9, 1946 and referred to the Special Committee on atomic energy. 29 p. (79th Cong., 2d sess. S. 1824.)

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Contents: Part 1, Nov. 27, 28, 29, and 30, 1945; Dec. 3, 1945. Statements of Dr. A. Sachs, Maj. Gen L. R. Groves, Dr. H. C. Urey, Dr. I. Langmuir, Dr. V. Bush.

Part 2, Dec. 5, 6, 10, and 12, 1945. Statements of Dr. J. R. Oppenheimer, Dr. H. A. Bethe, Dr. P. Morrison, Dr. S. A. Goudsmit, Dr. L. Szilard, Dr. J. A. Simpson, Dr. C. Williams, Dr. A. M. Weinberg.

Part 3, Dec. 13, 14, 19, and 20, 1945. Statements of Dr. R. Gunn, Commodore W. S. Parsons, Vice Adm. W. H. P. Blandy, Rear Adm. W. R. Purnell, Rear Adm. L. L. Strauss, F. R. Creedon, H. E. Thompson, H. A. Winne, and E. H. Brown.

Part 4, Jan. 24, 1946. Statement of Vice Adm. W. H. P. Blandy.

Part 5, February 15, 1946. Statements of Maj. A. P. de Seversky, Gen. T. F. Farrell, Col. S. Warren, P. H. Nitze, Prof. H. L. Bowman, Dr. L. L. Terry, Dr. P. Morrison, Dr. L. N. Ridenour. Revised statement of Dr. A. Sachs.

——— *Atomic energy Act of 1946.* Hearings before the Special Committee on atomic energy, U. S. Senate, 79th Cong., 2d sess., on S. 1717, a bill for the development and control of atomic energy. Washington, U. S. Gov't. print. off., 4 parts, 1946.

Contents: Part 1, Jan. 22 and 23, 1946. Statements of H. D. Smith, W. H. Davis, Hon. J. Forrestal, Vice Adm. W. H. P. Blandy, and Hon. H. L. Ickes.

Part 2, Jan. 25, 28, 29, 30, 31, and Feb. 1, 1946. Statements of Dr. R. M. Hutchins, Dr. R. Redfield, Dr. R. G. Gustavson, Prof. E. H. Levi, Dr. H. Davies, Dr. H. Shapley, Dr. I. I. Rabi, W. Davis, R. Swing, Dr. J. von Neumann, Hon. H. A. Wallace, Dr. K. T. Compton, Prof. E. Teller.

Part 3, Feb. 7, 8, 11, 13, and 14, 1946. Statements of J. A. Rafferty, G. E. Folk, E. D. Bransome, F. F. Kett, I. Stewart, Capt. R. A. Lavender, Commander R. A. Anderson, A. C. Klein, B. Manly, Hon. R. P. Patterson, F. B. Jewett.

Part 4, Feb. 18, 19, and 27, 1946. Statements of Mrs. H. A. Stone, Mrs. A. C. G. Mitchell, J. C. Parker, Dr. R. McDonald, Mrs. H. Sibley, Commander S. Brunauer, Maj. Gen. L. R. Groves.

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ATOMIC ENERGY

HEARINGS

BEFORE THE

SPECIAL COMMITTEE ON ATOMIC ENERGY
UNITED STATES SENATE

SEVENTY-NINTH CONGRESS

FIRST SESSION

PURSUANT TO

S. Res. 179

A RESOLUTION CREATING A SPECIAL COMMITTEE
TO INVESTIGATE PROBLEMS RELATING TO
THE DEVELOPMENT, USE, AND CON-
TROL OF ATOMIC ENERGY

PART 3

DECEMBER 13, 14, 19, AND 20, 1945

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ATOMIC ENERGY

THURSDAY, DECEMBER 13, 1945

UNITED STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to adjournment, at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Johnson, Millikin, Hickenlooper, and Hart.

Also present: Vice Adm. W. H. P. Blandy, Deputy Chief, Naval Operations for Special Weapons; Rear Adm. William R. Purnell, Assistant Chief of Naval Operations for Matériel; and Rear Adm. Lewis L. Strauss, special assistant to the Secretary of the Navy; Edward U. Condon, scientific adviser; and James R. Newman, special assistant to the special committee.

The CHAIRMAN. The committee will be in order.

Gentlemen, we will let you handle your presentation in your own way.

Admiral STRAUSS. Mr. Chairman, we have two introductory paragraphs, with your permission.

The invitation to the Navy to appear before your committee this morning has not afforded sufficient time for the preparation of a formal statement, but in the light of the fact that the Navy does not appear before your committee to urge any special position, advocate any particular point of view, nor sponsor any pending legislation, there would not appear to be any purpose in a statement beyond such as may be elicited in the course of response to your questions.

The Navy is represented here today by Vice Adm. W. H. P. Blandy, Rear Adm. William R. Purnell, Commodore W. S. Parsons, Dr. Ross Gunn, and myself.

Admiral Blandy, formerly Chief of the Bureau of Ordnance, until very recently in command of amphibious groups in the Pacific, is now Deputy Chief of Naval Operations, his special duties being in charge of all interests in the Navy in atomic energy, guided missiles, and related matters.

Admiral Purnell is Assistant Chief of Naval Operations. From the outset of the Manhattan project, he has been the principal Navy representative on the Military Policy Committee for the atomic projects.

Commodore Parsons is Admiral Blandy's principal assistant. He combines the background of the Regular officer with that of the physicist. He has been associated with the development of the Manhattan enterprise since May 1943. He took the first atomic bomb to the Pacific and supervised its delivery all the way to the target.

Dr. Gunn is attached to the Naval Research Laboratory, where, at his suggestion and under his direction, the separation of the uranium isotope, or more properly the enrichment of uranium, was first successfully performed on any appreciable scale and many months before any other project had been inaugurated.

As for myself, I am special assistant to the Secretary of the Navy and have been serving as the Navy member of the Interim Advisory Committee on Atomic Energy.

We had expected, if you had no specific plan as to how you wished us to present the Navy aspect of this, to open with Dr. Gunn, to follow him with Commodore Parsons, Admiral Purnell, and Admiral Blandy summing up.

The CHAIRMAN. Admiral, that will be quite satisfactory, I am sure.

I presume that the Navy is conducting rather intensive research and study into the integration of this weapon into future naval operations. I understand, of course, we could hardly expect any testimony on that score today, although I do not want to restrict any testimony that you might need along that line. We would be glad to have it.

I was of the opinion that perhaps that work might be proceeding rather expeditiously and that after we return from the Christmas holiday we would hear the Navy again, either in open or executive session, as you gentlemen would determine, on your thoughts on the integration of this matter into the Navy's program for the national defense.

I wish you would proceed along those lines, if you would.

Admiral STRAUSS. We certainly will welcome the opportunity to appear again, Senator, whenever it is the pleasure of the committee, and I think with respect to those specific points you mentioned, if they should come up today, that Admiral Blandy and Admiral Purnell will be those witnesses who would be qualified to discuss them.

The CHAIRMAN. I might say further to you gentlemen that we have been leaving with the witnesses, of necessity, the election, if they are asked some question they feel should be answered in executive session, to just say so, and we will afford that opportunity. No offense will be taken if you say just that.

All right, Admiral.

Admiral STRAUSS. Dr. Gunn.

STATEMENT OF DR. ROSS GUNN, TECHNICAL ADVISER TO THE NAVAL ADMINISTRATION OF THE NAVAL RESEARCH LABORATORY

Dr. GUNN. Mr. Chairman, I think I would like to open my remarks by explaining to the committee the reasons lying behind the Navy's interest in this problem, in relation particularly to the work of the Naval Research Laboratory.

Admiral Blandy and Commodore Parsons will be more interested in the bomb, but our original approach was in a little different direction, which we knew had a direct bearing on the bomb problem.

I think a good many of us have been considerably alarmed in the last few years at the rate at which our coal and oil reserves were disappearing. We emerged from the war, and even though the Navy had oil reserves of various kinds we have cut into those reserves in a very deplorable manner.

I think that future generations will probably have something to say about our waste of the tremendous hydrocarbon reserves, oil and coal. The utility and usefulness of coal and oil under present-day developments in organic chemistry cannot be measured in terms of what they will do to run furnaces, boilers, and engines. The amount of oil and coal available is distinctly a fixed quantity. We are not getting any more. It takes millions of years to make it, and when it is gone, it is gone.

A good organic chemistry industry can make medicines, oils, lubricants, plastics—thousands of things that modern man and civilization requires and must have.

Many of us have worried about that, as I said, and within the last 15 or 20 years we have realized that there were other sources that might be tapped. Some of us were not at all surprised when, early in 1939, the conversion of the uranium nucleus was observed and energy from that transformation was made available.

As I see it, the main function of nuclear transformations is to take on the job of turning the world's wheels and driving its ships. In spite of the awful manner in which it has been presented to the world, I, for one, welcome it as giving a promise of a longer civilization than we would have ordinarily looked forward to; because at the rate we were going we certainly wouldn't have fuel to turn the wheels of industry in another 500 years.

One of the jobs of my Mechanics and Electricity Division at the Naval Research Laboratory is to explore the fundamental aspects of power production, utilization, storage, and conversion. We have spent years studying special methods of power production and conversion that were suitable for special naval applications. We have explored the use of special fuels, new methods of power storage, new types of engines that will achieve a particular objective; for example, the range and speed of a military ship is of the utmost military importance, and many an engagement at sea has been broken off under otherwise very favorable circumstances because the fuel supply was getting low and the ship didn't have enough fuel. Many a man has lost his life and ships have been lost while refueling at sea under adverse weather conditions or in the presence of an enemy submarine.

Obviously, if a fuel were available that was powerful enough to provide power for a capital ship, for example, for a year or more, such a fuel is obviously invaluable to the military services and will increase the military usefulness of that ship to a major degree.

We need more power; we need more speed. Our present-capacity to carry energy, if you please, is limited by the bunker size and what fraction of the ship's displacement we can assign to fuel. The Navy's installed horsepower of large units that are constantly in operation is measured in tens of millions. It is the largest single user of such power in the world, and for this reason the Navy has a profound interest in all aspects of power conversion.

We had been alert to the implications of nuclear power even before the announcement of the uranium fission, and we actually had under way in March 1939 work at the Naval Research Laboratory looking toward the utilization of nuclear power in ship propulsion.

I would emphasize again that the interest of the Naval Research Laboratory, which I particularly represent, has been in the practical utilization of nuclear power rather than the bomb aspects.

Admiral Strauss thinks that it might be worth while for me to review what we have done at the Naval Research Laboratory on this program, and I think I can summarize it very quickly and tell you why we want to use it.

Of course, the announcement that triggered off this recent change in our thinking was the announcement by two Germans of the fission of uranium and the further suggestion that this fission could be promoted by the fission of another particle, which had happened a short time before. In other words, we promote what we call a chain reaction. In January 1939 that announcement was made, but we were uncertain as to what part of the uranium material was important. There are two kinds of uranium in ordinary uranium, 235 and 238.

Senator HART. Was that January 1939?

Dr. GUNN. That was January 1939 when it was announced in this country. Many of us had been on the alert for this; and I must say that you should recognize that the scientist, since he has accepted the so-called Rutherford atom, has known that energy of this order of magnitude was going to be available sometime if we just knew how to unlock it. The energy was there, but we didn't know how to make it available.

On March 17, 1939, there was a discussion at the Navy Department, with both Navy and Army officers present, and scientists of the Naval Research Laboratory, of which I was one. A meeting was held, at which Professor Fermi and Professor Pegram, of Columbia University, were present. Fermi was known to me as a highly competent physicist, unexcitable, conservative, and while he did not definitely state that uranium chain reaction would take place—and this is a critical matter—he was fairly sure it would from all the data he had.

A few days afterward, in company with our Director, Hollis M. Cooley, a captain in the Navy at that time and, incidentally, son of Dean Cooley at Michigan, I went to Admiral Bowen, who was Chief of Engineering at the time, and asked for a minimum amount of $2,000 to get the work going on this project.

Our analysis showed, and it has been borne out completely, that there were three or four main problems to solve, one of which was the determination of which part of the uranium was the effective one. We now know what that is.

The next problem was to separate out the effective components, the so-called isotope separation problem; and the other one was to produce suitable chemicals that would permit this separation. One just cannot throw uranium into a hopper and separate it out. It is a big technical problem to do it actually.

We realized that if we could get enough of the active material together we could, if the theoretical people were right, take thermal energy from the so-called pile and convert it through the use of an engine into a propulsion system. We realized that if we could get very pure material it probably had application to a bomb, but that was not the laboratory's specific interest.

I have cited one case in which we are interested in nuclear power; namely, the case in which we would like to increase the range and speed of our surface ships. There is another possibility which appealed to us even at that time, and that is in a submarine. The great limitation in a submarine, as we have determined as a result of our experiments at the laboratory, is the fact that one must take down in a submarine not only the fuel but also one must take down the oxygen. That is true even in a battery, for in a battery operation you take down essentially oxygen in one plate and metallic lead in the other. In general, that limits the range and submerged speed that one can get, because one must provide volume and weight for the fuel and volume and weight for the oxygen with which to burn it.

Now, the utility of atomic power in submarines lies in the fact that one takes into the submarine one material only, and out of that one material it is possible to promote a nuclear reaction which will give you heat.

Moreover, the fact that the amount of energy per atom is so tremendous in a nuclear reaction means that this thing is going to be concentrated. It is hard to think of any ship more concentrated than a submarine; so, in a sense, the uranium conversion has direct application to the submarine problem. It is a possibility at least.

I don't think it is necessarily desirable to go into the details of this matter except to point out that, if there is any particular use for nuclear power, the submarine certainly suggests itself as a good place to try it.

With the foregoing background in mind, I would like to put on the record that on June 1, 1939, after analyzing this problem and making arrangements for cooperation with Prof. Jesse Beams at the University of Virginia, a memorandum was sent to our director on the possible uses of uranium power in the Navy.

Later on, various letters were sent out, but the important thing, I think, is to point out that even as early as February 1940, in cooperation with Professor Beams at Virginia, we had secured modest amounts of enriched uranium. By modest amounts I am thinking in terms of a gram or so.

By July 1940 we had actively set up a program in cooperation with the Carnegie Institution of Washington, the University of Virginia, and Columbia University, a forward-looking program that would ultimately lead to a power-producing pile.

We financed the work with the help of the Bureau of Ordnance, the Bureau of Ships, and the Army Ordnance at that time to an extent of about $40,000, and the work was coordinated entirely through the Naval Research Laboratory.

As a result of that work two or three things emerged which bear repeating.

The Carnegie Institution contract—the Department of Terrestrial Magnetism, this was—was to support a new method of isotope separation which Dr. Philip H. Abelson had examined and run some preliminary experiments on. It looked like a good wartime way of doing it, and our support put that method on its feet. We built a pilot plant at the Naval Research Laboratory and drew off samples of modest amounts for analysis. These showed that it was a practical method.

The CHAIRMAN. Is that the thermal diffusion method?

Dr. GUNN. That is the liquid thermal diffusion method.

The CHAIRMAN. What date was that?

Dr. GUNN. That contract was in effect and we were working with them in July 1940. The liquid thermal diffusion pilot plant at our laboratory—and this work was finally transferred to our laboratory along with Dr. Philip Abelson—was set up and operating in December 1942, and operating on such a basis that the data that we obtained at that time were later shown to be essentially correct.

It also happened that in December 1942 General Groves was invited to our laboratory and saw our outfit.

We gave to him the quantitative data that we had at that time, and suggested that it might have an important bearing on the national production. However, the Army took no action on our method until June 1944, which was 18 months later.

As a result of our work, and being sure that we had a method which was tolerably good, we went ahead with the help of the Bureau of Ships, and in June 1943 we recommended that we build a plant in Philadelphia, but construction was not started until November 1943 because we couldn't get the authority to do it. That plant was finally put in operation and we were taking samples off of it, in July 1944. We had some difficulty getting raw materials, but that was finally straightened out. I think the success or nonsuccess of that plant should not be discussed here.

This review of our part in the production of uranium isotopes is given, sir, to emphasize the fact that we are actively interested in power and its utilization in the Navy, particularly the special problems that face the naval service. We think that by means of our very early work we have shortened the time it took to produce the critically required material. If we had not worked on the thing at the start and early supported these university people we think perhaps the national production might have been delayed.

The CHAIRMAN. Doctor, how much money has the Navy spent altogether?

Dr. GUNN. The Naval Research Laboratory, including the experimental work at Philadelphia, expended \$2,000,000. To that \$2,000,000 should be added an amount which, as close as we can estimate, is about \$1,000,000 assigned to the Naval Boiler and Turbine Laboratory at Philadelphia, direct from the Bureau of Ships.

The CHAIRMAN. That would be \$3,000,000 altogether?

Dr. GUNN. That would be about \$3,000,000 that the Navy itself put into it.

The CHAIRMAN. What contact did you have with the Army on the problem between the first meeting that you had, which I believe was in 1939 with Army Ordnance? What meetings did you have with the Army or they with you in the interim period up until General Groves was shown what you had done in December 1942?

Dr. GUNN. There was established a committee, the S–1 Committee of the NDRC, which had an Army representative. At one time General Styer was on it, and they had, I think, two other representatives from time to time. The chairman of this committee was Dr. Briggs, who was then Director of the Bureau of Standards. The Army was informed of the work carried on by the committee through their representative.

The CHAIRMAN. Were you on the committee?

Dr. GUNN. I was on the committee for a time.

The CHAIRMAN. Did you report to the committee as to what the Navy was doing on it?

Dr. GUNN. The chairman of the committee was kept in touch with everything that we did.

The CHAIRMAN. That is Dr. Briggs?

Dr. GUNN. That is Dr. Briggs.

The CHAIRMAN. When was that committee set up?

Dr. GUNN. I am sorry, sir, I don't know; but you will find that in the Smyth report.

Senator HART. To connect up some of this early chronology, Doctor, the first witness before this committee gave a good deal of data covering the chronology of those early years.

I believe you stated that your first move outside your laboratory in order to get started was on March 20, 1939. Is that correct?

Dr. GUNN. That is correct.

Senator HART. Doctor, have you any idea as to when the President was first acquainted with the possibility of atomic fission?

Dr. GUNN. I understand that there was a meeting with a Mr. Sachs—I judge that is the man you refer to—on October 11, 1939.

Senator HART. Insofar as you know, did the Navy Department ever make these ideas known to the President prior to Dr. Sachs, whom you mentioned?

Dr. GUNN. I would not know about it, sir, if they had. I was too far down the line.

Senator HART. Do you recall receiving anything from Dr. Einstein in August 1939 that antedated or postdated your original undertaking of this problem?

Dr. GUNN. As far as I know, our laboratory never received any communication from Professor Einstein. In part answer to your original question, the Director of the Naval Research Laboratory did send to the Secretary of the Navy on November 13, 1939, a general review of our interest and proposals in this matter.

Senator HART. In case it ever was called to the President's attention directly by the Navy Department, who would know?

Dr. GUNN. I think Admiral Bowen, who was Chief of the Bureau of Ships at that time. The laboratory was operating under the Bureau of Ships, and he would be the man who would know.

Senator HART. You mentioned Dr. Sachs. In his testimony he stated that during those early steps, I believe in 1939, there had been an adverse report by the technical adviser of one of the services in the summer of 1939, and it was because of that that he, Mr. Sachs, went directly to the Commander in Chief, meaning the President.

Do you think that technical adviser could have come from your laboratory?

Dr. GUNN. I am sure that he wouldn't have come from our laboratory.

Senator HART. Did you hear Dr. Sachs' testimony?

Dr. GUNN. I read parts of it; yes, sir.

Senator HART. Do you know or have you any opinion as to why he said that there was a previous adverse report?

Dr. GUNN. I haven't the slightest idea why he would say it. I suppose that was his experience.

The CHAIRMAN. Doctor, when you met with Fermi and Pegram on March 17, 1939, did you put them under contract, or was any arrangement made with them for them to work on this problem?

Dr. GUNN. No, sir; not at that time.

The CHAIRMAN. You had great confidence in Fermi?

Dr. GUNN. We think very highly of Fermi. He was an experimenter in nuclear physics, and was an outstanding exponent at that time.

The CHAIRMAN. Was any arrangement made that Fermi and Pegram be put under contract and the Columbia project be started?

Dr. GUNN. That came later.

The CHAIRMAN. When?

Dr. GUNN. We made arrangement to set up the Columbia contract with our laboratory in July 1940.

The CHAIRMAN. In February 1940 you had gotten one gram. Now, where was that gram produced?

Dr. GUNN. I misled you, sir, in my testimony there. That was one gram of a 10 percent enriched sample, and that was produced at the University of Virginia. That was not pure metal, which you apparently interpret my testimony to mean.

The CHAIRMAN. But in July of 1940 you had concluded a contract with Columbia University?

Dr. GUNN. That is correct.

The CHAIRMAN. Was it the Navy that set up the Columbia project?

Dr. GUNN. The Naval Research Laboratory was the coordinating agency for the Bureau of Ordnance, the Bureau of Ships, and the Army Ordnance. The Army was in on that allotment of funds at that time.

The CHAIRMAN. Did you have any correspondence with Fermi and Pegram between March 17, 1939, and February 1940?

Dr. GUNN. I am quite sure we did. I had considerable correspondence with Pegram, and I think it fell in that interval.

The CHAIRMAN. I understand, Doctor—I am not certain of this, and I do not make it as an assertion of fact—that when Fermi and Pegram went to see you people in the Navy on March 17, 1939, they came away from that conference much discouraged, and that it was as a result of that discouragement that they got in touch with Dr. Sachs, who in turn got in touch with the President.

As I say, I don't vouch for that at all, but that is my recollection either of testimony or conversations to which I have listened.

Dr. GUNN. I think that is a fair deduction from what happened. You gentlemen must realize that this picture looks a great deal different today than it did look then. Here was a group of scientists who had been looking for something like this, but we didn't quite believe it. We didn't object in the least to the conversion of nuclear energy. It was conceded that energy was there all right, but the chain reaction, the idea of one molecule tripping off another, and that one tripping off another, and the same thing going on in a chain, was distinctly something that placed us in the position of being "from Missouri." We weren't sure of it.

I think everyone would be discouraged. I was discouraged. The laboratory didn't go into this work with the idea that the result was all going to fall out in a year or so. If we had known—and that is the point—that there was actually going to be a sustained chain reaction, we would never have got a chance to look at it. There would have been thousands of scientists working on it immediately.

The CHAIRMAN. Well, it was after Roosevelt, in the spring of 1940, had the meeting with Sachs that things began to happen.

Dr. GUNN. Well, unfortunately that is the way you get money to do a job in the Government service.

Senator HART. May I correct you, Mr. Chairman? I think that that date was October 1939.

The CHAIRMAN. October 1939? My recollection was confused. It was after the fall of France that additional effort was put in, and it was after that that things began definitely to happen.

Dr. GUNN. That is right.

Senator HART. Doctor, during those early days in the spring of 1939, did you or your associates or any one up in the Navy Department pay very much attention to the possibility of fission as a weapon rather than a source of power?

Dr. GUNN. Not very much attention to it specifically. We realized the two important solutions would fall out together, sir, and we knew that if we could solve the power problem the bomb application would automatically come out with a very small amount of additional work.

The CHAIRMAN. Doctor, how big were the contracts that you first made?

Dr. GUNN. Our first contract went to the Carnegie Institution. We tried to give them some money, and they said, "No; we don't like to take a contract; we will do it for you for nothing."

Finally we prevailed upon them to take a contract in the amount of $2,500, which was simply to cover the costs of some work that Dr. Abelson started there. That contract was dated November 3, 1940. As I say, they did work for us without charge and as a public duty.

Columbia University, on July 18, 1940, entered into a contract for $29,700, and on the same date, July 18, 1940, we entered into a contract with the University of Virginia for $13,000.

The work at Virginia was under the control of Dr. Jesse Beams. The work at Columbia was under Professor Pegram, and that at the Carnegie Institution was under Dr. John A. Fleming.

The CHAIRMAN. After General Groves took the thing over, how close was liaison kept with the Navy on this thing?

Dr. GUNN. There was liaison, sir, but I think it was one way; down at my level it was. Probably there was liaison farther up, but I did not experience it.

The CHAIRMAN. You mean you didn't know what was going on in the project?

Dr. GUNN. I had no idea what the Army was doing.

The CHAIRMAN. You had no idea?

Dr. GUNN. Except by making a guess. Being a scientist, I could make an intelligent guess.

The CHAIRMAN. Did you have any idea that there was a two billion dollar project under way?

Dr. GUNN. I don't know how much it was. I know it was a pretty big project, because we couldn't get additional people after it got under way.

The CHAIRMAN. General Groves is in Army Engineers, isn't he?

Dr. GUNN. That is correct.

The CHAIRMAN. Do you have liaison with the Engineers? Does the Navy have liaison in this branch with the Engineers or with Ordnance?

Dr. GUNN. That I cannot answer. I don't know of it. It didn't reach to our laboratory. I can only speak of what happened at our laboratory, sir; I cannot speak for the Navy as a whole on that matter.

The CHAIRMAN. Are you the Chief Physicist for the Navy?

Dr. GUNN. No; I am superintendent of two divisions at the Naval Research Laboratory, the Mechanics and Electricity Division and the Aircraft Electrical Research Division.

The CHAIRMAN. You were the fellow in the Navy that ought to know about this, weren't you?

Dr. GUNN. That is right.

The CHAIRMAN. You didn't know about it?

Dr. GUNN. I didn't know about it.

The CHAIRMAN. Did you make any attempt to find out?

Dr. GUNN. Yes, sir.

The CHAIRMAN. When you did, what were you told?

Dr. GUNN. I just didn't hear anything, sir; that was all.

The CHAIRMAN. How did you make the attempt—by letter or by phone?

Dr. GUNN. By direct personal contact, and I tried to write letters.

The CHAIRMAN. You tried to write them?

Dr. GUNN. I wrote letters, sir; I am sorry.

The CHAIRMAN. Did you get answers?

Dr. GUNN. No.

The CHAIRMAN. Acknowledgments?

Dr. GUNN. Yes.

The CHAIRMAN. What was in the acknowledgments?

Dr. GUNN. That the matter under consideration would be taken up with higher authority.

The CHAIRMAN. As far as you know, it never was?

Dr. GUNN. As far as I know, it never was. I think those are questions that should be directed, sir, to the military members of this naval representation.

The CHAIRMAN. Well, you have the Smyth report, though?

Dr. GUNN. Yes, sir.

The CHAIRMAN. Maybe that is what they were waiting for.

Senator JOHNSON. I should like to ask if you are familiar with the thermal diffusion set-up at Oak Ridge?

Dr. GUNN. No; I have never seen the gaseous diffusion plant, sir. In the early days before it was reorganized I had a good, full acquaintance with what was being done, but along about the time war began—December 6, 1941—the S–1 Committee was reorganized and we were disassociated from the project. I don't know what happened after the war began.

Understand, sir, that our laboratory has really done only one part of this job. We set out to take on the whole thing, but we did one job apparently too well, and we spent the rest of the war doing that one job.

Senator JOHNSON. What do you mean by saying "apparently too well"? I didn't know any job could be done too well.

Dr. GUNN. We have worked out a successful method for producing the fissionable material, and the country urgently needed it. That is what we did. We turned it out.

Senator JOHNSON. That is some other material?

Dr. GUNN. No; this is the separated isotope of uranium.

Senator JOHNSON. And they kept you on that particular job; is that what you mean?

Dr. GUNN. That is right.

Senator JOHNSON. Doing that particular job?

Dr. GUNN. That is correct.

Senator JOHNSON. Was that a fundamental part of the whole operation?

Dr. GUNN. Yes, sir; that was a fundamental part of it. There were three ways of doing it, three ways of separating isotopes, as summarized by the Smyth report.

Senator JOHNSON. At least three ways.

Dr. GUNN. At least three ways—I am sorry—the electromagnetic method, the gaseous diffusion method, and the liquid thermal diffusion. Our process was the liquid thermal diffusion process, and that is the one we worked on.

The CHAIRMAN. When you say "liquid," do you say that instead of the steam plant?

Dr. GUNN. Instead of the gaseous.

The CHAIRMAN. There is a thermal diffusion process—isn't that what they call it?

Dr. GUNN. They are both thermal, both the liquid and the gaseous are thermal diffusion processes.

The CHAIRMAN. What does the Smyth report say they used?

Dr. GUNN. They used all three.

The CHAIRMAN. The thermal process?

Dr. GUNN. They used both our system, the liquid, and the gaseous thermal diffusion, both of them.

Senator HART. I think the Smyth report limits its description of the gas diffusion to "gas." They don't mention "diffusion" in the title.

The CHAIRMAN. That is what confused me.

Mr. CONDON. Perhaps I ought to say here that your question, Senator, refers particularly to the thermal diffusion plant at Oak Ridge, I suppose, and that is the liquid thermal diffusion method that was developed by the Navy, I believe.

Senator HART. I think, Mr. Chairman, that in most of our description, and possibly in Dr. Smyth's report, the word "liquid" is left out of the description.

The CHAIRMAN. That is what confused me.

Senator MILLIKIN. I would like to know now whether the plant at Oak Ridge is a liquid thermal-diffusion plant, or whether it isn't?

Dr. GUNN. Oak Ridge has three plants, sir; one of every kind.

Senator MILLIKIN. And is there a liquid thermal diffusion plant there?

Dr. GUNN. There is.

The CHAIRMAN. Were you consulted about the construction of that plant?

Dr. GUNN. Yes, sir. Dr. Abelson went down there and spent some 2 or 3 months, and 10 of our men spent some months down there to help operate it and get it organized.

Admiral PURNELL. You designed it, didn't you?

Dr. GUNN. We designed it; yes, sir.

The CHAIRMAN. When you were applying for information, was it about other methods of separating the isotope?

Dr. GUNN. Well, sir, I was charged apparently with the research work that the Navy was doing at that time, or at least I thought I was, and I was trying to look at the problem as a whole. Naturally there were certain parts, and when you got one part going, you naturally turned to the next part to try to get that going. I wanted to find out in general what we should be doing.

Naturally I was trying to see the picture as a whole, sir; and I was interested in knowing what was going on so that in laying out my program of work I would not duplicate what other people were doing.

Now, it was suggested that we go ahead and get this information ourselves, but I was brought up to think you should not waste your money, and I didn't want to duplicate effort. I wasn't going to be a party to spending millions of dollars, or even one hundred thousand, to duplicate some work I knew my fellow scientists were doing elsewhere. It didn't make sense to me, so I refused to expand our work at that time because I was forced to work in the dark.

The CHAIRMAN. Does that mean that you were compartmentalized?

Dr. GUNN. Oh, I was compartmentalized all right.

The CHAIRMAN. Was that for security reasons?

Dr. GUNN. I think, sir, that should be addressed to Admiral Purnell.

The CHAIRMAN. All right.

Senator MILLIKIN. I should like to invite your attention, Doctor, to the fact—it appears to be a fact on the record—that the Germans did not compartmentalize. They were all working on an over-all basis, with the result that they never got anything done by the end of the war.

The CHAIRMAN. Do you think that follows as a result, Senator?

Senator MILLIKIN. I think you could argue that the method used of compartmentalizing, while offensive to science, resulted in the objective.

Senator HART. Might I say, Senator, that possibly instead of describing it as compartmentalized, that the scientists were managed.

Senator MILLIKIN. I can understand why that would be offensive, and I can also understand why it might be a good thing if you were seeking in a short time to produce a certain result.

Dr. GUNN. I don't believe scientists are as temperamental as some people say they are. We all recognize that there is a valid reason for security. There are two reasons for it, one to keep the enemy from finding out what you know, and also to keep the enemy from finding out what you don't know.

I think most scientists are willing to "play ball" on that basis when it is necessary.

Senator HICKENLOOPER. I understand, Doctor, that the chief efforts of the Naval Research prior to the time that this set-up was an over-all proposition, the Oak Ridge plant had been established, and so on, were devoted entirely to the development of the liquid diffusion method of producing this material, and that under your direction the Navy did go on until this method was perfected.

Let me ask you if in that development of that process you suffered any restrictions of accessibility to methods and to means directly affecting that particular process?

What I am trying to get at is whether you were restricted in information or in working in that particular process, or whether the restrictions applied to the gas diffusion method and the electric method and the plutonium development.

Dr. GUNN. But, sir, I would point out to you that we were developing this information. No one else in the world had it, and obviously we had access to our own information.

Senator HICKENLOOPER. I realize that. I am not discussing the question of the advisability of restriction of that information. I am trying to see if I can narrow it down to what was restricted and what wasn't, on the theory that if they adopted a strict compartmentalization philosophy as to this development program—whether we agree with it or not—there might have been at least some plausible reason as to why it should be done for the over-all project.

I am wondering whether the restrictions you have referred to on information applied to any information that you needed or that you wanted which applied directly to the liquid thermal diffusion process. Were you restricted as to that?

Dr. GUNN. There was no outstanding limitation. We had some difficulty in getting things we wanted, but they were straightened out ultimately. Of course, we had to do some fighting to get them.

Senator HICKENLOOPER. I would presume those difficulties would increase in proportion as you got into other fields where you meet, as Senator Vandenberg called it, an iron curtain.

Dr. GUNN. I never saw an iron curtain, but I think I understand what that means.

Senator HICKENLOOPER. He gave a very graphic description of the iron curtain. That is a question I wanted to get clear in my mind.

Senator MILLIKIN. The iron curtain in your business, Doctor, is when they tell you, "This will be referred to higher authorities."

I got the impression from something you said, Doctor, that on the whole you view this development of atomic energy as beneficent to the world rather than as harmful to the world.

Dr. GUNN. I am satisfied that is correct.

Senator MILLIKIN. That, of course, depends on whether we can harness the destructive features of it.

Dr. GUNN. That is correct.

Senator MILLIKIN. If we could harness the destructive features, then we would have nothing but the beneficent features left, and that, of course, opens the whole problem we have before the committee. It has been repeated here several times that when you use atomic energy for power purposes you are three-quarters of the way along toward using it for war purposes.

I think you have probably already answered the question that I intended asking you. If we cannot control that next, last step, then perhaps it would be better if we didn't take the first three steps. What would you say as to that?

Dr. GUNN. I don't know. That is a hard question, sir. I think I will leave that to the statesmen to answer.

Senator MILLIKIN. I won't press it further.

Senator HICKENLOOPER. I think the doctor is a citizen, and so are we all. I would value his opinion, if he cares to give it.

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Senator MILLIKIN. It happens I have to leave in a moment, and I want to ask two or three questions of the doctor.

Let me ask you this, doctor: Who were the nuclear scientists working with you at the time you conducted these early experiments?

Dr. GUNN. I was the only one that was qualified in the early days, and I finally hired away from the Carnegie Institution, after we had a contract with them, Dr. Philip H. Abelson, who was the codiscoverer of element 93 and he has been with me throughout this operation.

Senator MILLIKIN. Are you familiar with the testimony of Dr. Sachs?

Dr. GUNN. I have read parts of it, sir, but I would not say I was familiar with it.

Senator MILLIKIN. As I understood his testimony, he portrayed a picture of a neck-and-neck race between the scientists of various countries to make a weapon out of atomic energy and that he sold that picture to the President specifically on the ground that Germany was about to develop this kind of a weapon at most any moment.

Are you aware of the fact that we have had testimony that at the end of the war Germany had not even commenced to build a plant?

Dr. GUNN. That is correct.

Senator MILLIKIN. You spoke of this energy as a substitute for our dwindling resources in oil and coal. Would you say that we have suffered, considering the amount of coal we have, a serious depletion of coal?

Dr. GUNN. Not of coal, but distinctly of our oil reserves.

Senator MILLIKIN. But we do have very well-known methods expanded and developed by the Germans during this war of making oil out of coal, so that if we did not have this substitute method, and even if we ran out of oil, we could fall back on coal as a source of all the fuel oil we could possibly use over the long foreseeable future. Is that not correct?

Dr. GUNN. That is correct.

Senator MILLIKIN. Would there be any control factors in a pile in a submarine or a boat that might get out of control in the event of a hit which would cause larger damage than is now caused if you hit your steam plant or something of that kind?

Dr. GUNN. I would prefer to answer that in executive session, sir.

Senator MILLIKIN. What other nations, if you care to say, are working on this problem from the naval power standpoint?

Dr. GUNN. I have no direct information on that question.

Senator MILLIKIN. As far as you know, no other navy maintains a research program with the specific object of developing power for naval vessels?

Dr. GUNN. Right.

Senator MILLIKIN. Thank you very much, Doctor.

The CHAIRMAN. Doctor, did Naval Intelligence furnish you, from time to time, or at any time, with any information as to what was going on in Germany with regard to this project?

Dr. GUNN. No, sir; I never asked them for any information on the subject. I didn't think Naval Intelligence was informed in this matter.

The CHAIRMAN. I gather from your testimony, Doctor, that at least in this project there was no unification of the Army's and Navy's efforts in the matter?

Dr. GUNN. I think there was somewhere, but it didn't drift down to me. I didn't experience it.

The CHAIRMAN. And you were chief of the nuclear development——

Dr. GUNN (interposing). I was chief of one part of the work.

The CHAIRMAN (continuing). Having to do with nuclear energy, and nobody else in the Department except yourself was in charge of that work?

Dr. GUNN. I am glad to say that, throughout this whole matter, Commodore Parsons, who is here before you, was definitely associated with it, and I felt quite happy that the Navy had someone who was fully informed and, if anything important came up, the Navy had access to it, at least. Whether I had it is beside the point.

The CHAIRMAN. You didn't get it from Commodore Parsons?

Dr. GUNN. I will let you ask him that question, sir.

The CHAIRMAN. All right.

Senator HART. Mr. Chairman, I wonder if I might get an answer from either Admiral Purnell or Commodore Parsons to my question about whether or not the President was informed through the Navy Department of these early developments. Do you know, Admiral Purnell?

Admiral PURNELL. No, sir; I cannot answer that. I did not get here until July 1942, sir.

Senator HART. Does Commodore Parsons know?

Commodore PARSONS. I first heard of the project in May 1943, so it was far along before I got in on it.

The CHAIRMAN. If you would like the answer to that question, Senator, perhaps for the record they can furnish that information.

Senator HICKENLOOPER. Dr. Gunn, I would like to ask your opinion, partly in your capacity as a scientist, and partly in your capacity as a citizen—who is, I think, generally a pretty smart fellow—because I would value your opinion as such.

First, as a scientist, do you know of any substantial or revolutionary scientific discovery with tremendous potentialities for the good of humanity that has ever been discarded or has, in fact, ever been curtailed so far as scientific investigation is concerned?

The point of my question is: Are we going to stop investigating this atomic field from a scientific standpoint in spite of anything we may do in the way of laws, agreements, or anything else? Is science going to stop that?

Dr. GUNN. Well, I don't think you can stop progress. I think the answer to that is so obvious that it requires no discussion. We never have stopped it and never will. For short periods of time there have been impediments but averaged over a long period of time such discoveries have always proceeded.

Senator HICKENLOOPER. I think the answer is obvious, too, but we have a record to file here, and I wanted to have your opinion on that.

Now, as a scientist, and also as a citizen who undoubtedly has given some thought to general political aspects as life goes on, do you believe—considering human nature, considering the magnitude and the technicalities of this thing, or a combination of the political and scientific fields—that it is reasonably feasible or possible to continue with scientific investigation to the limit of our ability as we learn more, to develop this atomic field of energy, and to devise some human way to limit it to the development of energy for the public good and to stop, control, or prohibit that last 25 percent, after you get the material, from going into bombs?

Dr. GUNN. Well, sir, that is a tough question, and I want to answer that as a citizen.

Senator HICKENLOOPER. We have got to answer that here.

Dr. GUNN. As a citizen, I am not too happy about the proposals made by some of my fellow scientists. I would like to have one question answered before I go along with their recommendation on international agreements.

If there is any basis to scientific endeavor, it means that if we perform an experiment five times and get a certain answer, the basis of our belief is that if we do it the sixth time we will get the same answer, or the tenth time, unless the fundamental variables have changed.

When people talk about international agreements, I would like to ask them to give me a quantative figure of the probability of an international agreement lasting 25 years, 50 years, or 100 years. And if that probability isn't finite and of appreciable size, then I say we should not do the experiment over again. That is all I know about it, sir.

Senator HICKENLOOPER. I don't think there is any difficulty in the mind of anybody as to what we should do with this thing. We should prohibit its use as a weapon. It is easy for anybody to say that. I don't mean to say that is exactly what you said, but that is the end result here.

We should prohibit its use as a weapon because of the horror and the vastness of its destructive power; but between having this awful thing on our hands, and what we should do with it, and how we should accomplish that result of prohibiting its use for the destruction of humanity, are some of the questions that this committee is going to be called upon to try to answer.

Manifestly, in my mind, science is going on to experiment. You cannot stop it. You couldn't stop it in the electrical experimentation, and electricity has been used to kill people. You couldn't stop it in gunpowder, although it has peacetime uses and is beneficial; yet it has gone into the field of destruction and killing, and countless other things.

Radio investigations, electronics, and all those things with their vast peacetime good have been turned to some of the most terrible killers that we have when man feels he is in danger.

Now, this can go to a point where it will produce energy. It will produce materials that can be beneficial to medical research and public health. It will ease life and probably give us a lot of comforts at some time in the future, and yet there is always that last 25-percent step there through which the material that will bring the benefits can be taken in order to bring about the most destructive thing that we yet know.

I think if we did have some kind of a snub we could put on that thing to snub it right down to the uses for benefits, of course that would be one answer. If we could stop it, or stop some dishonest nation from violating its contracts, or doing things of that kind, to use or divert some of this to the weapon stage, well and good. If we cannot, then what?

Dr. GUNN. Well, sir, we are all looking for a snub to be applied at the right time. The trouble is rascals fix it so there is grease on the snub.

In figuring the probability of international agreements lasting long periods of time, I would like to set over against that the probability of unilateral agreements lasting over long periods of time.

The Monroe Doctrine has lasted for a long time. It was not an international agreement; it was a one-man agreement. I think that is the only way.

Senator JOHNSON. Backed up by force, Doctor.

Dr. GUNN. Yes; backed up by force.

Senator JOHNSON. And it was only as good as the force back of it?

Dr. GUNN. That is correct.

Senator HICKENLOOPER. I would like to go into the matter of inspection, and I am not trying to cross-examine you.

Dr. GUNN. I am glad to be cross-examined, but I don't know anything about it.

Senator HICKENLOOPER. Neither do we. You have nothing on me, at least, in that respect.

Inspection has been discussed here, and manifestly that is a very plausible field for discussion. It gives a very plausible answer on the surface: "Sure; go in and inspect all these people, and the minute you find them diverting, do something to them."

What?—that is anybody's opinion, but that can be worked out.

I don't know whether you have gone into this sufficiently, or whether your experience in this field has been sufficiently extensive in the weapon end of the thing to say that, but if you would care to give an opinion, do you believe that it will be feasible to establish such an inspection system that can detect and immediately make available the information as to the diversion of this material in that last 25-percent step at a reasonably early period in its diversion before people can start making bombs that will go off?

Dr. GUNN. I don't think any scientist really knows the exact answer to the question you have propounded, but I think it can be done.

We have powerful instruments—Geiger-Mueller counters, we call them—which detect quite a small amount of material, and if backed up by adequate and competent and continuously observant personnel, I think it could be controlled. The trouble is, of course, that someone will perhaps grow careless.

I would put it this way: I think it is not impossible; I think it would be a hard job.

Senator HICKENLOOPER. Have you thought a great deal about this inspection?

Dr. GUNN. No, sir; I honestly don't know anything about it.

Senator HICKENLOOPER. Thank you, Doctor.

Senator HART. May I ask any of the witnesses to answer this, whichever one knows most.

The Navy Department has given out a statement dealing with future experiments, using the bomb against a ship or ships. I would like to ask if, in planning this experiment, the Navy Department intends to make full use of all the scientific knowledge and experience available in this country?

Admiral BLANDY. No final plans have been approved, Senator, for those tests. We are in the act of planning them now. We have not come to that particular bridge yet, but we certainly will.

Senator HART. My question is: Do you intend to use all of the talent which is available in making the detailed plans for this experiment?

Admiral BLANDY. I wouldn't say that we intended to use all of the talent available in the entire country. I think that might be an unwieldly organization. But we do intend to consult the scientists whom we consider qualified and responsible in that matter; yes, sir; particularly to take care of the hazards involved.

Very thorough study will be made of the hazards in planning the details of the test so as to minimize the danger not only to those of us involved but to anyone else.

Senator HART. Will there be full cooperation with General Groves' organization?

Admiral BLANDY. Yes, sir.

The CHAIRMAN. Admiral, when do you prophesy that this test can be held?

Admiral BLANDY. We have set no exact date, but I think we can do it sometime in the coming summer.

The CHAIRMAN. Has a joint board been set up?

Admiral BLANDY. There has been established a Military Advisory Board to General Groves. There also has been established a committee for planning the test, but that committee has not completed its work.

The CHAIRMAN. Has the personnel of that committee been announced?

Admiral BLANDY. The personnel of the committee has not been announced; no, sir.

The CHAIRMAN. Do you intend to announce it?

Admiral BLANDY. It would not be in my province to announce that. It is a committee under the Joint Chiefs of Staff.

The CHAIRMAN. I wish you would take it up with the Secretary and let the committee have a statement as to the personnel, what branch of the service they represent, which is going to supervise the test.

Admiral BLANDY. I will do that, sir; but, as I say, that cannot be done yet because the exact organization has not been determined, the organization for executing the test and for appraising it. It is in the process of being determined now, and I am sure the names of the personnel involved will be published as soon as that work is completed.

Senator JOHNSON. Is it planned to make this test in the nature of a depth bomb and also in the atmosphere above the sea?

Admiral BLANDY. Studies are being made of both of those phases, but, as I say, the details of the test have not been completed.

Senator JOHNSON. I want to ask the Doctor a question. He made reference to a submarine using uranium power. I presume that the problem of eliminating the death rays or gamma rays has been overcome for that purpose?

Dr. GUNN. Sir, I think that ought to be discussed in executive session. It is a technical matter.

Senator JOHNSON. A physicist testified yesterday and suggested that it might be advantageous, especially in wartime, for sea traffic to be all done by submarines, or to be largely done by submarines; that is, large ships moving below the surface of the sea, escaping the storms and the waves and other resistance.

Have you made a study of the propulsion of very large cargo ships?

Dr. GUNN. Sir, I would rather delay that to an executive session. I think we should observe, however, if the enemy doesn't know where you are, they are not going to drop a bomb on you; and if you are in a submarine, they wouldn't know.

Senator JOHNSON. Yes; I think that is quite obvious, and that is one of the reasons why the physicist suggested that that held great possibilities for the future protection of transportation.

Dr. GUNN. I won't disagree with him.

Senator JOHNSON. This same physicist testified yesterday that the atomic era began on December 2, 1942.

You have testified to the chronological development of this whole matter. Do you agree that historians will say that December 2, 1942, was the date the atomic era began?

Dr. GUNN. I would like to word that as the "beginning of the era on the earth." Atomic processes have been taking place in the stars for a great many millions of years.

Senator JOHNSON. And have probably taken place on earth, too, before man came here; but that is the historical date?

Dr. GUNN. I think that is correct. That is the date at which the first pile was started. It operated very weakly, but it showed that the numerical calculations were substantially correct.

Senator JOHNSON. And the chain reaction was in effect?

Dr. GUNN. The chain reaction did in fact take place. If we had known that one simple fact, irrespective of all technical developments—if we had known this one simple fact when uranium fission was first announced, I think we could have gone ahead a great deal faster, and the scientists would have been willing to recommend a greater expenditure of money more rapidly if we had been sure of that one thing. That was the crucial experiment.

The CHAIRMAN. Doctor, as I take it, you believe that the liquid thermal diffusion method that the Navy developed and operated in December 1942 on a laboratory scale, which General Groves saw in December 1942, had a material bearing upon the development of the process?

Dr. GUNN. Yes, sir.

The CHAIRMAN. As I understand your testimony, and I want to get it straight, the Army, however, took no action until 18 months later?

Dr. GUNN. On our method, sir. They had other methods they were actively pushing, but on our method they took no action.

The CHAIRMAN. On your method there was nothing done for 18 months?

Dr. GUNN. That is right. Our method had the serious objection that it took a great deal of steam to operate it. We recognized that it is not a method one would normally select in peacetime, when one had plenty of time. It had the recommendation of being exceptionally clean. We felt, weighing all the factors, and having the steam boilers in the country, it offered a practical solution that looked better to us than anything else that we had seen.

Naturally we were prejudiced, and thought it was pretty good. I think the other methods are good, and I am amazed at what they have done with them. I think the Manhattan project did an amazingly good job in the time they had to work on it.

Senator MILLIKIN. Doctor, from the testimony of one of our previous witnesses the impression was brought to my mind that if you explode an atomic bomb at great depth you would produce a sort of marine earthquake. I assume that the Navy has a vast store of information and experience on the effect of underwater concussion. Am I correct in that?

Dr. GUNN. That is correct in terms of ordinary explosives, sir; but we have no data, obviously, on the atomic explosive.

Senator MILLIKIN. If you know the forces that are released at a given moment at a given depth in the water, you can calculate with reasonable accuracy how far that will extend and what the effects will be within an area?

Dr. GUNN. That is correct.

Senator MILLIKIN. Would it be appropriate in open hearing to ask you whether you gentlemen have made calculations on the effect of the atomic bomb if dropped at depth and if dropped at less than depth in an assumed disposition of naval forces?

Dr. GUNN. Some rough and highly speculative calculations have been made. I honestly don't recall the final results, but they lead to results which we would infer from simply the land data, I think.

The CHAIRMAN. How do you gentlemen now wish to proceed?

Admiral STRAUSS. We would like to offer Commodore Parsons' testimony, Mr. Chairman.

STATEMENT OF COMMODORE W. S. PARSONS, ASSISTANT TO THE DEPUTY CHIEF, NAVAL OPERATIONS FOR SPECIAL WEAPONS

Commodore PARSONS. I came into this project at a fairly late date in its career. It was, I think, the 5th of May in 1943.

I was informed by Admiral Purnell that I was assigned to this project and was instructed by Admiral King as to the security limitations, which were of course paramount at that time.

The CHAIRMAN. Commodore, wouldn't it be a good thing if you were to tell us about your previous experience that led the Navy to bring you into this work?

Commodore PARSONS. All right; I will do that.

I was assigned to the duty of experimental officer at the Naval Proving Ground at Dahlgren, about 40 miles down the river, in August 1939, and was associated with some of the original NDRC ordnance experiments which began in the fall of 1940.

Senator HICKENLOOPER. Mr. Chairman, I would rather have these alphabets interpreted.

Commodore PARSONS. That is the National Defense Research Committee originally, which later transformed into the Office of Scientific Research and Development, as far as the parent organization was concerned.

That, of course, as the war proceeded, led into more and more scientific and accelerated ordnance development, especially experimental ordnance, and in April 1942 I was called to Washington for additional duty, which turned out to be about 5 days a week as Special Assistant to Dr. Bush in connection with the development of the radio proximity fuse. That was development in which, you might say, the electronic initiative was taken by the section under Dr. Tuve, and the backing and enthusiasm for the production were taken by the Bureau of Ordnance and the Navy Department; so it was a fair combination to put an experimental officer from the Navy Proving Ground into the middle of the scientific organization, so that he was wearing two caps.

That led to taking the fuses into battle in January of 1942. I made it a condition to get down there, presumably with a one-way ticket; but it turned out to be a two-way ticket.

I came back, and this project descended on me in May of 1943, I think partially as a result of saying good-bye to Dr. Bush.

I think the ordnance concept of the project was crystallized somewhat in April of 1943. The physics laboratories at Los Alamos were then under construction, and a committee went out there, composed of Dr. Tolman as chairman and quite a few scientists and engineers who had experience in ordnance developments. During the war they advanced the idea that the ordnance work would have to be so closely integrated with the physics work and the chemistry that a proving and testing ground would have to be constructed in the immediate vicinity of the laboratory and presumably under the direction of the laboratory. That led to getting an ordnance engineer nominated for the job of Ordnance Division leader at Los Alamos.

The set-up at Los Alamos was not conducive to the immediate construction of proving grounds for heavy ordnance work, being 50 miles from the nearest railroad and having ravines and mountains all around; but it was possible, with the priority and urgency of the project, to get results in spite of that.

I would say throughout 1943 there was very little except theory to go on. We finally forced ourselves to design one or two types of workable bombs, and then having hypothesized them we built models of them and got started that way in actual work with B–29's in the early spring of 1944.

The concept of the laboratory turned out to be good, but about one-tenth of what we actually needed in terms of men and materials. It expanded, I think, from the original idea of 70 good physicists to many times that number, and a lot of lesser talent besides.

By the middle of 1944 we were getting active materials from Oak Ridge and Hanford, and experiments in physics threw more light on the design that was required. We made some very discouraging discoveries in physics which controlled our ideas of design, but nevertheless there was always ahead a good chance that the thing would succeed in at least one way, making a bomb.

We organized the delivery group of aircraft in September 1944, and from that time on we were training our delivery B–29 crews, and at the same time experimenting in the perfection of the bomb itself.

By the spring of 1945 we had the active material coming in faster and faster, and the experiment, fortunately, the ordnance experiment, also bore fruit; and it was possible by the early spring to take the first step to go to an advanced base and start the laboratory buildings and assembly buildings which were essential to the building of the bomb in battle.

Parallel with that, we prepared for the test in the desert, which we hoped would be a test of a bomb which could be delivered in battle and not some monstrosity which could only be set up over 2 or 3 acres of ground. Of course, we assumed that the test we made in New Mexico would succeed, and we had all of our groups en route to the Marianas when the bomb went off in New Mexico. It did succeed, and we were ready to go in less than 21 days.

The CHAIRMAN. In other words, Doctor, from the time that you entered the project there was the hardest kind of work to get it out as quickly as you could, and there was no delay at all that you can tell us about except the delays that were consequent to the difficulties of the project?

Commodore PARSONS. That is right.

The CHAIRMAN. And the bomb was delivered as quickly as it possibly could be delivered?

Commodore PARSONS. Yes. I think the material which went to Hiroshima probably had not been 3 weeks out of Oak Ridge, out of separation, or Hanford. It was going that fast.

Senator HART. Commodore, to carry you back a little, you used the word "monstrosity" just now.

Do you mean that there had to be a great deal of adjustment of ideas between the ordnance engineering personnel and the scientists who had to devise the means by which the bomb would be exploded?

Commodore PARSONS. No; I don't think there was much adjustment, if you mean friction in the adjustment. It was an absolute confirmation of the need to have the engineering on the bomb done with the physicists and by the physicists.

With the changes being made as they were in that development, the basic engineering had to be done practically by the Nobel-prize-winning physicists who were developing the bomb. It turned out that way. An ordinary engineer is about two stages removed from the furthest advances in nuclear physics, obviously, and that was the integration that we had to have.

Senator HART. It was decided that the bomb should be used from a plane. Did you take great part in deciding upon the dimensions, and so on, of something that would be practicable of use?

Commodore PARSONS. Yes. We worked on the problem beginning in December 1943, trying to settle on something which could be carried by an existing airplane. The B-29 was then a secret, and it had a lot of weaknesses which were eliminated in the next year, I would say; but we adopted the B-29 without serious modification as our airplane. We realized that if we built something that could only be carried in an airplane which had to be tailored to it, we would probably not make the war even if the bomb was developed. So we forced ourselves to take an existing successful airplane as the carrying vehicle.

Senator MILLIKIN. Commodore, may I ask whether the advance base was necessary to accommodate the airplane or the peculiar nature of the bomb?

Commodore PARSONS. The advance base was not necessary to accommodate the airplane, because they already had in the Marianas almost a thousand B-29's based there. It was the most tremendous concentration of air power that I think has ever occurred, and we just cashed in on that.

Senator MILLIKIN. But the bomb problem itself made it necessary to get as close to the target as possible, without going into the bomb problem? I mean, could you produce the same result from San Francisco, assuming you had the proper plane?

Commodore PARSONS. Staging it across, you mean? Oh, yes.

Senator MILLIKIN. Could you have assembled your bomb at San Francisco and carried it from San Francisco to the target, assuming you had the plane to do it, as well as you could from your advance base?

Commodore PARSONS. Yes.

Senator MILLIKIN. In other words, the proximity of the base to the target is not an essential factor so far as the bomb is concerned?

Commodore PARSONS. That is correct.

The CHAIRMAN. What is the distance of that nonstop flight from Tokyo to Washington?

Commodore PARSONS. I think it was 6,500 miles.

The CHAIRMAN. How far would it have been from the Aleutians down to Hiroshima and Nagasaki and back again?

Commodore PARSONS. I don't know, sir.

The CHAIRMAN. Does anybody know that, approximately?

Admiral PURNELL. I think it is approximately the same as from the Marianas.

The CHAIRMAN. You mean it is approximately the same distance from the Aleutians down to Hiroshima as it is from the Marianas up to Hiroshima?

Admiral PURNELL. Yes. I would have to look it up, but it is in that neighborhood.

The CHAIRMAN. So far as we can see, there would be no reason why you couldn't take the bomb from the Aleutians down there and return to base?

Admiral PURNELL. I would have to check that, but I think it is close.

Commodore PARSONS. If the distances are comparable, that is a correct assumption.

The CHAIRMAN. Of course, Commodore, with the improvement in airplanes that are projected, the possible distance for flight round trip is going to be much greater; don't you think?

Commodore PARSONS. Yes, sir.

Admiral STRAUSS. Mr. Chairman, I don't know whether I made it clear in my introductory description of Commodore Parsons that he was the weaponeer on the plane which delivered the initial bomb. He was present in person.

The CHAIRMAN. Well, I gather from that, Admiral, that you think it might be advisable to go into the experience itself.

Admiral STRAUSS. No; I simply felt my introduction was deficient in making that point clear.

The CHAIRMAN. Perhaps you should tell us about it, Commodore.

Commodore PARSONS. Well, I think I might say why that idea was sold originally. It is, I think, a sound philosophy in ordnance design to have the person who is responsible for the design, the reliability of the design, and the workability of the design, at all times have in the back of his mind that he is going to see it into the initial battle use. It has, let us say, a sobering effect on the ordnance designer, and I had had that philosophy in mind in other weapons.

It is such a good philosophy that I sold that idea to General Groves early in the game, so I had my ticket written about the summer of 1943 for that job.

The CHAIRMAN. You released the bomb personally; did you not?

Commodore PARSONS. No; I didn't pull the lever. I was there, and the identification of the target was confirmed with me.

Senator MILLIKIN. You prepared the bomb, didn't you, Commodore, for the job, without going into detail?

Commodore PARSONS. You mean in the airplane after the take-off?

Senator MILLIKIN. Yes.

Commodore PARSONS. I had an assistant who made the electrical tests on the bomb in flight. I went into the bomb bay and performed an assembly operation on it after the take-off, and then also supervised the final preparations which took place just before we climbed to delivery altitude.

We were about 20 minutes before the final climb which would put us at delivery altitude over the Empire and decided to make it a final bomb then and there, and of course we could have gone into reverse if we had to go back, but we made it a bomb about 20 minutes before we climbed to delivery altitude, and made final tests about 10 minutes before we reached the target.

Senator MILLIKIN. I had read that you did a lot of practice before you tried it on that trip.

Commodore PARSONS. Yes; we had to do that to prove each component, and unfortunately we didn't have all the components at the same time, so we had to make a large number of tests. It was so large and so apparently adequate that my assembly crews said they could hardly believe it was anything but one of the old practice bombs, because it involved all of the nonexplosive components.

Senator MILLIKIN. Tell us some more about that.

Commodore PARSONS. I would say there is another advantage in having the ordnance designer go along, and that is that when you cannot inform the crew of the nature of the design or anything except that it is an extremely powerful bomb, it is also steadying to the crew to have the ordnance designer riding with them on the delivery flight.

Senator JOHNSON. Did you see the bomb as it exploded? Were you looking in that direction, or could you feel the impact?

Commodore PARSONS. We certainly felt the impact. We were about 11 miles away, I believe.

Senator JOHNSON. And you felt the impact?

Commodore PARSONS. Yes; we felt two shocks; one, the direct path, and the other the first reflection from the ground.

To answer your question about whether I saw it go, I did not see the one on Hiroshima actually function because we had just completed a maneuver to get a lot of distance between us and the bomb, and that put our tail toward the bomb. The only one who could see it clearly at that time was the tail gunner.

Senator JOHNSON. Was the light so bright it blinded him?

Commodore PARSONS. I know this: He had his polaroid goggles set to maximum extinction, and he was also looking down into his machine gun when the bomb actually went. He got quite a lot of flash, anyway.

I got a flash through the side window, which indicated that the sky was sufficiently bright, even looking 90° from the bomb, to give you a flash through full-extinction polaroid goggles. That was at 8:15 in the morning, Japan time.

At 5:30 in the morning, New Mexico time, I was looking at the first atomic bomb from a B-29 rehearsing the Hiroshima job, and the flash there was tremendous, of course, because it wasn't in competition with the sun. It lit up the whole sky, and it also went through these goggles, not quite blinding but almost blinding through full-extinction polaroid goggles.

Senator JOHNSON. How far away were you at that detonation?

Commodore PARSONS. I think we were about 28 miles slant range.

Senator JOHNSON. Did you feel the impact?

Commodore PARSONS. Barely. It was a very soft impact which was only felt by myself, the pilot who felt it on his controls, and the bombardier. The rest of the crew did not notice it at 28 miles.

The CHAIRMAN. How much of a toss did you get over Hiroshima?

Commodore PARSONS. Well, the crew who had been over Germany a lot and had been in heavy flak said it was just like a very close—about 20 to 25 feet—heavy antiaircraft shell bursting.

The CHAIRMAN. Was it like hitting an air pocket at all?

Commodore PARSONS. It is sharper than that. With an air pocket you usually have a slight warning. This thing came just like a blow.

I think Ashworth, who was over Nagasaki, said it was as if the B-29 were being beaten by a telephone pole.

Senator MILLIKIN. Did the flash have any unusual color?

Commodore PARSONS. We couldn't tell the color, because we were seeing it through these goggles. If you look at an electric arc through those goggles, it looks bright purple; and that is what this thing looked like, bright purple, like a tremendous electric arc.

Senator MILLIKIN. If you had looked at normal flak through the same goggles, would it have appeared the same?

Commodore PARSONS. The bursting of an antiaircraft projectile? No; I think it is much on the blue side. It is so hot it is like an arc rather than the color of a detonating explosive.

Senator MILLIKIN. If you looked at a big TNT explosion on the ground through those same glasses, would there have been any difference in the appearance of the flash?

Commodore PARSONS. It is very different, really. TNT will give a ball of fire which is red, I think, at night; and this is white or blue.

Senator MILLIKIN. The colored movies gave the effect of a very weird sort of light, at least weird because it is different, I suppose.

Admiral STRAUSS. Polaroid goggles depend on alined quinine crystals. They transmit only one color at extinction.

Senator MILLIKIN. Let me ask you this, Commodore: Assuming that we want to develop atomic weapons, in time, am I correct in the assumption that they could be delivered in a routine way, the same as a normal bomb, or will they always require sort of personal attention and handling in addition to that which you give to a normal bomb you are dropping out of a plane, let us say?

Commodore PARSONS. Well, I think they will always require attention by highly qualified people until nuclear physics is as common as ordinary explosive chemistry is now.

Senator MILLIKIN. You believe that in the evolution of the subject, if we evolute—if you would call it that—that you could deliver the bomb with a rocket or a pilotless plane?

Commodore PARSONS. I certainly do.

Senator HICKENLOOPER. I know we had some discussion the other day about the investigations in either Nagasaki or Hiroshima by a scientist who was over there investigating.

I don't believe his discussion as to the extent of this light was in executive session, was it? Didn't he discuss that in open meeting here about the question of this priest who was 3 or 4 miles away?

The CHAIRMAN. That is my recollection.

Senator HICKENLOOPER. As I recall Dr. Morrison's testimony, he said there was a priest about 4 miles away from the point of explosion of this bomb that went off over Nagasaki—one of the two places, anyway—and he said that the priest was apparently looking right in that direction, at that explosion, about 4 miles away on the ground, and he said they had no record or evidence of any effect on his eyes in any way, shape, or form, no blindness nor temporary blindness, as I recall.

He didn't say that there was not any, but he did not have any statement to make on that. It was my impression that being that close and looking right at it, at the tremendous blinding flash, from all we have read and heard, it should have some perhaps permanent effect on his eyes.

Commodore PARSONS. Well, I don't quite understand that priest's experience. I should think his feeling would be that he was blinded for half a day, or something like that.

Senator HICKENLOOPER. As I recall Dr. Morrison's testimony, there was no special emphasis laid on that, and I think he said there was a bright light, but they didn't have any record of any particular outstanding effect on this man's eyes. They got a direct report from a priest who had gone down there to help get some of the people out of there.

Commodore PARSONS. That does not quite check with the experience of one man who did not have blinders on his eyes in the New Mexico test. I don't know just how far he was away, but something in the order of 6 miles, and of course it was 5:30 in the morning and his eyes were dark-adapted, so he was in a position to be blinded much more easily than someone in the middle of the day with the sun shining. That man didn't recover for a day and a half.

Senator HICKENLOOPER. In all fairness to the statement that was made the other day, I think Dr. Morrison said they didn't have too much special data on that, but as far as he knew, there was no unusual effect, nothing that they had recorded as any general effect on the eyes.

The CHAIRMAN. I think that was General Groves, Senator, who had the letter from the Jesuit priest. He is the one who told us about that.

Senator HICKENLOOPER. As I recall it, it was a scientist, and I believe it was Morrison who had actually gone over there to view these things.

Commodore PARSONS. Two of our people in the delivery airplane, who were sitting up in the forward seats, the copilot and the bombardier, did not have their goggles on; they forgot to put them on. Of course, we were heading away from the thing, and they got the impression of a tremendous flash, but that is all. They were not damaged. They were not looking directly at it.

Senator HICKENLOOPER. It would be bad to have a blind copilot on a trip like that.

The CHAIRMAN. Because of business on the floor, we will have to recess. There are some other things that we will want to hear from you, Admiral Purnell and Admiral Blandy, at 10 o'clock tomorrow morning, if that will be satisfactory. And, of course, Admiral Strauss, we want to hear from you.

Admiral STRAUSS. Will you want Dr. Gunn back again?

The CHAIRMAN. No; I believe not.

Admiral STRAUSS. Or Commodore Parsons?

The CHAIRMAN. I think, Commodore, unless you have something particular you want to tell us, that will be quite satisfactory.

I take it we will not be very long with you gentlemen tomorrow.

Admiral PURNELL. Frankly, Mr. Chairman, most of the information that I have has been covered by General Groves and Dr. Bush; that is the work of the Military Policy Committee; and as far as my part of the Navy effort goes, representing the Navy in the project, I can put it this way: It was probably the easiest job I ever had in my life. I had a White House overriding priority plus Admiral King back of me. I don't know of anything that could make work easier for you than that.

I can answer Dr. Gunn's statement on the information, but, in fact, General Groves could do it much better.

I passed on the requests that he sent up, I think, through Admiral Mills. They were taken up in the Military Policy Committee and discussed, and also the reports that were made of the process at the laboratory were passed on to the examining board which was set up under the scientific end of the project. It is my recollection that Dr. Briggs was the liaison man, and when any information was secured in the project which was considered to be of value to Dr. Gunn in his research, it was supposed to have been passed. At what time, I haven't any information. I could probably get it.

Senator MILLIKIN. Mr. Chairman, it would probably be more appropriate for executive session, but I should like to hear from somebody in the Navy as to the Navy's role in the possible development of atomic energy as a weapon, offensively and defensively.

Admiral BLANDY. I think I should probably answer that, Senator, because those are my present duties.

Senator MILLIKIN. Do you think that should be in executive session?

Admiral BLANDY. I think so, but some of it I could answer in open session.

Senator MILLIKIN. We could make a start with that in the morning.

The CHAIRMAN. We will recess until 10 o'clock tomorrow morning.

(Whereupon, at 12:15 p. m., a recess was taken until 10 a. m. Friday, December 14, 1945.)

ATOMIC ENERGY

FRIDAY, DECEMBER 14, 1945

UNITED STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to adjournment, at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Russell, Connally, Byrd, Johnson, Austin, Millikin, Hickenlooper, and Hart.

Also present: Dr. Ross Gunn, technical adviser to the naval administration of the Naval Research Laboratory; Commodore W. S. Parsons, assistant to the Deputy Chief, Naval Operations for Special Weapons; Edward U. Condon, scientific adviser; and James R. Newman, special assistant to the special committee.

The CHAIRMAN. This morning we will hear from Admiral Blandy. Will you go right ahead, Admiral.

STATEMENT OF VICE ADM. W. H. P. BLANDY, DEPUTY CHIEF, NAVAL OPERATIONS FOR SPECIAL WEAPONS

Admiral BLANDY. My connection with the subject of atomic energy lies in the present and the future rather than with past developments.

On the 13th of November of this year the Chief of Naval Operations, with the approval of the Secretary of the Navy, established a Deputy Chief of Naval Operations to coordinate within the Navy Department all matters relating to research, test and development of atomic energy, guided missiles, and related devices, and to represent the Navy Department in Army-Navy and other composite organizations dealing with the same matters.

I was ordered to duty in that capacity on the 22d of November.

It might be worthwhile to give a brief résumé of my service, which apparently prompted the Navy Department to order me to that duty. I have been throughout my career both a combat-line officer and, since immediately after the last war, a postgraduate in ordnance engineering. From February 1941 to December 1943 I was Chief of the Bureau of Ordnance of the Navy Department, and from January 1944 until July 1945 I commanded a group of the amphibious forces under Admiral Turner and participated in the campaigns of Kwajalein, Saipan, Palau, Ulithi, Iwo Jima, and Okinawa. From July until November 1945 I commanded the cruisers and destroyers of the Pacific Fleet.

I have had my present duty such a short time that it has naturally not been possible to formulate a complete policy for the approval of the Chief of Naval Operations and the Secretary of the Navy regarding development of these special weapons, but consistent with such limitations as may be imposed by Executive order, national law, and international agreement, it is my intention to utilize atomic energy to the fullest extent for naval purposes. That utilization will, of course, include atomic power as well as atomic explosives.

The exact manner in which we will use them, of course, is not even well known yet, and I would not be able to disclose in open session even our particular present plans.

At the present time I think that practically any one's idea as to how these things can be used for naval purposes will be more or less conjectural, even on the part of the officers most expert in the knowledge of atomic energy.

The tests of the atomic bomb against naval vessels, which we hope to conduct this coming year, will constitute a general guide toward what we may expect when bombs of certain type utilizing atomic explosives are placed in certain positions with respect to ships.

The CHAIRMAN. I take it, Admiral, you are not going to wait for the actual tests in order to formulate a plan of integration based upon what the physicists tell you they think the tests will be.

Admiral BLANDY. A plan for integration for what?

The CHAIRMAN. Of the atomic bomb into the future Navy.

Admiral BLANDY. That is quite correct.

The CHAIRMAN. My point is that I don't think you ought to wait until next summer until you actually run a test before thinking about how the thing is going to be integrated, but rather, based upon what the physicists tell you now, integrate it as far as possible and improve it by the tests. That is only my reaction, for I would assume you would approach it that way.

Admiral BLANDY. I am glad you brought that point out, Mr. Chairman, because that is exactly what we intend to do. We intend to go ahead and get confirmation of what we now predict will happen when the tests are conducted.

The CHAIRMAN. Have you gone pretty well along on those predictions, Admiral?

Admiral BLANDY. I haven't, personally, but the scientific personnel, both civilians and officers, have done so.

I would like to say one thing, Mr. Chairman, in extension of my reply to a question you asked yesterday. The Planning Committee, which is planning those tests, is composed of officers from all interested branches of both services.

The CHAIRMAN. Including the Army Air Corps?

Admiral BLANDY. Army Air Forces, Ground Forces, Navy Surface Forces, and Navy Aviators.

The CHAIRMAN. Admiral, do you suppose that after we come back in January, and in executive session, it might be possible for you to have here the officers and civilians who have been computing for you, shall we say, the life expectancy of surface ships in view of this thing? Would you have it in shape at that time?

Admiral BLANDY. I would like to have time, Mr. Chairman, to take that under advisement.

The CHAIRMAN. We will keep in touch with you on that.

Admiral BLANDY. I would like to make this comment now, though, in that connection, not directly in reply to your question, but because there seems to be an impression that the usefulness and the reason for existence of a certain type of vessel or aircraft or weapon is determined by what can destroy it. That is a fallacy which seems to be quite common. Actually what renders a ship obsolete is not what can destroy it, but what can replace its function. Now, so long as that ship is needed to perform an essential function, it makes no great difference what can destroy it. If a badly needed ship is destroyed, we will replace it.

Take the aircraft carrier in the recent war, for instance. The aircraft carrier was a comparatively vulnerable ship, especially with all the gasoline and other inflammables abroad, and explosives in the form of bombs and ammunition. Nevertheless, when our carriers were sunk we replaced them with other carriers, because nothing else could do the job. The same is true of aircraft. Just because they are shot down, we do not stop building them.

Senator JOHNSON. But if the destruction is so effective that a ship cannot perform a useful function, then of course it becomes obsolete; so you do have to take into consideration the element of destruction.

If a navy can be destroyed before it can perform any useful function, then of course it becomes obsolete just as the bow and arrow did. I do not mean to infer that I believe that that is the situation.

Admiral BLANDY. In such case, we would become an entirely continental Nation and have to defend ourselves from our own territory.

Senator JOHNSON. But I don't think that is the situation.

Admiral BLANDY. I would like to point out, Senator, that there are, of course, numerous ways in which ships can be destroyed, but the question of probability comes in, too. The cheapest and easiest way to destroy a ship is, of course, by a match, but in order to do it you have to get the match into the powder magazine. That is fantastic, but ships actually have been destroyed by time bombs placed in their magazines when they were in a navy yard. The British had one destroyed that way in the last war. She got out of drydock and up to Scapa Flow, where she blew up; and the only explanation was a time bomb planted by German agents.

Senator JOHNSON. But of course that brings into play the element of personal failure, and personal failure never will be entirely eliminated, but relatively so, and it has been.

The feeling about such a thing as the atomic bomb is something that no human being can do anything about.

Admiral BLANDY. But the atomic bomb still has to be delivered into close proximity of the ships.

Senator JOHNSON. That is correct.

In connection with your reply, I want to ask if there is any defense against the atomic bomb?

Admiral BLANDY. There is no defense that I know of, Senator, at the present time except destruction of its carrier.

Senator JOHNSON. To intercept the carrier.

I also want to ask, Admiral, if you think there will ever be another great war, a world war, in which atomic bombs will not be used?

Admiral BLANDY. Any answer I would give to that, Senator, would be merely a guess.

Senator JOHNSON. Yes; I am certain of that; but you are an expert.

Admiral BLANDY. That would require not only a knowledge of weapons, but probably a greater knowledge of human nature than I possess. I would say that the chances are pretty strong that in the unfortunate event of another major war atomic weapons would be used.

Senator JOHNSON. They are so effective that it just seems out of the question to me that if we do get into another war, one side or the other, and perhaps both sides, will not be using them. I cannot picture a world war in which they will not be used because of their vital effectiveness.

Senator HART. Admiral, in connection with Senator Johnson's original question to you, it is perfectly true that, over the vast reaches of the ocean, goods and men are going to be transported in peace and in war, and on the surface of the ocean.

In your estimation that is correct, is it not?

Admiral BLANDY. Yes, sir.

Senator HART. And in the event of war, with that transportation absolutely a necessary part, men will be fighting from, and on, and in, ships no matter what weapons are in existence to destroy them. Is that the case?

Admiral BLANDY. That is my belief, Senator.

Senator HART. Even if there were no surface warships at all, built as such, men still would be fighting from ships by means of guns or torpedoes or whatever can be thrown onto them when hostilities begin. Is that right?

Admiral BLANDY. I think that is highly probable; yes; so long as the sea is used for transportation. It is conceivable that the time might come when we no longer need to use the surface of the sea; but that time is certainly very far into the future.

If the sea were no longer needed as a highway and everything traveled by air, then you would no longer need fighting ships on the sea, because control of the sea would be unnecessary.

But I believe that the potentiality of any nation to make war is dependent on three, and only three, factors: her manpower, her materials, and time. If two opposing nations were equal in those three factors, the one will win which makes the most profitable utilization of all three of those factors.

It may be worth while, in order to gain time, to do what would ordinarily be uneconomical in the utilization of manpower and materials. That is, you may consume them at an extremely rapid rate, but if you gain time in war—which is all important—it might be worth while. It might be worth while, for instance, to transport armies completely by air, when and if that can be done, and keep them supplied by air over large expanses of sea, even though it could be done much more cheaply by surface ship so far as consumption of manpower and materials is concerned. The determining factor in this case would be time.

As I said before, however, this is looking pretty far into the future, and for a long time to come we are going to need to use the surface of the sea. It is and always has been the Navy's primary mission to gain that use for ourselves and to deny its use to the enemy; and that is what we did in the last war. We had to use the sea to get materials and troops to Germany and to the islands in the Pacific, and we had to defeat the German submarine on the one hand, and all arms of the Japanese Navy on the other to gain that use. We also had to deny the use of the sea to Japan in order to keep her from bringing raw materials into Japan and sending out men and materials to the bastions of her stolen empire.

The CHAIRMAN. I am glad that, when you said the things we need are manpower, materials and time, you didn't say money.

Admiral BLANDY. Well, money is only a medium, I think. The fundamentals are manpower, materials and time. Money is a means of utilizing those things.

Senator JOHNSON. Before you leave that point, I would like to express the hope that the Admiral includes science with the three elements. I presume that is in the manpower.

Admiral BLANDY. That is part of the manpower. That is the brain power that lies in the manpower. There is also the will to win, but I consider that, too, as part of the manpower.

The CHAIRMAN. Admiral, I am not in any sense a military or naval strategist. I know nothing about it, and I approach it from that viewpoint, and when I try to think about it I realize my lack of background.

It does occur to me, however, that when these tests are run, in order to reassure the American people, it might be well to have a civilian board of scientists review the tests before they are run, a board that might be appointed by the President. I just throw that suggestion out, because there is going to be a tendency, you know, for a lot of people to say: "Well, the battleship boys want to keep their battleships. The aircraft boys want to keep their aircraft carriers."

It strikes me it might be a good idea to have some review by this board. What do you think about that?

Admiral BLANDY. Mr. Chairman, I heartily concur, and I shall convey your suggestion to the Planning Committee.

As I said yesterday, I am not doing all the planning for this thing; it is a joint effort of the Army and Navy. The Planning Committee's work hasn't been completed or approved, but I happen to know that they do contemplate a very similar thing, except I believe that the board will be composed of civilian scientists and officers, because it is possible that the civilian scientists alone might draw some incorrect deductions from a military standpoint without the guidance and assistance of some military and naval officers. But they certainly will be included for planning the tests, for conducting the tests, and for appraising the results.

Senator JOHNSON. Mr. Chairman, I don't want to pose as an expert or a crystal gazer, or anything of that kind. However, it does seem to me that it is apparent that atomic energy has driven the ships off the surface of the sea, but at the same time it has provided the means whereby ships below the surface of the sea can operate effectively by giving them the power. I don't see how a ship on the surface can resist the atomic bomb, but that doesn't mean that navies are obsolete provided they will adopt a new technique. If they will go below the surface, they will still be in the picture. If they don't, it will be just too bad.

Admiral BLANDY. There are a lot of people who will agree with you, Senator. I think I will wait for the tests.

Senator JOHNSON. Yes, I will wait for the tests, but the physicists and experts have convinced me that ships on the surface of the sea are going to be ducks on the pond, and I want to see them go down below where they cannot be seen and reached by the atomic bomb.

Senator HART. Mr. Chairman, may I supplement Senator Johnson's ideas in this way: I am thoroughly in agreement with him except I think that he does not realize how big the pond is, how much room there is to cover on this pond, which throws back to the element of probability which Admiral Blandy put in the picture.

You naturally have to take a risk, but if what is to be obtained by taking that risk is commensurate, then you take it and remain on the surface of the sea.

Senator JOHNSON. Yes; I think that is a very strong point and, if I were defending against a foreign power using atomic bombs, I would much prefer them to waste the atomic bomb sinking one ship than I would to have them drop it in the center of New York City, just on the point of effectiveness.

Of course from that point of view, a few ducks on the pond nicely scattered might serve a very useful purpose as a protection to our cities.

Admiral BLANDY. Mr. Chairman, if I may I would like to say one more thing about these tests. Insofar as I have anything to do with it, my own attitude is entirely objective. I don't want to prove anything; I don't want to disprove anything. I want to get the truth so we can come out with the best possible result.

The CHAIRMAN. That is the spirit I want to promote—not to prove anything, but to go at it as a scientist goes at it to analyze the thing and find out objectively, under the best possible conditions, what are the facts.

Admiral BLANDY. In other words, I want it to be a test and not a contest.

The CHAIRMAN. That is very well said, I think, very well said.

I feel as Senator Johnson does. Senator, you are not a naval expert and neither am I, and we probably disagree with Senator Hart. I feel, too, that it is going to be pretty tough on the surface ships—but we obviously cannot take any action on it until the tests prove or disprove that belief.

Senator JOHNSON. And then prove the other belief, too, the constructive belief of building ships that can withstand the atomic bomb, and I believe it can be done.

The CHAIRMAN. You mean surface ships?

Senator JOHNSON. No; I mean go down under where the atomic bomb cannot reach them or cannot discover them.

Senator HART. Then, you will get the submarines into the papers in the next war.

Admiral PURNELL. I might add that it may be the best vehicle for delivering it when it takes a rocket form.

The CHAIRMAN. Are you through, Admiral?

Admiral BLANDY. Yes.

The CHAIRMAN. Admiral Strauss.

Admiral STRAUSS. You were in the midst of Admiral Purnell's testimony when we adjourned yesterday, Senator.

The CHAIRMAN. Admiral, the last thing I remember you said was that you had a pretty easy job because you had a White House priority and backing by Admiral King.

Was it easy because of that, or was it easy because you didn't have very much to do?

STATEMENT OF REAR ADM. WILLIAM R. PURNELL, ASSISTANT CHIEF OF NAVAL OPERATIONS FOR MATÉRIEL

Admiral PURNELL. It was easy because all I had to do was to ask for it.

The CHAIRMAN. Ask for what?

Admiral PURNELL. For the Navy support to the projects, and I got it, with no questions asked.

The CHAIRMAN. You were the Navy's representative upon the Interim Military Policy Committee?

Admiral PURNELL. That is right, the Military Policy Committee.

The CHAIRMAN. Were you in pretty close touch with that development at Oak Ridge?

Admiral PURNELL. I have been to Oak Ridge, yes, and I knew what they were doing.

The CHAIRMAN. When did you first go down there?

Admiral PURNELL. January 1944, I think it was.

The CHAIRMAN. Did you know before that what was being done down there.

Admiral PURNELL. Yes, sir; I was detailed by Admiral King late in August of '42, and I became a member of the Military Policy Committee when it was formed in September of '42.

The CHAIRMAN. Did Dr. Gunn's requests come to you?

Admiral PURNELL. They came through me, yes.

The CHAIRMAN. And you transmitted the information you got to Dr. Gunn?

Admiral PURNELL. I didn't get any.

The CHAIRMAN. You didn't get any?

Admiral PURNELL. No, sir, it didn't come back to me.

The CHAIRMAN. To whom did it come back?

Admiral PURNELL. There were two different boards of scientists appointed at different times to study the reports from the laboratories, and also, when specific requests were made, I delivered those to the Military Policy Committee, and I think they were delivered to Dr. Bush—either Dr. Bush or Dr. Conant.

The CHAIRMAN. What I am trying to find out, Admiral, is, after you delivered your request to the Military Policy Board, what did they do then?

Admiral PURNELL. They were then passed to these two boards that were appointed, and as I remember it Dr. Briggs was the chairman of one of these boards, and he was also designated as the liaison to pass information to the laboratories.

The CHAIRMAN. Admiral, you were the top fellow in the Navy on atomic energy?

Admiral PURNELL. Yes, sir; I was the senior one.

The CHAIRMAN. You were the senior member?

Admiral PURNELL. Yes, sir.

The CHAIRMAN. Did you receive response to your requests for information that were transmitted by Dr. Gunn through you?

Admiral PURNELL. I received reports at the Military Policy Committee meetings that that was being handled and looked out for by those boards that were appointed and by Dr. Briggs.

The CHAIRMAN. Yes, but you asked for information; did you get it?

Admiral PURNELL. The laboratory asked for it, and I delivered the request, because I was the Navy representative on that committee.

The CHAIRMAN. But did you get it back?

Admiral PURNELL. Not through me, no, sir. I was told it was being handled by the scientists through Dr. Briggs.

The CHAIRMAN. They were supposed to give it back through some other channel to Dr. Gunn?

Admiral PURNELL. Direct, yes, as far as I know.

The CHAIRMAN. But Dr. Gunn has testified he never got it.

Admiral PURNELL. Well, it was the understanding, I think, with the Manhattan project that information that was considered by the scientists to be of value to the research laboratory would be passed to them. That was my understanding.

The CHAIRMAN. So you never got any, so it was never of any value.

Admiral PURNELL. I never got any, no, sir.

The CHAIRMAN. Do you know of anybody else who get any?

Admiral PURNELL. No, except the assurance I got that it would be handled; that is all.

The CHAIRMAN. But it wasn't handled.

Admiral PURNELL. Well, I take Dr. Gunn's word for that, yes.

The CHAIRMAN. You were in constant touch with Dr. Gunn?

Admiral PURNELL. No, sir.

The CHAIRMAN. At least he kept asking you or furnishing you with memoranda of things he would like to be provided.

Admiral PURNELL. They usually came through Admiral Van Keuren.

Dr. GUNN. And Admiral Mills.

Admiral PURNELL. They were passed to me in letter or memorandum form and I delivered them to the Military Policy Committee.

The CHAIRMAN. I can see them going up, Admiral, but I cannot see anything coming back.

Admiral PURNELL. In the first place, I don't think they would let that information get very far out of the regular channel. The channel that was established for the passing of that information was through Dr. Briggs to the laboratory to Dr. Gunn.

The CHAIRMAN. Then, in other words, Admiral, you were a one-way street. You took it up, but it didn't come back through you.

Admiral PURNELL. It didn't come back through me, no, sir.

The CHAIRMAN. As far as you know, the only way it came back was through Dr. Briggs to people that were interested?

Admiral PURNELL. That was the established channel for the flow of information.

The CHAIRMAN. Who were the people who were interested in the Navy?

Admiral PURNELL. The Bureau of Ships, due to the fact that the Research Laboratory was under the Bureau of Ships at that time.

The CHAIRMAN. Who was in charge?

Admiral PURNELL. Admiral Cochrane and Admiral Mills.

The CHAIRMAN. Where are they now?

Admiral PURNELL. They are here, sir.

The CHAIRMAN. We had better hear them.

Admiral PURNELL. Frankly, I think they are in the same position that I am, that they passed them to me and I passed them to the Policy Committee, and then they were studied by the scientists. What happened after that, I don't know, sir.

The CHAIRMAN. In other words, are you saying that Admiral Mills and Admiral Cochrane did not get anything back?

Admiral PURNELL. No, sir; I don't think that channel was established. It was later on in the project.

Senator HART. Mr. Chairman, I was likewise having something of a misconception of what the Policy Committee, of which Admiral Purnell was a member, were doing as regards research. My understanding from what he says now is that it was really a higher level concerned with the production and what was to be done from the military standpoint; and it was rather natural that between scientists the channel should be direct. Is that right, Admiral?

Admiral PURNELL. That was the plan on which we worked; yes.

The CHAIRMAN. I confess—and I may be stupid about it, Admiral-that I have not got the set-up at all clear in my mind, and I want to get it clearly set up.

Dr. Gunn was in charge of the laboratory. He was your chief man in nuclear physics.

Admiral PURNELL. He was on the power end, Mr. Chairman. He was not in the explosive end at all.

The CHAIRMAN. Who was on the explosive end?

Admiral PURNELL. No one in the Navy. That was entirely in the Manhattan District project.

The CHAIRMAN. You had nothing to do with atomic energy for explosive purposes?

Admiral PURNELL. Entirely, but not for power purposes. That is, the Manhattan District devoted very little attention to a development for power.

Senator MILLIKIN. Mr. Chairman, may I make a suggestion?

To avoid confusion both ways, let me suggest that the witness be asked to describe the chain of authority upward for power and upward for weapons, as far as the Navy is concerned, from the laboratory up.

Admiral PURNELL. There was really no organization for the development of power.

Senator MILLIKIN. I am speaking now only of the channel of communication from the laboratory up to wherever it went on the power side and on the weapon side.

Admiral PURNELL. On the power side, it came up from the research laboratory through Admiral Van Keuren to the Bureau of Ships.

Senator MILLIKIN. Who was the Admiral?

Admiral PURNELL. Admiral Van Keuren was in charge of the research laboratory. Then Admiral Mills was detailed to handle it in the Bureau of Ships. He usually brought it personally to me.

Senator MILLIKIN. Then it went to you?

Admiral PURNELL. Yes, sir.

Senator MILLIKIN. Then where did it go?

Admiral PURNELL. I took it personally to the Military Policy Committee. It never went into what we call correspondence channels.

Senator MILLIKIN. Now, if anything were to come back, what happened?

Admiral PURNELL. Then the Military Policy Committee, primarily under the direction of Dr. Bush aided by Dr. Conant, set up boards or committees—I don't recall just what they were called at the time—first, to study the process that was developed at the laboratory, and next to go over the reports of their progress, and then in ordinary conversation at the committee's meetings there would be discussions.

Senator MILLIKIN. You are talking about scientific meetings?

Admiral PURNELL. The Military Policy Committee meetings.

The CHAIRMAN. Of which you were a member?

Admiral PURNELL. Yes, sir.

Senator MILLIKIN. Do you mind if I get clear where that sat in the hierarchy?

Admiral PURNELL. I had better start down from the top, then. The first committee established was the one under the Vice President. I am not sure of the composition of that committee. It was Mr. Wallace, the Secretary of War, General Marshall, Dr. Bush, and I think one other member.

Senator MILLIKIN. That is what you referred to when you referred to the military committee.

Admiral PURNELL. No, sir; that was the Presidential committee.

Senator HART. I think that set-up is described in Dr. Smyth's book.

Admiral PURNELL. That is right.

Senator MILLIKIN. I think we ought to have it here, because we have got so much confusion as to what this channel of communication is.

Admiral PURNELL. Now, under that committee, which passed on very general topics, the Military Policy Committee was set up by the President. Dr. Bush was the chairman, General Styer was the Army member, I was the Navy member, and Dr. Conant was alternate to Dr. Bush. General Groves was executive officer of that committee and in direct charge of the project. The questions of policy, the decisions of processes to be followed, and expenditures, what plants should be built, and the size of them and when they should be added to, a discussion of the reports made, and what we could expect from each one of the processes, and so forth, were the questions that were handled by the Military Policy Committee.

Senator MILLIKIN. Starting then from the laboratory, that went up through you to this Military Policy Committee?

Admiral PURNELL. Yes, sir.

Senator MILLIKIN. Now, if anything were to come down—and I understand nothing did come down—it would come through those same channels?

Admiral PURNELL. No, sir; those were not official correspondence channels. That was merely a way of getting a request from the laboratory to the policy committee.

Senator MILLIKIN. If that policy committee had decided to send something back, what possible channels might it have used?

Admiral PURNELL. The committees to study the reports and the requests from the laboratory were set up by Dr. Bush, I think. I would not say that for sure. General Groves may have set them up, and, I presume, on recommendation of Dr. Bush. I think Dr. Briggs was chairman of both of those committees, except one report which was very technical and very scientific. I am not sure but what Dr. Tolman was the chairman of that.

Now, Dr. Briggs was the contact between those committees and the Naval Research Laboratory.

Senator MILLIKIN. If the committee wanted to send word back to Dr. Briggs, it would have normally sent it through that contact?

Admiral PURNELL. Yes, sir.

Senator MILLIKIN. And so far as you know, no word came back through that contact?

Admiral PURNELL. No, sir. The only assurance I got was the fact that when information was available that was of value to the laboratory in their work it would be passed to them.

Senator MILLIKIN. Then, may it be fairly concluded that the policy committee to which you referred presumed to determine what the naval laboratory should or should not work on?

Admiral PURNELL. Well, the scientists did, and we approved it.

Senator MILLIKIN. That is what I mean.

Senator AUSTIN. Admiral, do you participate in it?

Admiral PURNELL. In the policy committee, yes sir.

Senator MILLIKIN. Should we trace out the weapon angle of this? As I understand it, the Navy was not interested in the weapon angle; or am I wrong in that?

Admiral PURNELL. We were decidedly interested in it.

Senator MILLIKIN. You did not work on it?

Admiral PURNELL. The work particularly that Commodore Parsons did was, I should say, as important as almost any part of the bomb.

Senator MILLIKIN. Is there any question before the committee, Mr. Chairman, as to whether we should trace out the channels as far as the weapon end is concerned.

The CHAIRMAN. I think not. I think it is pretty clear as to what the situation was there. I was just trying to find out why Dr. Gunn, who had requested information from time to time that would be helpful to him, hadn't gotten it. Apparently the liaison back from Dr. Briggs was never established.

Admiral PURNELL. I don't recall that any specific information was ever requested. It was reports on what the laboratory was doing. Then the scientists judged, knowing what we did, from the Manhattan District whether anything discovered there would help progress at the Naval Research Laboratory.

The CHAIRMAN. Did you ever get anything back, Dr. Gunn?

Dr. GUNN. No official information.

The CHAIRMAN. No official information?

Dr. GUNN. That is correct.

The CHAIRMAN. Did you ever talk to Dr. Briggs about the results?

Dr. GUNN. Many times, and I asked for information from time to time, which apparently we were not to receive, and he said, "Take that up with your naval representative."

Senator CONNALLY. You say you didn't get any official information. Did you get any unofficial?

Dr. GUNN. There was some small amount of information going around which bore on the problem; that is correct.

Senator CONNALLY. Well, it was from authoritative sources, wasn't it?

Dr. GUNN. Not necessarily.

Senator CONNALLY. Well, it wasn't hall talk?

Dr. GUNN. No; that is correct.

The CHAIRMAN. Do you have anything further, Admiral?

Admiral PURNELL. No, sir; I don't think of anything.

Commodore PARSONS. I might give an example of how the information went in the other direction from the Naval Research Laboratory.

We wanted to know something about the separation of isotopes by the method that they were developing, so Dr. Oppenheimer wrote a letter to General Groves saying that this information would be of value to us and requesting that it be obtained.

General Groves turned that request over to Dr. Conant, who, I think, through Admiral Purnell or Admiral Mills, requested the reports. The reports came almost immediately. That was the channel we used.

The CHAIRMAN. Who did the reports go to?

Commodore PARSONS. To Los Alamos.

The CHAIRMAN. You are talking about furnishing them to Los Alamos?

Commodore PARSONS. I am saying I was at Los Alamos, you see. We conceived the need for that report, and that is the way we got it.

Senator CONNALLY. What report?

Commodore PARSONS. It was a report on progress on the separation of isotopes.

Senator CONNALLY. In the Naval Laboratory?

Commodore PARSONS. That is right.

Senator JOHNSON. Mr. Chairman, I want to ask Admiral Purnell a question or two in regard to the liquid thermal diffusion plant at Oak Ridge.

You say you visited Oak Ridge several times?

Admiral PURNELL. No, sir; I have only been there once since the project got started.

Senator JOHNSON. But I understood yesterday from Dr. Gunn's testimony that the Navy was particularly interested in the liquid thermal diffusion process.

Admiral PURNELL. Yes, sir.

Senator JOHNSON. Did you concur in the present status—not saying what the present status is—of the liquid thermal diffusion experiment at Oak Ridge? Did you concur in that, or are you in accord with what is done there now?

Admiral PURNELL. Yes, sir. If you remember Dr. Gunn's testimony yesterday there was a small pilot plant—you would call it that wouldn't you, Doctor?

Dr. GUNN. That is correct.

Admiral PURNELL. There was a small pilot plant here at the Research Laboratory. Later that was expanded. In its relation to Oak Ridge it was still a pilot plant. It was built at Philadelphia at the boiler laboratory on account of the availability of steam.

The design and construction of the plant at Oak Ridge were made directly from the pilot plant at Philadelphia and designed by Dr. Gunn and Dr. Abelson, I think. Dr. Abelson trained the men to operate the one at Oak Ridge, and on that line of the development came directly into the Manhattan project.

The CHAIRMAN. I take it, Admiral, that the output from the Navy was good, but the intake wasn't very much?

Admiral PURNELL. Well, it probably wasn't on the power side, and there was no need for it on the explosive side. We were primarily interested in getting a bomb.

I am not a scientist and I cannot judge it, but I saw no hope whatever of harnessing atomic power during this war, or even for the next war; I don't know. Now, the power development was primarily what the Research Laboratory was studying and working on.

When it became known that they could use the product from the liquid thermal diffusion to increase the output of the electromagnetic process at Oak Ridge, that was when that development was drawn into the Manhattan project.

The CHAIRMAN. I have only one further question.

Dr. Gunn, how many requests did you make in writing?

Dr. GUNN. I don't know how many were made in writing, sir—perhaps three or four.

The CHAIRMAN. How many did you get back?

Dr. GUNN. I think any information that I wanted amounted to zero.

Senator CONNALLY. Is this a post-mortem over who did it between the two services, the Army and the Navy?

I knew they were in a squabble about uniting or being divided, but I didn't think it went to the point of what had happened already.

The main thing was that you got the bomb, didn't you?

Admiral PURNELL. Yes, sir.

Senator CONNALLY. You couldn't have two outfits working on it at the same time very successfully?

Admiral PURNELL. Yes; and I think if there was a slip or if I slipped in passing information—it was not my channel to pass it down—I would attribute it to the fact that we were after a bomb, and we knew that power could be developed in time after the bomb was used.

Senator CONNALLY. Certainly power is secondary or "third-dary" or "fourth-dary" to me. I don't think the power is of any great consequence at the moment, but I hope that the Army and Navy will show a little more spirit of cooperation without fussing at everybody after it is all over and the bomb has been discovered.

I have always supported the Navy and am a big Navy man; but I think they ought to be big too.

Senator JOHNSON. Mr. Chairman, I would like to direct the question which I asked Admiral Purnell to Dr. Gunn.

Without saying anything about the present status of the liquid thermal diffusion process at Oak Ridge, are you entirely satisfied with the present status?

Dr. GUNN. Yes; I think that the operations down there have demonstrated that it is useful. The question that you ask is really twofold, one a technical one and one a practical one.

I think it is fair to say that the scientists are not satisfied with any method of isotope separation. We think they are all rather expensive, and in that sense we are unsatisfied.

But in terms of what we have, I think utilization at Oak Ridge was entirely satisfactory.

Senator JOHNSON. My question is more whether or not the liquid thermal diffusion process had its day in court?

Dr. GUNN. Yes, sir.

Senator JOHNSON. And had its opportunity?

Dr. GUNN. Yes, sir.

Senator JOHNSON. Thank you, Doctor.

The CHAIRMAN. Admiral Strauss, have you anything to add?

Admiral Strauss. No, sir.

STATEMENT OF REAR ADM. LEWIS L. STRAUSS, DEPUTY CHAIRMAN OF THE ARMY-NAVY MUNITIONS BOARD AND SPECIAL ASSISTANT TO THE SECRETARY OF THE NAVY

Admiral STRAUSS. Mr. Chairman, I think I am the least important of the Navy witnesses. I should perhaps qualify myself for being here, as Admiral Blandy has done. I am not expert in either the strategy or the policy of the matter. My interest in the subject began as early as 1938 when I set up a foundation and started work in a laboratory at the California Institute of Technology that had been turned over to me by the Institute, on the production of isotopes by bombardment of the familiar elements with high-speed particles from a surge generator of special design that I constructed together with some friends of mine; and when the successful experiment in atomic fission took place in Germany a year later, we naturally turned to that as a more direct method of producing the materials we sought, the purpose of which was primarily to facilitate research and eventually therapy in the field of cancer.

When I reported for duty in the Navy in 1941 I had the good fortune to be assigned to Admiral Blandy, whom I served as principal staff assistant when he was Chief of the Bureau of Ordnance. I have since been an adviser and assistant to the Secretary of the Navy in these and related matters.

I relieved Under Secretary Bard upon his resignation as the naval member of the Interim Advisory Committee on Atomic Energy. My function here has simply been to organize this testimony.

I doubt whether I have any information that is of value to your committee; but such as it is, it is at your disposal.

The CHAIRMAN. The Medical Bureau of the Navy has been very progressive in times gone by. Have they done any experimental work, as far as you know, in using this for medical treatment?

Admiral STRAUSS. I am unable to say, sir; but I think it would be an interesting field to explore, and Vice Admiral McIntire, if called before this committee, would be qualified to testify.

The CHAIRMAN. Is there anything else, Admiral?

Admiral STRAUSS. I have nothing to add, sir.

Commodore PARSONS. Some question was raised about the possible squabbles about cooperation between the Army and Navy.

I was naval officer from the middle of Naval Ordnance and sat in the middle of the councils of the Manhattan District as associate director at Los Alamos, and I would say the cooperation was almost ideal. That included the Air Forces, also, the Manhattan District, the Navy, and the Air Forces.

I think Admiral Purnell will bear me out. The whole question was winning the war and getting the bomb into the war as fast as possible.

The CHAIRMAN. I am glad to hear that.

Gentlemen, if there is nothing further to add, we will thank you very much, and will be seeing you again.

The committee will meet again on Wednesday morning at 10 o'clock to hear testimony from some industrialists and engineers who have been in the process of getting prepared.

(Whereupon, at 11 a. m., the committee recessed until 10 a. m., Wednesday, December 19, 1945.)

ATOMIC ENERGY

WEDNESDAY, DECEMBER 19, 1945

UNITED STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to adjournment, at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Johnson, Tydings, Austin, Millikin, Hickenlooper, and Hart.

Also present: Edward U. Condon, scientific adviser, and James R. Newman, special assistant to the special committee.

The CHAIRMAN. The committee will be in session.

Mr. Creedon.

STATEMENT OF FRANK R. CREEDON, FORMERLY WITH STONE & WEBSTER ENGINEERING CORP.

The CHAIRMAN. Mr. Creedon, you are from Stone & Webster, and I believe you took considerable part in the Manhattan project.

Mr. CREEDON. Yes, from January 1, 1944, to January 27, 1945, I was the resident manager for Stone & Webster Engineering Corp. in charge of the construction of what we called Y–12. My association with Stone & Webster Engineering Corp. consisted of this special assignment only. I have not been associated with Stone & Webster since January 27, 1945.

The CHARIMAN. Y–12 is the gas diffusion plant?

Mr. CREEDON. No, that is the magnet plant.

The CHAIRMAN. The electromagnetic?

Mr. CREEDON. Yes, sir.

The CHAIRMAN. Now, sir, I imagine the committee will have some questions to ask you, but I would like to have you go ahead and tell us about what you did, how difficult you thought it was while you did it, and possibly you can give us some estimate as to how long you think it would take any other industrial nation—without being specific about it—to accomplish the same thing.

Mr. CREEDON. Prior to my part in this job, I was the Deputy Rubber Administrator under Mr. Jeffers in charge of the synthetic-rubber construction program, and, prior to that, for the Army engineers, in charge of the construction of all munitions plants. Therefore I had seen a great many of our very large construction efforts during the war.

From the standpoint of complexity and magnitude this was at least 2½ times the size of the largest war project that I know of. As for complexity of installation, it was also the most complex and the most difficult to install.

Some of the problems and difficult design and installation phases were, I think, that we had to design and install a vacuum system that was more nearly perfect than any vacuum system that I know of that ever was installed on any construction project.

Senator AUSTIN. May I ask a question there for identification?

The CHAIRMAN. Surely, Senator Austin.

Senator AUSTIN. Was this electromagnetic system one where great care had to be exercised about cleanliness and absence of moisture?

Senator AUSTIN. Signs on the floor, "Do not spit here"?

Mr. CREEDON. Yes, sir.

Senator AUSTIN. All right; that just helps to bring the picture back to memory.

Mr. CREEDON. Also the oil system was an extremely difficult problem because of the nature of the oil and the extent of the system. It was very difficult to get a tight system and to get satisfactory circulation.

Some of the very difficult problems involved were the design of what we call magnets, the design of bins or tanks, the design of manifolds, the design of diffusion pumps, the design of vacuum pumps, and it was a matter of designing and installing something that we had never had any previous experience with—and I don't think anybody else did, either.

The CHAIRMAN. Did you have charge of building any of the synthetic-rubber plants?

Mr. CREEDON. All of them, sir.

The CHAIRMAN. Would you give us a comparison of the difficulties encountered in that? After all, that was a somewhat new field, too, although the ground, I believe, had been plowed somewhat in making synthetic rubber.

Mr. CREEDON. Yes; I could say that the design and construction of Y–12 was much more difficult than the design and construction of any of our synthetic-rubber plants in that it was, as I say, embarking on things that had never been done before from an engineering standpoint.

Senator HART. Mr. Creedon, have your experiences led you into touch with the state of industries similar to yours in other foreign countries, so that you have a fair acquaintance with their abilities?

Mr. CREEDON. No, sir.

The CHAIRMAN. Mr. Creedon, is there anything else that you would like to tell us about your experience there? How many men were under you at any one time?

Mr. CREEDON. At the peak?

The CHAIRMAN. Yes.

Mr. CREEDON. Approximately 30,000.

The CHAIRMAN. Roughly, how would you divide those 30,000?

Mr. CREEDON. I would say 6 percent, or thereabouts, administrative, probably another 4 or 5 percent strictly engineering, and the balance would be supervisors, superintendents, mechanics, and laborers.

Senator AUSTIN. May I ask a question at that point?

Were the same men used for operations who were employed for construction of these delicate machines with fine pipes that had to be welded with great accuracy and strength?

Mr. Creedon. No, sir.

Senator Austin. So that you had to have a construction gang on there first to put them in?

Mr. Creedon. Yes, sir.

Senator Austin. Now, as to maintenance, they had to be maintained with great care all the time, didn't they?

Mr. Creedon. Yes, sir.

Senator Austin. Did Stone & Webster handle that?

Mr. Creedon. That was handled by the operator, Tennessee Eastman Corp.

Senator Austin. Your connection then with that electromagnetic plant ended with the installation, did it?

Mr. Creedon. Well, we completed the installation and turned an operating plant over to the operator and stood by with mechanics for a short period in order to help tide over and help them take up the maintenance; yes.

Senator Austin. There must have been a period of education in there; that is, from the engineering to the operating transactions there must have been a liaison to understand that plant?

Mr. Creedon. Indeed, for example, in operating the complicated oil system, their people came in and worked beside our people while we operated the various valves, and so forth and so on, until they became familiar with the system.

Senator Austin. Now, from the laying of the foundation to the putting on of the finishing touches to the plant, how long did it take?

Mr. Creedon. Approximately 2½ years.

Senator Austin. And during the 2½ years you had the service of how many men on construction?

Mr. Creedon. Well, our peak on construction was roughly 28,000.

Senator Austin. In this transaction, what factor did research and special skill play? Was it an indispensable thing in the construction of this plant to have men who had the special skills to try the plant out in advance and make a picture of it?

Mr. Creedon. Yes, they had, of course, to study out and prepare and present basic scientific data.

Senator Austin. Did Stone & Webster handle all of that? Were they the people who furnished the ideas that went into this plant?

Mr. Creedon. No; they were furnished by the scientists.

Senator Austin. And Stone & Webster did not have them on their pay roll?

Mr. Creedon. No, sir.

Senator Austin. Thank you.

The Chairman. In other words, the scientists were the architects, and you were the contractors?

Mr. Creedon. No, the scientists were not the architects. The scientists furnished the rough basic scientific data, and then Stone & Webster had to take that basic scientific data and convert it into designs and drawings.

The Chairman. Now, did you have a crew of mechanical engineers to do that job?

Mr. Creedon. Oh, yes. All drawings for procurement or for construction were by others than the scientists.

The CHAIRMAN. What did you do after you got those drawings made? Did you go back to show them to the scientists and go over them together before you actually proceeded to work?

Mr. CREEDON. In certain drawings the scientists collaborated, and then the operator collaborated very extensively in practically all drawings.

The CHAIRMAN. You do a world-wide business, don't you—Stone & Webster?

Mr. CREEDON. Yes, sir.

The CHAIRMAN. Who is the man in your organization who could give us the best bird's-eye view of the state of engineering and mechanical accomplishments around the world, and the ability of the other firms around the world to compete in the field with you?

Mr. CREEDON. I would say Mr. J. R. Lotz, the chairman of the board.

Senator AUSTIN. I have a question on this organization set-up. Is there any one man in the organization of Stone & Webster who handles all of these different foreign projects?

Mr. CREEDON. They all head up under Mr. Russell Branch, the president of Stone & Webster Engineering Corp.

Senator AUSTIN. For instance, for China you have a person who has charge of the Far East, do you not?

Mr. CREEDON. I do not know.

Senator AUSTIN. And for European service, Spain, for example, you have somebody who attends to that particular activity of Stone & Webster in Spain?

Mr. CREEDON. I do not know.

Senator AUSTIN. You also have many different subsidiary companies that handle the different activities in the foreign fields?

Mr. CREEDON. I do not know.

The CHAIRMAN. I wonder if you would talk with Mr. Lotz and Mr. Branch, Mr. Creedon, and tell them that we will be interested in hearing from them after the Christmas recess.

I think, Senator Hart, that is what you would like particularly, and you, Senator Austin—a sort of over-all view.

If you will talk to them and tell them we will be in contact with them, we would appreciate it. Ask them to come down; it won't take them very long.

Senator AUSTIN. Does Harry Arthur have anything to do with these activities in foreign fields?

Mr. CREEDON. I do not know.

Senator MILLIKIN. After your consultation with scientists, then you would lay this out in the form of drawings and specifications? That would be your own function?

Mr. CREEDON. Yes, sir.

Senator MILLIKIN. And then of course the job would be to translate that into actual machinery?

Mr. CREEDON. Yes; that is correct, to place orders against those designs.

Senator MILLIKIN. In a normal large construction job, of course, you try to conform to standard materials as much as possible?

Mr. CREEDON. Yes, sir.

Senator MILLIKIN. And that greatly facilitates the job if the standardized materials are available?

Mr. CREEDON. Yes, sir.

Senator MILLIKIN. I think you have made it rather clear, but I would like to emphasize it if it isn't clear, that the design of this particular plant to which you have been referring got almost completely outside the field of standard design and standard materials. Is that correct?

Mr. CREEDON. That is correct, sir.

Senator MILLIKIN. And when you get ouside of that field, I assume that you have special problems of metallurgy, for instance in the making of a valve. Is that correct?

Mr. CREEDON. Generally speaking we used standard valves.

Senator MILLIKIN. I don't care to name any particular machine, but aside from a few standard things of that kind, the main features of your plant were especially designed and required unstandard materials; is that correct?

Mr. CREEDON. That is correct, sir.

Senator MILLIKIN. And that in turn involved an enormous amount of specialized know-how, didn't it?

Mr. CREEDON. Yes, sir.

Senator MILLIKIN. Ramifying, you might say, through almost all of our industrial specialties in this country?

Mr. CREEDON. Yes, sir.

Senator MILLIKIN. Is there any country in the world today that has available to it that specialized know-how and the industry that would be available to make these specialized products?

Mr. CREEDON. Answering your question this way, I don't think that this project could be built without several great industrial companies; for example, to name three of them, General Electric Co., the Westinghouse Co., and Allis-Chalmers Co.

Senator MILLIKIN. Is there any country in Europe that either has in its own organization or has available to it in Europe in any one or more countries of Europe the know-how that we have been describing, and the specialized industry that could provide or set up a plant of this kind without great long delay?

Mr. CREEDON. So far as I know; no, sir. As to whether or not anybody in a foreign country could do, for example, what it was necessary for General Electric to do, or for Allis-Chalmers to do, I think that the representatives—which I believe are present—from those concerns could answer that better than I can, sir.

Senator MILLIKIN. Let me get your opinion on this: Supposing that X country in Europe wanted to assemble a plant of this kind. Could it, by shopping around, do an assembly job, get something, let us say, in Y country and something else in Z country and something else in A country? Would it be feasible to shop around and finally assemble a plant?

Mr. CREEDON. You mean including shopping around in the United States?

Senator MILLIKIN. Let us exclude shopping in the United States for the time being.

Mr. CREEDON. I don't believe that a plant similar to this could be built in a foreign country without the aid of concerns in the United States.

Senator MILLIKIN. You have in mind Switzerland, France, Belgium, Holland?

Mr. CREEDON. Yes, sir.

Senator MILLIKIN. And what is left of Germany?

Mr. CREEDON. Yes, sir.

Senator MILLIKIN. Sweden?

Mr. CREEDON. Yes, sir.

Senator MILLIKIN. Could Great Britain do the job?

Mr. CREEDON. Without the United States, no, sir.

Senator MILLIKIN. Could Great Britain do the job with the aid of other European countries?

Mr. CREEDON. I don't believe so.

Senator MILLIKIN. Thank you very much.

Senator AUSTIN. How about Canada?

Mr. CREEDON. I don't believe so, not without the aid of our great concerns in America.

Senator MILLIKIN. I assume you would qualify your answer to this extent: That given limitless money and limitless time they probably could build up the necessary techniques and the necessary industries to do the job?

Mr. CREEDON. Oh, yes; certainly.

Senator MILLIKIN. Could you put a time factor, or is there a time factor in your own mind as applicable to the various hypothetical situations that I have portrayed to you? Supposing any continental country in Europe started out to reproduce this plant. Supposing it had the money to reproduce it, and suppose it could shop around in Europe, continental, and Great Britain.

How long would it take to make a fair replica of what you have created here?

Mr. CREEDON. I don't know enough about the situation in foreign countries to give an intelligent answer to that question.

Senator MILLIKIN. Then you judge it would take a long time?

Mr. CREEDON. Yes, sir.

The CHAIRMAN. Have you traveled extensively in Europe?

Mr. CREEDON. No, sir.

The CHAIRMAN. Have you ever been in Europe?

Mr. CREEDON. No, sir.

The CHAIRMAN. Have you ever done any construction work outside of the United States?

Mr. CREEDON. No, sir.

The CHAIRMAN. You really haven't much of a basis for those answers, Mr. Creedon, have you?

Mr. CREEDON. I believe that is correct, sir.

Senator AUSTIN. Let me interpose at that point: I understood your answers as such that you can apply them to the United States. It would take a long time to begin at the beginning and reproduce one of these plants right in the United States with all our facilities, would it not?

Mr. CREEDON. Yes, sir.

Senator AUSTIN. About how long?

Mr. CREEDON. You mean to reproduce one of these plants in America?

Senator AUSTIN. Yes, starting at scratch here. Suppose we had wiped them out and they no longer exist, and we want to start over. How long would it take to reproduce a plant for this electromagnetic process?

The CHAIRMAN. Knowing what he knows now?

Senator AUSTIN. Yes, exactly, with your advantages now.

Mr. CREEDON. An all-out effort on the part of America and American industry?

Senator AUSTIN. Oh, no. I cannot imagine another war. We are going to stop that, so we probably wouldn't get an all-out effort.

But in peacetime, suppose that we had been so wise or unwise as a Congress that we decide we will just efface these things, we will wipe them out. By and by we are provoked to start afresh in peacetime without all that propulsive power of war. How long would it take us to erect an electromagnetic plan equally as efficient as the one that you did?

Mr. CREEDON. Oh, approximately 4 years.

Senator TYDINGS. May I ask a question, if you have finished, Senator?

Senator AUSTIN. Yes; I have.

Senator TYDINGS. Assuming that in the next year or two some country would come to your concern and to other concerns associated with you and make an attractive contractual offer to do similar work as the work which you have just described, how much would you lengthen your estimate of the time necessary to complete the plant, assuming there was reasonable cooperation and availability of the materials necessary to a foreign country?

Mr. CREEDON. And reasonable cooperation in getting, for example, materials that were needed from America?

Senator TYDINGS. Well, my question envisages a situation where you would have all the cooperation which a foreign government could give you, a great power that was in a position to make attractive offers to those who might want to supply the information, the technical and scientific knowledge, and was in a position to buy that in the world market so that there would be a reasonable flow of information that you might want to get to do this?

Mr. CREEDON. I should think it might take——

Senator TYDINGS. A year or two more, would you say?

Mr. CREEDON. Probably 7 or 8 years total.

Senator TYDINGS. In other words, to condense my own question, if your concern was hired to do this work in a foreign country and there was reasonable availability of material and science, you feel that you could do the work in 6, 7, or 8 years?

Mr. CREEDON. Perhaps 8 years, yes.

Senator TYDINGS. Now, assuming that there is unlimited money behind this project in a foreign country, what impediments do you see to completing such a plant if the foreign nation in mind could buy the advice, the scientific and engineering skill that it required to construct the plant?

Mr. CREEDON. The difficulty would be in that event the procurement of the necessary equipment, and so forth.

Senator TYDINGS. Well, suppose, for example, that I was the foreign agent having charge of this, and I would come to your concern and say, "I would like to employ your firm to do a particular job, one of the jobs or all of the jobs connected with this operation, and I will give you cost plus 15 percent profit and would arrange the exchange so you can take your profit back to your own country by deposits in your own country from month to month."

Would you undertake it?

Mr. CREEDON. I couldn't answer that. It would have to be either the chairman of the board or the president of the company.

Senator TYDINGS. Assuming that you were the chairman of the board or the president of the company, would you undertake it?

In other words, my question is simply this: What is to stop a foreign country from hiring your concern or any other concern at attractive prices to do the work?

Mr. CREEDON. If I were the chairman of the board or the president of the company, I would not take it; no, sir.

Senator TYDINGS. You would not take it for patriotic reasons?

Mr. CREEDON. Yes, sir.

Senator TYDINGS. But assuming that the government didn't ask you, that the government simply said, "You are not in a position to turn over any information that you have learned in connection with this project, but you are at liberty to build in accordance with any blueprints or specifications that are furnished you in advance."

Would you then take it?

Mr. CREEDON. No, sir.

Senator TYDINGS. Is there any conceivable circumstance where you feel you would take it?

Mr. CREEDON. No, sir.

Senator TYDINGS. Suppose there is an agreement for the control of peacetime atomic energy, an international agreement, and our Government consents to the exchange of information for the manufacture of peacetime atomic energy, and that you were then offered this proposition to build a plant in accordance with that agreement. Would you then take it?

Mr. CREEDON. Yes, sir.

Senator TYDINGS. It has been testified here in public hearings that a large percentage of the difficulties of manufacturing the atomic bomb are eliminated by the manufacture of peacetime atomic energy. Do you follow me?

Mr. CREEDON. That is correct, sir.

Senator TYDINGS. Now, that being so, and if there was an international agreement for the control of peacetime atomic energy, would you then take it—assuming there was an international treaty which permitted you to do it?

Mr. CREEDON. Yes, sir.

Senator TYDINGS. There wouldn't be any reason why you shouldn't, as far as the Government had established the policy?

Mr. CREEDON. Yes, sir.

Senator TYDINGS. Just as a layman and as an engineer and as a citizen, do you think it would be wise that knowing the devastating potentialities of the atomic bomb we should make such a treaty for the peacetime manufacture of atomic energy?

Mr. CREEDON. Well, if plants will be built to manufacture atomic energy in peacetime, it would take very little to convert them, and I would be a little worried about that.

Senator TYDINGS. I take it your answer means this: That if you consent to the peacetime manufacture of atomic energy on an international basis or treaty arrangement, that in effect you have consented to the possible manufacture—60, 70, 75 percent, or some place in there, let us assume—of the bomb itself?

Mr. CREEDON. Yes, sir.

Senator TYDINGS. So that if you are opposed to the manufacture of the bomb and you invade that field of peacetime atomic energy, you really have given up three-quarters of your opposition to the manufacture of the atomic bomb, have you not?

Mr. CREEDON. Yes, sir.

Senator TYDINGS. Do you know how long it might possibly take from the time the manufacture of atomic energy for peacetime purposes was completed to taking up the remaining processes necessary to manufacture the atomic bomb?

Mr. CREEDON. Approximately a year, or 15 months, or something like that.

Senator TYDINGS. So that if the manufacture of peacetime atomic energy is permitted, you are within a year or less of the manufacture of the atomic bomb, should any nation desire to do so?

Mr. CREEDON. Yes, sir.

Senator TYDINGS. So I would take it from all your answers that in your opinion, if we have an agreement for the peacetime manufacture of atomic energy, we come pretty close to the possibility of the manufacture of the atomic bomb?

Mr. CREEDON. Yes, sir.

Senator TYDINGS. As a policy, have you given any thought as to whether or not we should try to stop the manufacture of peacetime atomic energy, having in mind the potential development of the atomic bomb from such a preliminary step?

Mr. CREEDON. No, sir.

Senator TYDINGS. You haven't given it any thought?

Mr. CREEDON. No, sir.

Senator TYDINGS. That is all, Mr. Chairman.

Senator JOHNSON. Mr. Chairman, may I ask the witness one question following Senator Tydings' questions?

The CHAIRMAN. Yes, sir.

Senator JOHNSON. Under what restrictions and limitations are you operating at present as to the engineering know-how, other than your sense of patriotism?

Mr. CREEDON. I don't know the answer to that question, but I could find that out.

Senator JOHNSON. You don't know whether you are free to reveal or divulge any of the know-how?

Mr. CREEDON. I am practically certain that we are not to divulge anything whatever.

Senator TYDINGS. Either at home or abroad?

Mr. CREEDON. Yes, sir.

Senator JOHNSON. And that is a restriction placed on you, perhaps, by General Groves?

Mr. CREEDON. Yes, sir.

Senator MILLIKIN. I would like to ask whether that is by way of verbal instructions or written instructions?

Mr. CREEDON. I am unable to answer that. I don't know.

I know this much: That Stone & Webster would not give any information of any kind to anybody without getting clearance.

Senator MILLIKIN. Of course, I know you would not, but I think that Senator Johnson has opened up a very pertinent inquiry. Personally, I would appreciate it if you would—if it is agreeable with the chairman—write the chairman whether your instructions to that effect do rest in writing or just verbal understandings.

Senator TYDINGS. And for how long a time they are to run.

Senator MILLIKIN. And it might not be a bad idea to send the instructions themselves.

Senator JOHNSON. Yes; we would like to know what all the conditions are.

Senator MILLIKIN. Has your concern made any studies on the dispersal of industry?

We have had a lot of testimony that we are so concentrated industrially in this country that we are subjected to extra-high hazards so far as the use against us of the atomic bomb is concerned.

Mr. CREEDON. To my knowledge, Stone & Webster have not made studies pertaining to dispersal of industry.

Senator MILLIKIN. Is there an engineer or any concern that might be able to give us expert testimony on that?

Mr. CREEDON. Offhand I can not think of any.

Senator MILLIKIN. It is a very speculative subject, of course, and I should not be surprised if it were a virgin field.

Senator HICKENLOOPER. Senator, I wonder if Mr. Creedon made himself completely clear in answer to your question as to whether or not Stone & Webster had made any surveys.

As I understood his answer, he said, "To my knowledge they have not."

Now, did you mean that you have knowledge that they have not, or that so far as you know they have not?

Mr. CREEDON. So far as I know.

Senator MILLIKIN. You were not indulging in a double negative.

The CHAIRMAN. Mr. Creedon, several of these integral parts were manufactured by General Electric, Westinghouse, and Allis-Chalmers?

Mr. CREEDON. Yes, sir.

The CHAIRMAN. And Chrysler Corp.?

Mr. CREEDON. Not on our project, not Chrysler; but the first three were on our project; yes, sir.

The CHAIRMAN. Chrysler did great work in another one of the methods?

Mr. CREEDON. On the Carbide & Carbon project, I believe.

The CHAIRMAN. Of course these are great plants employing thousands and thousands of workers?

Mr. CREEDON. Yes, sir.

The CHAIRMAN. Some of the items that they manufactured are large, and some of them, I take it, are small in size?

Mr. CREEDON. Yes, sir.

The CHAIRMAN. Capable—many of the important ones—of being lifted up and taken away in a man's overcoat pocket; is that true?

Mr. CREEDON. Yes, sir.

The CHAIRMAN. Do you know anything about the care that is taken at these three plants to see that that does not happen?

Mr. CREEDON. No, sir; I have not been connected with the project since January 27 of this year. I don't know just exactly what is done.

The CHAIRMAN. During the time of your connection with it, were you acquainted with any precautions that were taken at these three great plants with thousands and thousands of employees to prevent the contingency that I spoke about happening?

Mr. CREEDON. People walking out of the plants? Yes. To get out of the project you had to go through a gate where there was a guard.

The CHAIRMAN. You are talking about the Manhattan project now?

Mr. CREEDON. Yes, sir.

The CHAIRMAN. I am talking about back at these plants where they were manufactured.

Mr. CREEDON. I don't know the situation at Allis-Chalmers, General Electric, or Westinghouse, sir.

The CHAIRMAN. That, to say the least, would be a source of "information," would it not?

Mr. CREEDON. Yes, sir.

The CHAIRMAN. To any unfriendly person who was trying to get that information, and also trying to get a sample.

Mr. CREEDON. Yes, sir.

Senator TYDINGS. I have one more question.

Mr. Creedon, without qualifying yourself as an expert or world traveler, you are in the engineering field and, of course, have a pretty fair comprehension of the engineering ability and technique and thoroughness of other countries, because sometimes you do compete; isn't that correct?

Mr. CREEDON. Yes, sir.

Senator TYDINGS. Without naming them, and assuming the money was available, over a period of 8 years, what countries would you conceive from an engineering standpoint of being capable of manufacturing atomic energy—assuming the money was available, that they had the basic technique, and so on, and knowing the fact that this can be produced. How many countries do you assume would be capable of making atomic energy, if the money were available?

Mr. CREEDON. I don't believe I am qualified to answer that question.

The CHAIRMAN. Anything else, Mr. Creedon, that you would like to tell us?

Mr. CREEDON. No, sir.

The CHAIRMAN. Thank you very much, sir, for coming down.

We are now to hear from Mr. H. E. Thompson, vice president of the Carbide & Carbon Chemicals Corp.

STATEMENT OF H. E. THOMPSON, VICE PRESIDENT, CARBIDE & CARBON CHEMICALS CORP.

The CHAIRMAN. Mr. Thompson, Senator Austin would like to put in the record some facts concerning your qualifications.

Senator AUSTIN. In what capacity did you serve through Carbide & Carbon Chemicals Corp. in the erection of the plant or plants for the gas diffusion project?

Mr. THOMPSON. My work in connection with the K–25 project concerned itself with the engineering from the time we came into the project and agreed to act as operators of the plant when it was completed. That date was in December of 1942.

Senator AUSTIN. What had you been doing before this project was undertaken that gave the Government access to you as especially qualified to enter upon this project? What had you been doing with respect to the national defense?

Mr. THOMPSON. I entered this project as a member of Carbide & Carbon Chemicals Corp., but I believe that we were considered in connection with this project in part because of our contribution to the synthetic-rubber program.

Senator AUSTIN. What companies, other than the parent company, were involved in the construction of the gas diffusion plant or the operation of it?

Mr. THOMPSON. The gas-diffusion plant was engineered by a subsidiary of the M. W. Kellogg Co., known as the Kellex Corp., organized purposely for that job.

We were selected as the operators, but coming into the program early in its development, we were asked to join with Kellex and work with them in the engineering to approve the drawings as they were made, and assist in other ways, so that when we finally got the plant it would be also our idea of what such a plant should be.

Our Bakelite Corp. also had quite a bit to do with one of the important phases of the gas diffusion process.

Senator TYDINGS. Let me ask you there if the Bakelite Corp. is a subsidiary of yours.

Mr. THOMPSON. The Bakelite Corp. is a subsidiary of Union Carbide & Carbon Corp.

Senator TYDINGS. Is that the one Dr. Baekeland was president of?

Mr. THOMPSON. Yes; Dr. Baekeland is now dead.

Senator TYDINGS. But his son carries on.

Mr. THOMPSON. Yes.

Senator AUSTIN. What did the Bakelite Corp. have to do with this?

Mr. THOMPSON. The Bakelite Corp. worked particularly on the diffusion member that in many respects forms the basis of the diffusion process.

Senator AUSTIN. Did Carbide & Carbon Chemicals Corp. enter into this project?

Mr. THOMPSON. Yes; through its work with Kellex in engineering and designing the gas diffusion project and plant. Other subsidiaries of Union Carbide & Carbon Corp. were involved in other phases of the entire project, however.

Senator AUSTIN. Now trying to visualize them all, I would like to know with what authority you speak here as a witness. Were you an advisory engineer in all these activities?

Mr. THOMPSON. No, I was not. My engineering work was principally in connection with the K–25 project.

Senator AUSTIN. And that is the gas diffusion plant?

Mr. THOMPSON. Yes.

Senator AUSTIN. Its business was to separate 235 from 238, was it?

Mr. THOMPSON. Yes, sir.

Senator AUSTIN. And that was a method that was pursued throughout the effort to produce the bomb, wasn't it?

Mr. THOMPSON. Yes, sir.

Senator AUSTIN. It was one of the four known methods of separating 235 from 238?

Mr. THOMPSON. That is correct.

Senator AUSTIN. Now, did you have anything to do with the material end of this transaction, such as with the United States Vanadium?

Mr. THOMPSON. Oh, other units of the corporation had a great deal to do with other parts of the program.

The United States Vanadium Corp. was responsible for a very large part of the raw material. The Linde Air Products Co. developed means and carried out processes for conditioning that raw material so that the desired final product could be obtained.

Senator AUSTIN. In this canopy of the parent company, did the electrometallurgical activity also come?

Mr. THOMPSON. The Electro Metallurgical Co. made, I believe, a large part of the uranium metal that was used in the project, both the Tennessee project and the west coast project.

Senator AUSTIN. In addition to that, is it true that your parent company had to do with the graphite production that was used in this process?

Mr. THOMPSON. It is true. The National Carbon Co. developed and made huge quantities of the graphite that was used in the Hanford plant and the electromagnetic plant.

Senator AUSTIN. Speaking only in a general way, what do you say the contribution of Union Carbide & Carbon was to the production of the bomb?

Mr. THOMPSON. My feeling is that without the joint effort of all of those companies we would not have had the atomic bomb.

Senator AUSTIN. That is all.

The CHAIRMAN. Will you go ahead and describe to us further, if you wish, the work that you did.

I might ask you this first, Mr. Thompson: Have you engaged in any foreign work at all personally?

Mr. THOMPSON. No, sir; except to the extent of working with some of our Canadian subsidiaries.

The CHAIRMAN. Has Union Carbide & Carbon Corp. plants in foreign countries?

Mr. THOMPSON. Yes; some.

The CHAIRMAN. Where?

Mr. THOMPSON. Our Carbide & Carbon Chemicals Corp. has a plant in Canada.

The CHAIRMAN. Any in Europe?

Mr. THOMPSON. No, sir.

The CHAIRMAN. Any in South America?

Mr. THOMPSON. No, sir. Some of the other companies have plants abroad for the manufacture of batteries in many parts of the world, for the manufacture of carbide and ferro-alloys in Norway, and for the manufacture of some other products with which I am not acquainted; I think some carbon and graphite activities at certain points.

The CHAIRMAN. You mean subsidiaries of your parent company have plants in Europe in which they manufacture certain articles?

Mr. THOMPSON. That is correct.

The CHAIRMAN. Are they rather extensive operations?

Mr. THOMPSON. No, sir; they are not. The carbide plants and alloy plants in Norway, I believe, are the largest.

The CHAIRMAN. Do you know how many men, approximately, they employ or have employed?

Mr. THOMPSON. I do not.

The CHAIRMAN. Were they taken over by the Germans during the occupation?

Mr. THOMPSON. They were, sir; in occupied territories.

The CHAIRMAN. Who has them now?

Mr. THOMPSON. We have them, I think.

The CHAIRMAN. Now, that the Norway Government is back again?

Mr. THOMPSON. Yes, sir.

The CHAIRMAN. Have you traveled extensively yourself around the world?

Mr. THOMPSON. I have never been abroad except to Canada.

The CHAIRMAN. You have been educated as an engineer. What college did you graduate from?

Mr. THOMPSON. I graduated from the University of Illinois in engineering in 1914, and joined the Linde Air Products Co. as a research engineer at Buffalo in 1917.

The CHAIRMAN. I believe there have been some estimates given by the contributing companies to the War Department as to the time that they believe that this job could be done in other countries in the world. Did you participate in that estimate to the War Department?

Mr. THOMPSON. No; I did not.

The CHAIRMAN. Did you know about it?

Mr. THOMPSON. I heard about it afterward. Within the past week someone asked me if I had answered that question. I had not been asked.

The CHAIRMAN. Mr. George Harrison, of New York was the chairman of the committee that gathered that information, was he not?

Mr. THOMPSON. I believe so.

The CHAIRMAN. The chairman of the New York Life Insurance Co.

Mr. THOMPSON. Yes.

The CHAIRMAN. But you do know that your company furnished such an estimate to that committee?

Mr. THOMPSON. No; I really don't. The gentleman I was speaking to was with a different company; he had been asked.

The CHAIRMAN. As I understand it, Mr. Thompson, General Groves at our request contacted you personally?

Mr. THOMPSON. Yes, sir.

The CHAIRMAN. I might say for the record that General Groves suggested these witnesses, Mr. Creedon and Mr. Thompson, and also the other two witnesses who will be before us.

Have you had access to that information specifically that was given to that committee?

Mr. THOMPSON. No, sir.

General HART. Mr. Thompson, in connection with those subsidiaries which do business in Europe in particular, is there any engineering or development done by those plants, or do they get all of their know-how from America?

Mr. THOMPSON. All of it comes from America.

Senator HART. They do no research and no engineering whatever in those countries?

Mr. THOMPSON. That is correct.

Senator HART. Are any of those companies in any sort of affiliation with industries owned by the countries in which they are located?

Mr. THOMPSON. So far as I know, none of them is so connected.

Senator HART. It is entirely a matter of competition, and they have no connection whatever?

Mr. THOMPSON. That is correct.

Senator JOHNSON. Did I understand you to say, Mr. Thompson, that Carbide & Carbon Chemicals Corp. was selected to handle this work because of their experience in the manufacture of synthetic rubber?

Mr. THOMPSON. I said that I felt that perhaps our accomplishment in the synthetic-rubber program had had something to do with considering us as the operators of the gas diffusion process.

Senator JOHNSON. Did you yourself have something to do with the manufacture of synthetic rubber?

Mr. THOMPSON. Yes. Our company's contribution to the synthetic-rubber program was the production of butadiene from ethyl alcohol. Our principal operation was the plant at Institute, W. Va.

Senator JOHNSON. The United States might be classified as a "Johnny-come-lately," so far as the manufacture of synthetic rubber is concerned, might it not?

Hadn't other nations such as Germany and Russia reached a high state of perfection in the manufacture of synthetic rubber?

Mr. THOMPSON. I think that is true. I believe that for various reasons they were in the synthetic-rubber program or business long before we were. We got into the synthetic-rubber program as a matter of necessity.

Senator JOHNSON. If they were expert in the manufacture of synthetic rubber, they are well on their way toward an important step in the diffusion process, the gas diffusion process?

Mr. THOMPSON. No; I rather question that. I don't believe there is any connection between the two.

Senator JOHNSON. Mechanically or scientifically or otherwise?

Mr. THOMPSON. No, sir.

Senator JOHNSON. That is, knowing how to manufacture synthetic rubber would be of no assistance in the manufacture of the gas diffusion process?

Mr. THOMPSON. No, Senator. I think that the real point there was that Carbide & Carbon Chemicals Corp. had set up a schedule for bringing butadiene plants into production that seemed almost impossible of fulfillment; yet their experience in building processing plants was extensive enough so that they carried their program through completely on schedule.

My reference to the rubber program was not based on any process similarity between producing butadiene from alcohol and the gas diffusion process.

I believe that the experience we had in putting over the butadiene-from-alcohol program, which was one of the biggest the country had ever seen in the process industries up to that time, qualified us to give service in this gas diffusion process.

Senator JOHNSON. Not because of the similarity or know-how, because of your record for getting the job done?

Mr. THOMPSON. Yes, sir.

The CHAIRMAN. You were up to your neck in this synthetic rubber process?

Mr. THOMPSON. That was the principal Government plant activity of the Chemicals Co. until the work on this project came along.

The CHAIRMAN. Now, I have it in the back of my head that the know-how on that was developed in Russia. Were they not the first country to develop synthetic rubber out of alcohol?

Mr. THOMPSON. It is interesting that some of the early patents on the production of butadiene from ethyl alcohol were Russian and that some of the first research work in that field had been done by Russian scientists.

The CHAIRMAN. And they were in production on that before we were, were they not?

Mr. THOMPSON. That is correct.

The CHAIRMAN. That is a tremendously complicated piece of business in itself, is it not?

Mr. THOMPSON. On the other hand, the production of butadiene from ethyl alcohol is not a process which is particularly complicated.

The CHAIRMAN. You would think so if you looked at a picture of one of those plants.

Mr. THOMPSON. Well, the business of getting a high yield and of producing high quality material, of course, is something different again. I believe the plants that we built were much more efficient than any that had gone before.

The CHAIRMAN. Have you ever seen a tire made in Russia out of this process?

Mr. THOMPSON. No.

The CHAIRMAN. Have you ever seen a sample of the rubber?

Mr. THOMPSON. No.

The CHAIRMAN. Did you make use of those basic patents in any way in the operation of your plants?

Mr. THOMPSON. Not in the work that we did. Our process for producing butadiene from ethyl alcohol was developed by our own research group. It involved new catalysts and new operating conditions and gave considerably higher yields than the published processes before that time.

The CHAIRMAN. But the Russians had rolled their vehicles on their own rubber tires made out of the ethyl-alcohol process before we went into production on them?

Mr. THOMPSON. That is correct; yes.

Senator HART. May I carry that on a little further?

Do I understand, Mr. Thompson, that although the Russians did have the basic patent and were perhaps the first in the field, that as compared with our own accomplishment they still were in a rather crude stage although they were producing rubber? Is that a correct statement?

Mr. THOMPSON. I think I would modify it to a certain extent. You may remember that the United States sent a group to Russia to learn about their synthetic-rubber operations and they sent a group here. The exchange of information was not too extensive, but the Russian plants were certainly operating and they were making good butadiene; and they used that as a raw material to make good synthetic rubber.

I may say that the work of our company in that field concerned itself with the raw materials, butadiene and styrene, rather than with the process of making the copolymers or the finished rubber articles.

The CHAIRMAN. Considering the difficulties of making rubber through this process, in order for the Russians to have even engaged in the production that they did they must have had some accumulation of engineering personnel and scientific personnel to put that together. That would naturally follow; would it not?

Senator JOHNSON. I would like to ask to hear that question again.

The CHAIRMAN. I say the knowledge that we have that they were first in the field and they did make them, whether efficiently or not, presupposes that they had a group of engineering brains, engineering men with capability, gathered together in order to do that job?

Senator JOHNSON. Yes; undoubtedly.

Senator AUSTIN. Did the Linde Air Products Co. contribute to this gas diffusion process at all?

Mr. THOMPSON. They contributed a great deal to it, not only in the matter of personnel, but in the matter of additional work on the very heart of the gas diffusion process, the diffusion membrance, if you will.

Senator AUSTIN. That is one of the key elements in the plant; is it not?

Mr. THOMPSON. It is the basic one, without it, there would be no gas diffusion process.

Senator AUSTIN. How are they related to the Carbide & Carbon Chemicals Co.?

Mr. THOMPSON. All of these operating units that I have mentioned are subsidiaries of Union Carbide & Carbon Corp., which is the parent company.

Senator AUSTIN. Did they have to do with the vacuum system?

Mr. THOMPSON. The Linde group did not have to work with that particularly. The chemical group, the operators of K–25, were the ones that worked on that problem.

Senator AUSTIN. Looking at it as an over-all picture, then, Union Carbide & Carbon dealt with both the research, the design, and the engineering?

Mr. THOMPSON. Yes, sir.

Senator AUSTIN. On the gas-diffusion system?

Mr. THOMPSON. Yes, sir.

Senator AUSTIN. Did Chrysler Corp. produce anything for this gas-diffusion system?

Mr. THOMPSON. They did. They produced the diffusion units, called "diffusers," of which there were a great many of great complexity, a job that required all of the skill and the art of American line production such as is used in making automobiles, and Chrysler did an excellent job.

Senator AUSTIN. In the operation, after the plan had been erected, what part did Carbon & Carbide Chemicals Corp. contribute to the output of the plant?

Mr. THOMPSON. Are you referring to the Tennessee plant for diffusion?

Senator AUSTIN. Yes; the Tennessee plant. I have that in memory, as I visited it with this committee.

Mr. THOMPSON. The operation of the K–25 project at Tennessee was entirely under Carbide & Carbon Chemicals Corp. from the very beginning to the very end.

Because of the arrangements that were made with respect to Kellogg and Carbide & Carbon working jointly from the very start, Carbide & Carbon Chemicals Corp. was busily engaged at Knoxville long before there was much of a plant there to operate. Our work started when ground was broken, practically, and continued until the final unit of the first part of the project was in operation.

That contribution required selecting from our various groups operating men of the right qualifications, not only to operate the plant but to see that it was in shape and ready for proper operation when that time came.

Senator AUSTIN. Who is the man who is in charge of that plant down there all the time; who stays on the job?

Mr. THOMPSON. The one in charge of that entire operation is Dr. George T. Felbeck. The man in charge of the entire contribution of our corporation to all phases of the atomic energy project is Mr. J. A. Rafferty, vice president and a member of the executive committee of the parent corporation.

Senator AUSTIN. You are a vice president of that corporation?

Mr. THOMPSON. In charge of engineering; yes, sir.

Senator AUSTIN. Are you also vice president of Carbide Chemicals Corp.?

Mr. THOMPSON. Yes, sir.

Senator AUSTIN. If you hold any other position in this set-up, what is it?

Mr. THOMPSON. I am also a vice president of Bakelite Corp.

Senator AUSTIN. I want to say to you that the contribution that your great company made to the production of this bomb was a very great contribution, in my opinion.

Mr. THOMPSON. Thank you, Senator Austin.

Senator HART. As an engineer, Mr. Thompson, does that Tennessee plant, K-25, as far as its magnitude and complexity are concerned, represent about as large a task as you ever undertook in your professional capacity?

Mr. THOMPSON. Yes, Senator; it is; and I would like to say a few words on that subject, because I believe that it is an outstanding accomplishment in the whole field of engineering as it applies to major process industry plants.

There are many kinds of engineering that have been carried out on gigantic scales successfully, and they vary greatly in the character of the work and the character of what is produced. It is one thing to spend a lot of money building roads or traffic systems, and quite a different kind of thing to build hydro-power plants and the things that go with them. It is another kind of thing to build multiple-part plants like automobile plants.

The process industry phase of engineering, I believe, is something in which we in the United States have perhaps had more experience than in most places. The growth of our chemical industry has been rapid in recent years. The growth of our refining industry has been equally rapid, and the development of those industries has called for a type of engineering which involves hundreds of thousands of individual parts, procured in thousands of different places, all of which must be at the site at the right time and in the right order. They not only have to be there, but they have to be properly warehoused and stored so that when you want a certain one of them you know where to go to get it.

We have been carrying out rather good-sized engineering jobs in Carbide & Carbon Chemicals Corp. for sometime with quite a bit of success, and as time has gone on, we have, I think, improved our system. The best test that we had of it was in our contribution to the raw materials for the rubber program. It worked beautifully there.

But what did we have there? We had well worked out research back of what we were about to do; we had built a pilot plant that had been making a ton a day of butadiene for several months; we had been able to modify our design and engineering in the light of all the information gained in that way, so that the results we achieved in putting those plants into operation were more or less in the bag. We knew that, provided that we could get the materials and parts. I mention that as background.

I should like now to speak of this gas diffusion process for separating U–235 from U–238. Here was a case where research and development engineering and design were all going ahead at the same time. It is true that from a standpoint of scientific background that work had been started, I guess, in 1940 or '41, but at the time we were invited to act as operators of K–25 at the end of December in '42, while there was a lot of good theory back of that project, there wasn't the type of research and development that big plants are built on quickly.

Nevertheless, there was put together there a group which functioned and produced in a better way engineeringwise than any group I have ever seen. The project involved more money by far than any of the projects with which any of us had worked before.

You were called upon to design a diffusion plant before you knew what the diffusers looked like. You were called upon to lay out a plant that had thousands of pumps or blowers in it before you knew that you could get pumps and blowers to work under the conditions that were imposed because of the nature of the materials you were dealing with.

We were called upon to go out and build whole plants, such as the Allis-Chalmers plant to make these blowers, such as the Houdaille-Hersey plant to make barriers, such as the Chrysler plant to make diffusers, after you had the material; and here was this complicated thing proceeding on all fronts at the same time.

I think it is quite remarkable, the record that was made, and it is a record that goes to the credit of a vast number of contributing companies and to the Army. Their skill in getting material for this project was one of the most remarkable things in the war effort.

Actually, ground was broken for the power plant on June 1, 1943. The first boiler was in operation in March 1944.

The ground was broken for the diffusion plant on September 1, 1943, and the first process gas was put into that unit in February 1945.

In that time all the basic materials and pieces of equipment for that tremendous plant were being worked out. Not only that, but here was a plant that was to operate at a reduced pressure, with the dangers of leakage of air and moisture, and all those things. I might say that chapter X of the Smyth report gives a very interesting account of the facts surrounding the gas diffusion process.

So far as the scientific background and the early problems being faced, that plant was brought into operation requiring standards of tightness that had never been heard of before, tightness in a system that had as much as 600 miles of welding on pipes.

Senator HART. Rather large pipes, too?

Mr. THOMPSON. Many of them 30-inch and 24-inch pipes.

Strangely enough, too, there were times in that program when we were at the deadline with respect to some particular important fundamental part, and that part simply hadn't been produced, yet just before we hit the deadline—and this occurred not once but several times—we had not one solution but sometimes two or three.

We had in all of that many things. We had good procurement on the part of the Army. We were given priorities that I think ruined plenty of other fields of activity but helped us, and we had a fine engineering organization. To do that sort of a job required an engineering force of 2,000 men. Of that number, about one-half were of the service type, clerical, stenographic, accounting, purchasing, and guards; and of the remainder, there were about 600 in what we call engineering and design, about 200 field engineers, and about 200 engineers in the laboratories where research work was going on.

Perhaps one of the most important parts of the engineering organization concerned itself with procurement and expediting. The business of getting the thing that you need at the point at which you need it at the right time involved a whole force of men throughout the country ready to go into different plants, actually check the records of the vendors to see that they had ordered the things they needed to make what they were making, and in the event they hadn't ordered them, find out why, and sometimes carrying that to the second and third position, and following that up periodically.

Sometimes it required moving carloads of material from one plant to another to relieve log jams in machining operations, and so on, but all of that was carried out. The completion date scheduled for the last part of the diffusion plant, the K–25 portion of it—not including the K–27 project, which was added and is now being built—was August 23, 1945. The plant was actually completed August 5, 1945.

This achievement was the result of a major group effort, and a long list of names of those who contributed in a major way could be given. Limiting such a list to a bare minimum, one should mention Mr. P. C. Keith, executive in charge and technical head for the Kellex Corp., Dr. George T. Felbeck, whom we had made top so far as Carbide & Carbon Chemicals Corp., was concerned, Mr. Keith's assistant, Mr. Albert L. Baker, and Dr. Felbeck's assistant, Mr. Hartsel Kensey. They and those under them should be mentioned as putting over the biggest engineering job that any of us had ever seen in the quickest possible time.

Senator HART. Mr. Thompson, in speaking in these superlatives, and so on, what would you say was the greater accomplishment—under size or under complexity?

Mr. THOMPSON. Complexity, I would say.

Senator HART. At the same time the dimensions of it are about as large as anything with which you have ever been concerned?

Mr. THOMPSON. By far the largest.

Senator HART. You are vice president and engineer of a company that engages in a very large business in this country?

Mr. THOMPSON. Yes.

Senator HART. Mr. Thompson, you have given us the figures of how long it took. What is your idea of the ability of any other country in the world being able to accomplish the result at all?

And if they were able to do it at all, about how long?

Suppose we assume that the know-how, insofar as that one vital membrane of which you spoke, was at their disposal, that they knew what it was. Is there any country in the world that could produce that plant at all, and if so, what is your guess as to how long it would take?

Mr. THOMPSON. The answer to that question, as you suggest, gets into the field of guessing. It is a matter of trying to put yourself in the position of the engineers in the other country to see where they would be in comparison to where we were during the period of our work.

To answer your question, I might say first that I am not acquainted with the methods abroad and their set-ups, although obviously those of us in my profession are aware of the accomplishment in other countries, and I am certainly not of the mind to underrate the ability of the engineers or the production groups in foreign countries.

I think it is also clear that now that the atomic bomb is a known reality the business of building up to it becomes somewhat simpler.

So first, to answer in a generalized way, I am satisfied that foreign countries would be able to produce the atomic bomb and would be able to go through the K–25 project. We are speaking now particularly of the K–25 gas diffusion project and you assumed that they had the diffusion matter solved.

Senator HART. That they knew what it was and would have to develop their own process of manufacturing it.

Mr. THOMPSON. Well, in answer to the first part of your question, I am satisfied that these foreign countries could produce after some time something that would be equivalent to our K–25 gas diffusion process.

I am inclined to think that starting even now, with all the funds they might need and with plenty of incentive, if they felt perhaps somebody else was going to use measures against them—with all those things, it would still take much longer than it took us to do the job.

I would say, just guessing, that it would take them twice as long as it took us to do it.

Senator HART. That would mean 5 or 6 years?

Mr. THOMPSON. Yes; and when we say how long would it take to do that job, of course that really needs definition, because we know that from the standpoint of research and exchanges between the scientists working in this field that something had been started in 1940; so that this August completion date in 1945 makes it a 5-year project from the concept to the operating plant. But you were not thinking of that.

Senator HART. You would not be beginning back as far as 1940.

Mr. THOMPSON. That is right; but it would seem to me that from the standpoint of taking scientific knowledge as it exists today and going into the problem of building an organization, to put over such a project with unlimited means back of you and plenty of incentive to do it, it would take other countries twice as long as it took us.

Senator HART. Mr. Chairman, I have one or two questions to ask the witness along other lines. Perhaps in the interest of continuity, other members would like to question along this line.

Senator MILLIKIN. I would like to question along the line of Senator Hart's question.

Assuming that we give some foreign country—the best-equipped foreign country to do the job, whatever it is—our blueprints, our specifications, our formulas from beginning to end, how long would it take, in your judgment, for that best-equipped country to do the job?

Mr. THOMPSON. Just to be sure that I have that question accurately, we are going to give them the blueprints, we are going to give them all the information?

Senator MILLIKIN. The specifications, formulas, and all of the information. We will put it in their laps, and they are to proceed.

Mr. THOMPSON. When we say we are going to give that to them, we mean not only with respect to building what is down there at Oak Ridge, but also with respect to these plants for building the parts that go into it?

Senator MILLIKIN. We will tell them everything we know, except that we won't help them in any way whatsoever to build the plant. They must find whatever they need outside of the United States.

Mr. THOMPSON. That includes the membrane and all of the things—the complete information?

Senator MILLIKIN. It also excludes their use of our personnel. We keep our personnel. We keep everything that we have in this country, but we turn over the blueprints, specifications, the formulas, and everything we can tell them about the know-how.

How long would it take the best equipped country that there is, outside of the United States, to do the job?

Mr. THOMPSON. To put it that way, Senator, I think if you went to the best equipped country, one skilled in that type of construction, that they would have a plant in two and one-half to three years.

Senator MILLIKIN. Let me ask you what, in your judgment, is the best equipped country, outside of this country, to do that kind of a job—excluding, of course, Germany and Japan?

Mr. THOMPSON. Well, I really cannot answer that question. I just don't know.

Senator MILLIKIN. Is there any yardstick whereby men in your business measure the rating of countries chemically and industrially?

Mr. THOMPSON. Oh, yes.

Senator MILLIKIN. Give us a general rating, then, of a half dozen countries of the world that occupy the top rank?

Mr. THOMPSON. Well, I think ratings of that kind you would put on the basis of the tonnage of their different products, and in a given field.

Senator MILLIKIN. Does Great Britain have a general chemical field, for example? Do they produce everything, generally speaking?

Mr. THOMPSON. Of course, they are not one of the strong chemical-producing countries, but they have a chemical industry and it is growing; they have done some fairly good work in hydrogenation of coal and producing synthetic petroleum, and so on, but it is not particularly a chemical-manufacturing nation.

Senator MILLIKIN. How about Belgium?

Mr. THOMPSON. I think that is perhaps too small.

Senator MILLIKIN. Holland?

Mr. THOMPSON. That again is over on other side.

Senator MILLIKIN. Sweden has some great specialities.

Mr. THOMPSON. We can open up there a little bit in certain types of operation, yes.

Senator MILLIKIN. Does Switzerland have any large general chemical industry?

Mr. THOMPSON. I don't believe so. I think they are more in the physical sciences.

Senator MILLIKIN. How does France rate in that kind of comparison?

Mr. THOMPSON. I don't think particularly strong.

Senator MILLIKIN. Does Russia have a general chemical industry, generally developed and ramifying rather widely?

Mr. THOMPSON. No, I would say not. Russia finds its name in the chemical literature frequently in an important way, but so far as the carrying-out of chemical manufacture is concerned, it of course is not developed to a large extent so far.

Senator MILLIKIN. Is there anything to the south of us of any great importance?

Mr. THOMPSON. I don't believe so.

Senator MILLIKIN. As of today we are by all odds many times over the most important chemical nation of the world, are we not?

Mr. THOMPSON. That is right; excluding Germany.

Senator MILLIKIN. I intended that to apply all the way through.

It would take a great long time, would it not, for for any other nation to catch up with us?

Mr. THOMPSON. Yes, sir.

Senator MILLIKIN. Again excluding Germany?

Mr. THOMPSON. Yes.

Senator MILLIKIN. Thank you.

Senator HICKENLOOPER. I would like to ask one question in connection with the subject Senator Hart raised.

Assuming our position in 1941—that is, whatever know-how and plans we had at that time—but assuming that we were not at war and assuming further that we thought we might have to get into war sooner or later, although it was not immediately imminent on that day or that month—we were merely in a state of rather intensive preparation in peacetime—starting from that point in 1940 or 1941, how long do you think, from an engineering standpoint, it would have taken us in peacetime, even under some urge, to have perfected these plants to the point that they were perfected in 1945?

Mr. THOMPSON. Your question assumes peacetime, a reasonable urge, but not the same urge that applied to this project.

Senator HICKENLOOPER. Let us suppose we start 3 years from now, or even today, with the idea that perhaps we are going to have to fight somebody very soon, that it is reasonable to believe that, or that we were vitally interested in preparing an unbreakable defense for our country.

Senator Millikin suggests a valuable addition to this question. Suppose we didn't have it, but we had the know-how we had in 1941 and did know that somebody else had the bomb and had done the job, but assuming peacetime conditions and not the full emergency of the presence of war.

Do you think, for instance, that we could have built the plants in the time that we did build them—or that we could build the plants in the time we did build them under our social, political, and economic peacetime situation and the industrial demands of peacetime, and so on?

Mr. THOMPSON. I think that under the conditions stated in your question, it probably would have taken us about 50 percent longer to have built those plants.

First, the preference rating and priority that was put back of this project was the like of which no one had ever seen before. There was never a time in peacetime when you could get things that you wanted as promptly as you could get them for this project. That is the first thing, and so I am assuming that in peacetime it would have been quite a bit more difficult to get what we have put into this plant than it was during wartime.

Senator HICKENLOOPER. In other words, Mr. Thompson, in peacetime—even admitting that you had the priorities and the authority of the Government to go after them and get them—still probably the peacetime demands on these vast hundreds of thousands of other operations that were producing materials that you needed might have slowed this thing down quite a little; whereas they would just cut through all red tape, all conditions of other business and other activities, in order to meet this intense emergency of war.

Mr. THOMPSON. That is correct, and I also think that even under the conditions stipulated in your question, you would not have gotten the drive on the part of the personnel working on this thing that you did get under wartime conditions. They were simply all out.

Senator HICKENLOOPER. That is the human element, the natural human element?

Mr. THOMPSON. Yes.

The CHAIRMAN. Do you think, Mr. Thompson, that the conditions stated in Senator Hickenlooper's question, namely, that some other country had the bomb, might be the compulsion that would exist to hurry your estimate of time necessary or to shorten the estimate of time necessary?

Taking you as an American engaged in this proposition and informed that other countries or another country had the bomb, have you given any thought to the fact that that proposition might hurry you in your efforts?

Mr. THOMPSON. There is no doubt that that fact alone produces tremendous incentive on the part of the other fellow.

The CHAIRMAN. It would produce that incentive in you, would it not?

Mr. THOMPSON. Unquestionably.

The CHAIRMAN. And the fact that it was peacetime or wartime or in-between time would be disregarded by you, would it not, in your efforts to get this thing into production?

Mr. THOMPSON. I think that is correct.

Senator JOHNSON. Mr. Thompson, the reasons we made such speed were, first, that we had a totalitarian war government; and second, we had the patriotic urge.

Now, can't you picture some other country, a totalitarian country, that would proceed with all the priorities which we had, and they might substitute—if they didn't have the patriotic appeal that we might—the emotion of fear; and don't you think they could speed up and perhaps reach the stage of efficiency which we displayed, other things being equal?

Mr. THOMPSON. I think that the question of their speeding up to their maximum within their capabilities and aptitudes unquestionably would be produced in other places under the conditions you mention.

I wonder, however, if there is any other country that has quite the grouping of aptitudes plus experience in their fields that we have here. I am thinking of the whole business of multiple production, the same thing that made the automobile and the output of war airplanes. No other outfit has that to the same degree that the United States has developed it now.

That figured in a big way in making all sorts of underlying parts, the work of Chrysler and Allis-Chalmers in this field, the work of General Electric and Westinghouse in the project that Mr. Creedon spoke about, and the parts that went into our project—although special plants were not built for them. I mean to say that the business set-up, with experience back of it, able to translate over to making special things almost on a week's notice, is the type of thing that we have that I think no one else has.

Senator HICKENLOOPER. We have one other thing, in pursuit of Senator Johnson's question: The enemy was shooting at us; the bullets were flying. It wasn't a question of "we are pretty sure there will be a war next week, next month, or next year." We were right in the midst of the war, and the battle was on.

I think that may not be a completely controlling element, but it is a very substantial element in the ability to coordinate all of this know-how and the willingness of all our resources to at least make this thing a priority thing and devote its genius to that.

I think the presence of war is quite a thing in this or any other effort.

Senator JOHNSON. Yes; of course, plus the element of totalitarian approach. That is what we had.

Senator HICKENLOOPER. You can get the totalitarian approach in peacetime, you can get the orders issued in various ways in peacetime, but that last urge of the fellow over there on the other side of the hill shooting at you is something that comes only in wartime, right in the presence of war.

Senator HART. Mr. Thompson, are you disposed to alter your estimate of taking 5 or 6 years for any other country to achieve what we achieved in K–25?

Mr. THOMPSON. I still feel that is a good estimate, Senator.

Senator HART. There is one possible difficulty you didn't touch in that splendid statement about the accomplishment, which was in the field of metallurgy. Were there any great difficulties in that field?

Mr. THOMPSON. There were, and again the fact that in this country our metallurgy was well advanced and a living thing that merely had to be assigned to these special problems resulted in a great gain to the project.

Senator HART. What about the availability of the basic metals which came into the picture?

Mr. THOMPSON. The basic metals, of course, were of two kinds: (1) The material out of which the 235 was manufactured and (2) the materials of construction used in the plant itself.

I believe there is quite a bit of security requirements and secrecy thrown around the metal itself.

Senator HART. I didn't mean to bring in anything outside of construction.

Mr. THOMPSON. In the matter of construction, our metallurgy was most perfect, and it got into this project in several ways.

As to the materials of construction for the parts going into the diffusion plant itself, some were corrosive, which, if allowed to accumulate at a certain point, would become fissionable, which were highly poisonous; the metallurgy there was difficult and was only solved because of the groups we had to draw upon.

Again, in the metallurgy of certain phases of elements of the plant, the availability in this country of a trained and going metallurgical group solved those particular problems.

Senator HART. And when we asked you about other countries accomplishing that and you gave an estimate, did you have in mind the possible difficulties which they would encounter in the metallurgical field?

Mr. THOMPSON. I would say not specifically. I was trying to look at it in a general way, considering where they would be trying to do all of the things we did.

Senator HART. Mr. Thompson, you operated this K–25 plant. Is there anything you would like to tell us about the magnitude of difficulties in maintenance?

Mr. THOMPSON. I might say that there were a great many unknowns about the operation of the diffusion plant before it was put in operation. After all, it was impossible in the laboratory to test out in an effective way the effects that were to appear in time. There was no way of accelerating. There was the question, for example, of the diffusion members plugging up, and there was the question of their not being strong enough.

Most of those questions had to be answered by building the plant and putting it to work. Knowing that the failure of some of those things would be fatal to the project, the design incorporated every protection that seemed reasonable.

The operation of the plant might have been perfect from the standpoint of separation, but its life might have been too short. Fortunately, our experience so far has indicated that those matters that have to do with the life and the need of replacing and changing and taking out, and so forth, were well solved, or they were not going to appear, because we have a plant that is operating much better and will operate with much less maintenance than we suspected in the first place.

Senator HART. Then, from a practical standpoint, it has been neither troublesome nor expensive to keep up the maintenance?

Mr. THOMPSON. That is correct.

Senator HART. In the field of operation, is any great number of highly skilled personnel required once it was going, and were there any great difficulties in training them and getting them to carry along the work?

Mr. THOMPSON. In answer to that question, I want to say strongly, "Yes." Without getting into details that probably shouldn't be talked about, I think the approved and published statements thus far have indicated that this operation is one in which you have thousands of steps set one on top of another.

The kind of a separation you are making, you see, is a very sharp one. It is a delicate sort of a thing. It is more or less like running a distilling column, a rectifying column, with thousands of plates in it instead of 20 or 30; and if you disturb that complex unit, and not extensively, but every once in a while, at some point or another you may never get it out of equilibrium. You might have a perfect plant and get a plant that wouldn't separate 235 from 238.

That comes down to control. The control that was worked out for this project was one of the big things that has been most successful. I believe that one of the problems that some other group, attempting to do what was done in K–25, would be brought face to face with would be the difficulty of operation and of maintaining that complicated system in equilibrium so that you can get your end product out at the right purity.

Senator MILLIKIN. Would it be fair to say that it was sort of touch and go as to whether, after this whole thing got into its rhythm and got to operating—as to whether what you wanted would appear at the other end? Of course, you expected it, or you wouldn't have built the plant.

Mr. THOMPSON. Senator Millikin, I think the matter was this: It was realized that running a complicated system of that kind had to be based on good control, and the control end of it received a tremendous amount of attention.

Senator MILLIKIN. But if somewhere along the line, as you pointed out, there had been some little failure, you would have gotten that whole gigantic thing going and nothing would appear.

Mr. THOMPSON. I want to correct that a little bit. I may have made a statement that sounded that way.

Actually, we can cut out quite a portion of it without upsetting the whole thing. The point I wanted to make was this: If your operation was ragged enough so that you had a disturbance at the lower end one day, the next afternoon one at the upper end and the next afternoon one in the middle, and you had that accumulation of disturbances, it wouldn't be a matter of touch and go, it would be a matter of eliminating, that series of disturbances before you produced.

Senator MILLIKIN. It seems to me you produced a perfectly marvelous result, not having a pilot plant to work with.

Mr. THOMPSON. Those of us who worked with it felt that that was so. It was the only time, of course, that anybody had ever spent sums of money like those without a full pilot plant back of you.

Senator HICKENLOOPER. I want to say first, Mr. Thompson, that I think your statement that it is a rather delicate operation is a masterpiece of understatement. I think that probably no one but you expert engineers and scientists can have any appreciation of the extreme delicacy of this operation.

But I did want to ask your opinion on this, to see whether or not this is a correct assumption: I assume, leaving Germany out of the picture because it was a diversified chemical, engineering, and manufacturing country, and at least for a substantial period of time it will be completely out of the picture, isn't it safe to say that our country all through this process, both before the war, afterward, and now, has by far the greatest diversification of industrial know-how, including chemistry, science, engineering, and all of the factors, of any country in the world; and that that is backed up by basic research in these major fields that in the aggregate and for all practical purposes in this thing was far in excess of any other country in the world?

Mr. THOMPSON. I am sure that is right.

Senator HICKENLOOPER. And it was that backlog of basic research over a long period of industrial development in this country that enabled you to know that if something were needed, even though it were new in design and even though it were just being conceived, that there was a segment of our industry that at least had gone far in research into the general basic fields involved in the production of that article?

Mr. THOMPSON. I am sure that is right.

Senator HICKENLOOPER. And you could call upon that in the most tremendously diversified industrial plant in the world, which was this country?

Mr. THOMPSON. There is no question about it.

Senator HICKENLOOPER. If you hadn't had that diversification, in other words if there had been certain new pioneering fields where we had no basic research on some of the fundamental problems, it would have been a more difficult problem to do this job. You would have to go out and build up that backlog of research, and things of that sort were in many sciences already available.

Mr. THOMPSON. I am sure that is correct.

Senator HICKENLOOPER. Although the research might not have been available to that particular problem, but to the type of problem that was available.

Senator HART. I think we might state for the record that to Mr. Thompson "basic research" doesn't mean exactly what Senator Hickenlooper may have had in mind.

You will recall in his testimony he was talking about engineering research after the basic research is completed, and then the engineers take over and make it work.

Senator HICKENLOOPER. Yes; I appreciate that. I probably didn't get my question down to a specific outline as well as I could, and perhaps I can't express it as I tried to conceive it in my own mind. I am no engineer and no chemist, and I cannot go into those things accurately.

The CHAIRMAN. Mr. Thompson, you could put every scientist off the Oak Ridge property and not let them come on there for the next 6 months and operate this plant, could you not?

You have a going plant operated, as it still is, by your company with an engineering and production personnel. The job now is to maintain it in production and operation. That is an engineering job.

Mr. THOMPSON. The answer to your question, as you put it, is "Yes"—definitely.

I might clarify, however, by saying that in the operation of a plant of that kind there are parts of the operating end of it concerning the laboratory phases in which we have Ph. D.'s trained in chemistry, and so on. Now, you are not thinking of men trained in chemistry as scientists. You are thinking of the research background. That is behind us, so far as the K–25 goes. Those gentleman are no longer needed.

The CHAIRMAN. That is right. In other words, you can make fissionable material with your organization today?

Mr. THOMPSON. That is correct.

Senator HICKENLOOPER. The need of the top-flight scientists today, as I take it, is for advance research on other and different methods, or other fields, and so far as the present operation is concerned, their job is done.

Mr. THOMPSON. That is correct.

The CHAIRMAN. Are there any further questions?

I have one question that I would like to ask of you and Mr. Creedon in executive session, which will take just a few minutes.

The committee will meet tomorrow morning in open session at 10 o'clock.

(Whereupon, at 12:15 p. m., the committee retired into executive session; to reconvene in open session at 10 a. m., Wednesday, December 20, 1945.)

ATOMIC ENERGY

THURSDAY, DECEMBER 20, 1945

United States Senate
Special Committee on Atomic Energy,
Washington, D. C.

The special committee met, pursuant to adjournment, at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Johnson, Austin, Millikin, Hickenlooper, and Hart.

Also present: Edward V. Condon, scientific adviser, and James R. Newman, special assistant to the special committee.

The Chairman. Mr. Winne.

STATEMENT OF H. A. WINNE, VICE PRESIDENT AND MANAGER OF ENGINEERING IN THE APPARATUS DEPARTMENT, GENERAL ELECTRIC CO.

Mr. Winne, you are the vice president and manager of engineering in the General Electric Co.?

Mr. Winne. Yes.

The Chairman. Mr. Winne, according to the staff's information, guided a large portion of the development and manufacturing work done by the General Electric Co. for the Manhattan District program. He is the author of articles on electric furnaces and electrical precipitation and steel mills. He has been employed by General Electric since 1910.

Mr. Winne, will you proceed to tell us what you think of the difficulties of the work that you did for the Manhattan District project, and something about it?

Mr. Winne. I will be glad to endeavor to, Senator.

I suppose to clarify the situation it might help if I outlined briefly first the manner in which we participated, that is, very generally, the equipment which we furnished.

The Chairman. That is an orderly way to do it.

Mr. Winne. I presume whatever I say here is public, so no classified information should be revealed.

The Chairman. That is right.

Mr. Winne. Our connection with the project involved work for two of the main processes as described in the Smyth report, that is, the electromagnetic and the gaseous diffusion, so that my remarks will be confined primarily to those two methods.

Of course, due to the way in which General Groves rightly kept the different parts of the project compartmented, we did not have knowledge of all phases of even one of those two methods.

We supplied some standard equipment as well for the Hanford plant, but that was practically all of a standard nature. The major part of the equipment we furnished was that for the electromagnetic project which we termed the Stone & Webster job, because the over-all construction, and so forth, was handled by Stone & Webster.

I would like to emphasize that all the way through this project was given top priority in our organization. We put effort and people on it way beyond what we normally would on a project of the same dollars of magnitude, because General Groves had impressed upon us so thoroughly the importance of it.

For the electromagnetic project, we supplied among other things some high-voltage rectifiers, or cubicles as we termed them, a lot of transformers, switch gear, motors, and so forth. As an example of probably the most difficult part of our participation in that project, I might cite the high-voltage cubicles.

Each one of those was the size of a small room, and there were a great many of them. Each one involved around 7,500 different electrical components. I don't mean just screws, nuts, and bolts—that would run into the hundreds of thousands, probably, but different pieces of electrical equipment, such as instruments, tubes, transformers, motors, and so forth.

While, as I say, this was only a small part of the project, nevertheless it was necessary for us in our organization to use the facilities of practically every one of our works—the Pittsfield works, Schenectady, Lynn, Bridgeport, Fort Wayne, Philadelphia, Bloomfield, and our various research and general engineering laboratories. We even called on our subsidiaries, the General Electric X-ray Corp., which furnished a lot of vacuum tubes, and the Edison General Electric Appliance Co., which furnished a lot of heaters, and so forth.

In addition to that there were some 2,000 items which were obtained from outside contractors for each one of these numerous high-voltage cubicles.

The point I wish to make there is that we had—and this is typical, I think, of all American industry—the organization and the manufacturing facilities, and especially the background of technical knowledge, which enabled us to really contribute to the job and to get it through in the time it was required.

As illustrative of the necessity for that technical background, we found that when some of this equipment first went into service, we immediately had our hands and laps full of trouble, as was to be expected with anything as new and radical as this equipment was. We called upon one of our laboratories which had had, over the past 15 or 20 years, a very unusual background of experience along the line of this particular trouble, and there were about 25 engineers and test men who worked for several months carrying on a series of tests and investigations, as a result of which—just to show you the magnitude of the thing—the report covering the tests involved some 500 pages of typewritten matter and over a thousand what we term oscillograms, which are records made on very high speed recording equipment, and through which we found the sources of the trouble and were able to correct them in the equipment which was supplied.

Of course, one of the difficulties was that all the while this trouble was occurring, in order to meet the shipping schedules, we had to keep the equipments rolling out of the back door even though we knew that they would have to be changed afterward; but it was the only way possible to do the job in the time required, and when we found the trouble we had to go out in the field and correct it.

As another example, there was one particular phase of the equipment which we supplied which required very close control. Now, the type of control of which I speak—commercially, we think of an accuracy as within 1 percent as pretty good—we had to shoot for and obtain an accuracy of one-fiftieth of that, that is, 50 times as good, you might say. The only reason we were able to do that, I think, is because we had previously supplied from one of our laboratories a number of equipments to another branch of the armed services which were of an extremely special nature and were developed only after a lot of mental and manual travail, you might say, and we used elements from that particular specialized equipment to save the day on this Manhattan project and on this particular phase of it.

Again, what I am trying to emphasize is the fact that to do the job in the time that we did it—and I think when I say "we" I can say that I am speaking for all of the industries which participated, and certainly for General Electric—it was necessary that we have available that background of technical experience extending back over many years of engineering, design, and development, and production, as well as the facilities and the manpower to do the job.

On the gaseous diffusion plant, we supplied a lot of equipment in the way of turbines, a number of turbines, which were more or less special, and, again, to indicate right there the necessity for an already functioning industry, one of the first of those larger turbines was taken from another job which was partially completed. It was taken from that other job, some changes were made in it, and adapted to this job. Others were already in the schedule and coming along, which were diverted to this job.

Then, there were a number of transformers, switch gear, and so forth, but our main engineering contribution and the most difficult one was in connection with the instrumentation for the gaseous diffusion plant, and that we turned over almost entirely—as far as the engineering development work was concerned—to what we term our General Engineering Laboratory, which is an organization dating back a good many years with a very specialized personnel and facilities. They were called upon in a number of cases to invent, and in others to take ideas which were in the nebulous stage and bring them through the development stages into actual production. The result there was a large number of very special devices particularly adapted to this job which we would not have been able to produce in the time that we did had we not had this already functioning organization and facilities.

In addition, for the job we supplied a considerable amount of consulting service from scientists in our research laboratory, from technicians in our works laboratories, on such matters as welding and metallurgy, brazing, and that sort of thing.

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While I think very high tribute, of course, is due to the scientists who initiated the work from which this project resulted, the actual consummation of the project—the production of the material and of the bombs—was in my opinion only made possible because we had American industry, American engineers, American equipment ready to function. The scientists had built experimental equipment for use in their laboratories, but to operate them they had, you might say, hundreds—and I think that is literally true—of Ph. D.'s and similarly trained people. Industry had to take these ideas and put them into commercial equipments, in quantities, which could be operated by girls with high-school training or less, and with a minimum of maintenance and with as nearly as possible continuous operation.

A great deal of credit is due not only to the industrial manufacturers but also the organizations, such as Stone & Webster and Kellex, with whom we had principal contact, and there were many others, such as Tennessee Eastman, and so forth, for their work on the over-all project. I think the highest of praise is due to General Groves and his organization for the way in which they coordinated and pushed this whole project forward. I have sat in meetings with the General in which the personnel ranged from the scientists to the hard-boiled construction people, and he did a marvelous job of shoving the whole thing forward and getting it done.

Mistakes were made; we made mistakes. I think probably everybody connected with the project made mistakes. Because of the necessity for speed, it was done in a way that we normally would never think of doing an engineering and development job.

To take these high-voltage cubicles, for example, the ordinary way to proceed with that in our ordinary work would be to build one and put it in operation and see how it worked, and work the bugs out; and then from that build up the commercial designs for the remaining quantities, and go ahead and build them. But in order to meet the time schedule we had to start from the drawings on the paper and turn them out the back door, and then make such changes as were necessary later. While we can look back on it now and say we could start over again and do the job at less expense and perhaps in less time if we had the same urge—we couldn't do it in anything like the time we did without the urge of war, in my opinion; but looking at it from the other end, from the start, I do not know how the over-all job could be done any better than it was. I think it was a tribute to the Army, to American industry and everyone concerned with that—and I say that with due modesty for our part in it.

Senator AUSTIN. To what extent, were you dependent on the Army for materials?

Mr. WINNE. We very often had to call on the Army personnel to help us in expediting material from suppliers or component parts which we were getting from the outside. They were a great deal of help to us in that way.

Senator AUSTIN. You mean manufactured articles made by other concerns?

Mr. WINNE. That is right.

Senator AUSTIN. Were you dependent on the Army for raw materials?

Mr. WINNE. Well, I cannot answer that question definitely as to whether we ever had to call on them to help us get such things as steel and copper. I am not sure, but I rather think we did; but I cannot say that with absolute certainty.

I know we called on them a great many times for component parts from other manufacturers, and, of course, we had to call on them to arm us with directives or AAA priorities where needed, and that sort of thing, so we could help ourselves to get the material.

Senator AUSTIN. In peacetime, that situation where you could depend on the Army would not probably exist, would it?

Mr. WINNE. That is very true.

Senator HART. Mr. Winne, this background of industrial knowledge, know-how, and ability to produce is also a part of a good many other firms in this country with which I assume you have a certain amount of acquaintance; is that true?

Mr. WINNE. That is correct.

Senator HART. Going back, you, I understand, have been with General Electric for 35 years. Going back to 1910, when you began, and which covers the period of our very great industrial advance which has put us out ahead of the world, what were the circumstances as you now see it which so impelled us that we did set up in this country this marvelous industrial establishment in the heavy industries? What were the compelling and impelling circumstances?

Mr. WINNE. I would say offhand the profit motive of industry, the natural desire of all industry to improve its products, to expand its field, and thereby expand its business and carry on development work. You perhaps know our slogan: "More goods at less cost for more people," which is a slogan which we have tried to live up to right along. I think that is perhaps the greatest motive. It is probably trite to say, but the free-enterprise system had a great deal to do with it, I feel.

I don't know whether that answers your question, sir.

Senator HART. Not altogether. Which particular field of industry do you look back upon as having developed the fundamentals of mass production, rapid production of various difficult articles? Would it be the electrical field, or some other?

Mr. WINNE. Well, I think in general we think of the automobile industry as having more or less led the way in quantity mass production.

Senator HART. Have you been able to keep in touch with the state of industry in other parts of the world, particularly in Europe, over the last generation or so?

Mr. WINNE. Only in a very general way, speaking of my personal knowledge.

Senator HART. Have you any idea as to how it happened that with the possible exception of Germany the rest of the world fell behind our ability in production, in our heavy-industry ability to produce? Where did the rest of them fall behind us so badly?

Mr. WINNE. That is a very difficult question to answer, sir.

Senator JOHNSON. Did they fall back or did we lead out?

Mr. WINNE. I don't think that any of them have fallen back. I think practically all countries have gone ahead, but I think we have gone ahead faster than the majority of the other countries.

Senator HART. Aside from the possible sociological aspect of the free-enterprise profit system, and so on, we must have had other advantages in order to have gone out ahead of the world so fast, don't you think?

Mr. WINNE. Of course, we have had the advantage of raw materials, I think, to a considerable extent, at least over many countries. Of course, there are other countries which are not yet so far developed as we which have also quite large resources of raw materials. But taking the more highly developed countries, such as England, unquestionably, of course, our store of raw materials is much greater than theirs. That undoubtely has had considerable to do with it.

Senator HART. Looking into the future, Mr. Winne, what country in the world is most likely in your opinion to be able to overtake us if there is an urge to get into production of heavy industry?

Mr. WINNE. Judging by what one reads, and so forth, I should think the probable answer is Russia.

Senator HART. I believe your company has a good deal of representation in Russia, or has had?

Mr. WINNE. We have had some representation in Russia. So far as I know, we have no one there now.

Senator HART. Did you gather from those representatives any measure of Russia's ability to overtake us?

Mr. WINNE. No, I have not, sir. I am not in a position to give any valuable information on that point.

Senator HART. Thank you.

Senator HICKENLOOPER. Mr. Winne, may I ask your opinion on this: Suppose we started right now with the knowledge we had in 1941 or at the very beginning of this enterprise, and we knew that some other country had an atomic bomb actually completed, that they could make it, had the know-how and the process, and we wanted to start out to make an atomic bomb.

As I say, beginning with the information we had in 1941, in peacetime and not in the presence of war, what is your opinion as to the length of time it would take industry to do the job under those conditions?

I may go a step further and say that the point of my question is: Could we get the cooperation; could we get the intensive union of all industry, engineering, and so on, together to finally produce the thing in the time that we did—in peacetime?

Mr. WINNE. Of course, you must realize that my answer to this must be simply a matter of opinion, as obviously it cannot be based on actual facts.

Of course, on this project, the funds available were practically unlimited to get the job done.

Senator HICKENLOOPER. Let's assume that they are now.

Mr. WINNE. You are assuming also, then, that funds would be made available?

Senator HICKENLOOPER. That funds are available and priorities—or at least top orders for priorities—are just as strong as they were during the war.

Mr. WINNE. As I said, it is difficult to weigh what the effect on us would be of the knowledge that another country had atomic bombs ready to use if they wished to. It might put almost as much impetus behind us as actual war itself, but my belief is that it would not. I think it would probably take once and a half to two times as long, or something like that, under normal peacetime operations to do this job even with the funds available.

I just cannot conceive that in peacetime either the Government or industry would go ahead on the basis as I say we had to here, because of the urgent life or death nature of this job, almost, and be producing equipment while it was still in the very early developmental stages. That is entirely contrary to all normal industrial production.

Now, if you get enough urgency behind it, if we knew that atomic bombs were going to start coming over in a short time, if we didn't get something to combat them with, then you might possibly get speed of the same order of magnitude as we got in this case. There are so many intangibles.

Senator HICKENLOOPER. I am merely speaking to you as an engineer who has had a lot of experience in the human end of production. That is, you have to get human cooperation before you can turn out these things, and I am wondering whether a condition doesn't exist psychologically or otherwise in the presence of war, that is, in time of war, that probably enables these jobs to get done which even under the threat of war wouldn't be accomplished quite so fast?

Mr. WINNE. I think that is very definitely true. I think it would certainly take longer simply under the threat of war than it took us in actual war, and with the thought that possibly our opponents were only a jump behind us, or maybe not even a jump.

Senator HICKENLOOPER. In other words, when they are not actually shooting at you, there is a human tendency to be a little more certain about what you are doing—not to procrastinate, but to take a little more time and prove your theories.

Mr. WINNE. I think that same thing would apply to Congress in the allocation of funds to a thing like this. Don't you think so?

Senator HICKENLOOPER. Well, I have read the papers. I think it is true that in any human organization there are times when the urge and speed of accomplishment are a great deal more than at other times.

Mr. WINNE. I think, over-all, unquestionably it would take longer under any other conditions than it did under the war conditions, and it might be in the order of once and a half to twice as long, or something like that.

Senator HICKENLOOPER. Let me ask you this: Insofar as you have any knowledge or opinion on this, is there any country today—considering, of course, the devastation of German industry and its complete destruction—that can compare with our country in the whole field of basic research, engineering, over-all historical know-how in industrial and scientific fields of this kind?

Mr. WINNE. I think not, Senator, when you particularly bring in the manufacturing facilities and the engineering and technical background for producing the equipment necessary to produce the atomic bomb.

It is my personal opinion that there is no country today which could approach us on that.

Senator HICKENLOOPER. I am referring to the over-all picture now. Some might be able to make just as fine a piece of individual equipment as we could make here, and it is entirely possible that some country might make a finer piece of individual equipment than we are prepared to make here, but I am speaking of the over-all picture, because as I understand it, this operation is an over-all ramified operation in which all factors must be completely coordinated and must completely operate.

Mr. WINNE. That is my opinion, Senator; yes.

As I say, we had to call not only on practically all of our own organization, but on many other organizations in the country to supply parts just for the part which we supplied, and ours was only a portion of the total equipment used in the project.

Senator HICKENLOOPER. That leads me to just one more question. When a problem came up that you knew had to be solved in a comparatively unknown field, isn't it true that there did happen to be a segment of our engineering, or design, or industry, some place that had had some basic knowledge in that whole field upon which you could rely to develop this special thing?

Mr. WINNE. Very definitely so, Senator, especially within our own organizations. As I say, we called on our Pittsfield high-voltage laboratory when we ran into trouble in one place. We called on the General Engineering Laboratory. We called on other organizations. There was one particular part of this control in which we needed a very special vacuum tube. We happened to know that another company had a tube which might fulfill that requirement, and we found that they did; not all of the tubes they made did, but by selecting a comparatively small percent out of a great many they manufactured, we got the tubes that we needed to accomplish the desired results.

Senator HICKENLOOPER. In any event, if they had not had the particular tube, they had had some experience in the broad field of production that you wanted, and they very likely had the know-how to go ahead and develop the thing you would want.

Mr. WINNE. That is right, and we called on our General Electric X-ray Corporation for some very special tubes. We used the existing buildings, but we equipped and manned and put into operation a complete new factory for building large quantities of quite large-sized vacuum tubes that were required on this electromagnetic project.

Senator HICKENLOOPER. In other words, many other countries might have a certain portion of this field developed very highly, and yet on certain essential things they might find themselves at this point: "Well, we have no part of our industry that has ever explored that field very much; we have to start out and develop the whole thing."

Mr. WINNE. That is entirely possible, and I think probable. I could not say definitely.

Senator HICKENLOOPER. That would be a great factor in the final completion of this project?

Mr. WINNE. That, and also the mere magnitude of industry necessary to turn out the equipment required to do the job.

Senator HART. May I ask one more question?

Mr. Winne, comparing our industrial ability with others, and how we happened to get so far ahead, is it your opinion that our superiority has not been so much in the field of basic research as it has been in development research and our consequent superiority in working out designs for apparatus which lent themselves to production? Did our superiority lay in that, or are we also superior in our basic research?

Mr. WINNE. Well, Senator, I doubt if we have been greatly superior, at least in our basic research, to some other countries, but I do feel that we have been superior in our technical developments, our development of production methods and facilities for manufacturing highly technical and complex equipments.

As far as basic research is concerned, it is my feeling that we have not been much, if any, ahead of some other countries.

Senator HART. Is engineering research the proper term for the field in which we have been so superior?

Mr. WINNE. Well, you can term it engineering research, or engineering and technological development. There is a great deal of difference in definition as to the terms "research," "engineering," and so forth.

In our company we apply "research" primarily to fundamental searching into the unknown, you might say; whereas our "engineering development" is taking the results of research and putting those into practical use, and in developing the manufacturing facilities, and so forth, is where we primarily have been superior.

Senator HART. In your opinion, what other countries were on a level with us in basic research?

Mr. WINNE. Again, I have to rely largely upon reading, and so forth, and not from my personal investigation of their facilities, their work, and so forth, but Germany, in general, had done a very good job of basic research. England has carried on some outstanding basic research, and I think Russia has. Our Dr. Langmuir was over there a short time ago and was quite impressed with some of the research work they had been carrying on. I believe he outlined that to some extent to this committee.

The CHAIRMAN. Mr. Winne, have you traveled extensively abroad?

Mr. WINNE. No, I have not, Senator. I have not done any traveling abroad, that is, off this continent.

The CHAIRMAN. If you wanted to know the state of advancement of industries comparable to the one you represent, where would you go to find out?

Mr. WINNE. Do you mean geographically?

The CHAIRMAN. The various countries of the world. That information is probably better compiled in the Department of Commerce than any place else, isn't it?

Mr. WINNE. Well, of course, in prewartime we had, as a part of our general organization, what we called the International General Electric Co. which had representatives in most foreign countries and knew in a general way at least of the technological development in those countries. We cannot, of course, use those today, because we don't have the men abroad to the same extent, but we would have used that organization to find out what other countries were doing as well as we could.

The CHAIRMAN. Do you know about the facilities or the extent of the information in the Department of Commerce as to the development of industry in other countries of the world?

Mr. WINNE. I am not especially familiar with it, Senator, no.

The CHAIRMAN. It has occurred to me that they might be the best coordinator of that information.

Did you, as representing your company, make any estimate of the time that other countries might be expected to require to duplicate this performance to the George Harrison committee that was set up in the War Department to receive that information?

Mr. WINNE. No; I did not, Senator.

The CHAIRMAN. Do you know who in your company did make that estimate, or if anybody was called upon?

Mr. WINNE. I don't know that anyone has been called on, although they may have been. I don't know of any information of that nature that has been given to that particular committee, Senator.

Senator JOHNSON. Following the line of questions which have been submitted by the Senator from Connecticut, Admiral Hart, isn't it true, Mr. Winne, that the atmosphere here has been wholesome for the development of industry? Our educational program, the number of college graduates, and the number of technical schools and graduates from those technical schools, our free enterprise system together with the profit system, which is a reward for merit, and the attraction that our freedoms—the freedom of speech and the press which have permitted the friction of minds—have attracted scientists and technicians from all over the world to come to our country.

Haven't all of these things combined to make it possible for our industry to step ahead of the rest of the world, and isn't it really the combination of these things that has created the wholesome atmosphere for the advance of industry?

Mr. WINNE. I think I can wholeheartedly endorse that statement. Of course, as far as the technical colleges and industry are concerned, those two are interrelated. As industry has grown, its needs for the technically educated men have grown, and that has helped to increase the number of men in the colleges and the number of colleges. The two have more or less come up together.

Senator JOHNSON. The people in this part of the world may have what some folks call the creative mind or instinct, but don't you think that instead of having any superiority or any advantage over other peoples just as men were born naturally, that it had been because of these conditions?

Mr. WINNE. I think environment has a tremendous amount to do with that. That is, there are creative and brilliant minds in a great many other countries, as you all know. Of course, the brilliant people from other countries, many of them, have come to this country. I think the environment in this country—as you say, the free enterprise system, the profit motive, and so forth—has been primarily responsible for our progress. That is a rather trite statement, I know, but I think it is true.

The CHAIRMAN. Mr. Winne, radar was developed in England, wireless in Italy, fission in Germany, jet planes in Germany, V-2's in Germany, penicillin in England, synthetic rubber out of alcohol in Russia, and all of those things were put into production.

I am pretty proud of this country, too, but I do not want to get so proud as to believe that everything that has been done that is worthwhile in modern advanced technology and science has originated within the four corners of the United States, because it just isn't true.

Mr. WINNE. I would not claim that at all, Senator. That is why I said, in answer to the Senator's question, that there are brilliant minds in other countries as well as in this country. We have no monopoly on brains.

The CHAIRMAN. They have been able to translate their inventions into mass production, haven't they?

Mr. WINNE. I think not to the same extent that we have here.

Senator JOHNSON. That is the very point.

The CHAIRMAN. But you don't need mass production of atomic bombs, do you?

Mr. WINNE. No; but to produce a plant which in turn can produce atomic bombs in a short time you need essentially mass production facilities.

The CHAIRMAN. We did it in four different methods.

Mr. WINNE. That is right.

The CHAIRMAN. You, of course, would assume that any other country, the four methods having been proved, possibly would select one of those methods.

Mr. WINNE. I think any other country starting today has the advantage, Senator, that they know to some extent what we have done. They know we have been able to make these methods work. They possibly can analyze to determine which one, two, three, or all four are best, and to that extent would have a better start than we had.

There has been enough published on the basic researches, and so forth, to give other countries an advantage over what we had at the start of this project, it seems to me.

The CHAIRMAN. Keeping in mind that they would select one method, that they know that method would work, that they have been capable of doing these other things that I have mentioned, do you care to give any estimate for the record of how long you think any other country—being specific or not—could get into production on fissionable material?

Mr. WINNE. Of course, any such estimate is purely a guess.

The CHAIRMAN. I appreciate that.

Mr. WINNE. And purely a personal one. I feel that to do what we did in the time we did called for such diversified effort on the part of so many of our different industrial organizations—not from personal visitations or anything but simply from reading, as I said—no other country today can approach us in industrial facilities available; and therefore I feel that even granting that they would have somewhat of an advantage in the start it would take any other country considerably longer than it took us.

Now, whether that would be twice as long—and it might be on that order of magnitude I might think—again I want to emphasize that there are very few facts on which I am basing this. It is just a guess and a personal opinion. It might be once and a half; it might be three times as long—I don't know. I feel it would certainly be longer.

The CHAIRMAN. How long would you say it took us?

Mr. WINNE. Well, again, I can only cite our own experience.

We were given specifications on this equipment, and those specifications—I would emphasize—in turn were the result of long experiments in laboratories, and so forth. We were given specifications as to what it was felt was needed from us in either December of '42 or January of '43.

Now, again, that is only our part of the job. Of course, those specifications were changed many times as we went along, but that was really when we started to put the pencil to the paper to make designs for the equipments which we furnished about January of '43.

The CHAIRMAN. Are there any further questions?

Mr. Winne, thank you very much. I think your company made a great contribution to this project, and it was very kind of you to come down and talk to us today.

Mr. WINNE. We are glad to be of any help that we can.

The CHAIRMAN. Mr. Brown.

STATEMENT OF EDWIN H. BROWN, VICE PRESIDENT IN CHARGE OF THE ENGINEERING AND DEVELOPMENT DIVISION, ALLIS-CHALMERS MANUFACTURING CO.

The CHAIRMAN. Mr. Brown, you have been connected with the Allis-Chalmers Co. for 35 years, I notice, and you had some considerable experience with the Manhattan District project.

If the committee has no preliminary questions, I will ask you to go right ahead and tell us about your company's connection with the project and more particularly yours.

Mr. BROWN. The company had different orders and contracts with the Manhattan District and its representatives and contractors in excess of some 60, ranging from a very few dollars up to very large amounts.

The equipment furnished included nearly all of our standard products that went into the various projects. How much more equipment went into the mining industry, and others that were involved, we don't know.

Among these contracts there were two that I feel are pertinent to the subject of your committee in particular. One of them was for equipment having to do with the electromagnetic process, as described in the Smyth report, and the other had to do with electrically driven mechanical equipment for diffusion separation of gaseous products, both for equipment installed at the Clinton Engineer Works, Oak Ridge, Tenn.

Of the electromagnetic process equipment, we were the fabricators, the makers, the installers, and the developers of the manufacturing processes. We did not develop nor design the equipment. It was developed and designed, so far as we know, under the direction of Stone & Webster Corp. If I recall rightly, it was to them that we reported on the work in our plants. The principal electromagnetic equipment was of the heaviest type made by heavy industry. Its fabrication represented a difficult problem in our works, when we handled things up to the largest dimensions for machining, welding, and all the various shop operations, involving difficulty even in shipping and installation.

The actual manufacturing processes required the development of new methods. Some of them were beyond the scope of our experience, particularly in certain tolerances for welded products of the dimensions of this equipment.

This equipment, after shipment and installation with all the care that had been exercised by the various companies engaged at Oak Ridge, was contaminated by foreign matter, had to be taken out, returned to our plants, rebuilt with some additional fabricating development work being done, and returned.

The other particular contract which pertained to the processes of fission was for rotating pumping equipment for gases, electrically driven. On that work we were required to develop the apparatus, the design, as well as to manufacture, and we had to construct a plant in which to build the equipment. The difficulties I don't believe can be exaggerated. They drew on all the resources of the company, all of its personnel, all of its staff. I believe that for 8 months during

1944 our president probably took the job home to bed with him and woke up with it in the morning.

It involved the development of parts with surfaces, the accuracy and tolerance of which were measured in millionths of an inch, and the production of them by shop people in relatively large quantities. The basis of the design was worked out in laboratories with which we were not familiar. We were supplied initially with information, we understood, from Columbia and other places, perhaps some in Chicago, which was delivered to us, and we went on from there.

We have estimated at times that there must have been a corps of two or three hundred people in laboratories in different parts of the country supplying information regarding the results of the development we were carrying out. The job required the development of new welding, brazing, and soldering processes. It required repeated changes of material to get some parts that drew on the metallurgical knowledge of the country; to obtain metal parts that are accurate to tolerances measured in millionths of an inch and can be produced in a short time and be stable in operation. Some phases of metallurgy had to be learned as that job was carried forward.

There was a right-of-way for the company to obtain those services and to obtain material. There was complete freedom to make changes in material when it was necessary in order to get the job done.

The manufacture of this equipment required, in a large part of an appreciably large machine shop, maintenance of surgical cleanliness in connection with the work. The same problem of maintained cleanliness entered into the shipment of equipment; whether it could be shipped by truck, whether it could be shipped by railroad, whether it would have to be under temperature control. The erection and servicing of it at Oak Ridge required development there and the transfer of the knowledge from our shops and staff to groups there for maintaining and putting the equipment in service. This was a strain on everyone connected with this part of the project.

I believe, Senator, I have summarized the general conditions that pertained to these things. I want to assure you that I have not overemphasized the difficulties that were experienced, the number of people that had to be drawn in to solve them—the complete staff of our company; we don't know how much of the staffs of steel mills and laboratories throughout the country were thrown into the work.

Senator AUSTIN. Mr. Brown, is it true that you were a troubleshooter for operation of this machinery that Allis-Chalmers Co. produced after it was installed in Manhattan District at Oak Ridge, Tenn.?

Mr. BROWN. Yes, sir; during the manufacture, development, and the initial efforts to put the plant into operation.

Senator AUSTIN. In your work, are you at liberty to say what type of trouble you found down there with respect to machinery that had to be corrected generally? I don't care for details.

Mr. BROWN. Practically all of the trouble was diffusing knowledge, spreading knowledge out over people. There was failure to know how to maintain temperatures, to prevent corrosion, to start and stop things, to condition them properly before starting them up. We had learned some of it in our plants. It had to be transferred there. The solution was undertaken by the sending of men who had been trained in our place, the sending of laboratory men, the staff of the Kellex Corp., and others to try quickly to extend this knowledge.

Senator AUSTIN. Speaking of the metallurgical side of the problem, did you find that you had to make material changes in the structure of this machinery, particularly the pumping equipment for gases after it had been installed at Oak Ridge?

Mr. BROWN. Yes, sir; it was started up with one material in one particular part that I recall. That material was changed even while they were operating—taking them out of service and changing them—more than once, and I think that the last of the units is being equipped with the final material now.

Senator AUSTIN. Did that process prolong the period required for the production of the bomb?

Mr. BROWN. Our knowledge was so limited, Senator, that I really cannot say as to that. That is, we didn't know what material our machinery was to handle. That had an advantage—it didn't let us diverge from curing the troubles with which we were faced.

Senator AUSTIN. Thank you.

Senator HART. Mr. Brown, in which of those two plants, the electromagnetic or the gas diffusion plant, as you now look back upon the history, did you have the greater difficulty in the production, looking back over the completion of the designs and the eventual supply of the apparatus?

Mr. BROWN. The greatest difficulty was that for the diffusion process.

Senator HART. Was that the pumps?

Mr. BROWN. Yes, sir.

Senator HART. Had anyone in this country ever made pumps that were as difficult to make and which were called upon for as hard a task as were those pumps?

Mr. BROWN. The general type of pump, Senator, was of known standards, but to suit it for this purpose it became different from anything that had ever been built, so far as I know, in the world. Certain parts and appurtenances were developed and applied to it that weren't in existence before, I believe.

Senator HART. The number of those pumps was great enough so that the production was decidedly a mass-production problem; is that correct?

Mr. BROWN. Yes, sir; that is correct.

Senator HART. Mr. Brown, in your long service with Allis-Chalmers, have you acquired much knowledge of the state of heavy industry in other countries?

Mr. BROWN. From time to time, I have, Senator, rising chiefly around circumstances or conditions in connection with our power-generating equipment, particularly.

Senator HART. Did your company, before the war, have representatives all over Europe, for instance?

Mr. BROWN. We had an office, as I recall, in London—a sales office, and also a sales office in Paris.

Senator HART. But that was for selling only?

Mr. BROWN. We had some arrangements for manufacturing our products in some European countries—I believe France and England.

Senator HART. Did you, yourself, have much knowledge of what was going on in those offices or plants in Europe?

Mr. BROWN. No; not those particular plants. My European knowledge was based on visits to people regarding heavier types of apparatus.

Senator HART. I will ask you the same question I asked Mr. Winne. To what circumstances do you ascribe the fact that the United States went so far ahead of the rest of the world in the production of heavy machinery, or all kinds of heavy industry?

Mr. BROWN. I can only answer for myself, Senator. I have an opinion, but I can't say that it coincides with that of my associates or my boss.

I think that this country has progressed industrially to the extent that it has because we primarily manufacture for our own use and under a system that enables a person with imagination or desire to meet a need or even create a need or change a desire into a necessity, such as has been done here with the automobile, the electric appliances, and everything like that.

Senator HART. Does that mean that it is altogether in your estimation a difference in markets, domestic markets?

Mr. BROWN. Again, may I repeat that I am expressing my own opinions and not those of my company.

Manufacture for export, of which we do a large amount in our company, involves such capital lay-out, credit arrangement, organization, and foreign connections that it doesn't enable someone with limited means, a good idea, and energy to meet or create demands for goods.

Manufacture for a home market enables a country industrializing itself, so I think, to create a need, by the reduction of prices, for its own equipment.

Senator HICKENLOOPER. In other words, Mr. Brown, we produce ample raw materials upon which to work, and we have an ample market for the genius of a free industry to operate, given the rewards of his effort?

Mr. BROWN. Yes, sir.

The CHAIRMAN. Mr. Brown, is any of the research that you use in your company done abroad?

Mr. BROWN. Well, we have some license agreements and some work within my experience where we have utilized research that was done abroad, engineering research particularly.

The CHAIRMAN. Out of what country did that arise?

Mr. BROWN. England primarily; they originated or developed the steam turbine. We have had consultants in Germany advising us on designs.

The CHAIRMAN. Switzerland?

Mr. BROWN. Yes, we have had connections with Switzerland which were quite close, in fact, at times.

The CHAIRMAN. Did you draw anything of benefit out of those connections in the way of improving your product?

Mr. BROWN. Beyond question, I believe we did, Senator.

However, in dealing with licenses—take Switzerland for example—foreign licensors frequently want you under a license to do things exactly the way they do it. I don't believe most American companies do that when they have a license, and I know we do not.

The real benefit is shaded by the modifications we apply to such information and knowledge as we acquire from foreign sources.

The CHAIRMAN. Are there any further questions?

Thank you very much indeed, Mr. Brown.

The committee will now go into executive session.

(Whereupon, at 11:35 a. m., the committee retired into executive session.)

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ATOMIC ENERGY ACT OF 1946

HEARINGS

BEFORE THE

SPECIAL COMMITTEE ON ATOMIC ENERGY
UNITED STATES SENATE

SEVENTY-NINTH CONGRESS

SECOND SESSION

ON

S. 1717

A BILL FOR THE DEVELOPMENT AND CONTROL
OF ATOMIC ENERGY

PART 4

FEBRUARY 18, 19, AND 27, 1946

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ATOMIC ENERGY ACT OF 1946

MONDAY, FEBRUARY 18, 1946

UNITED STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to notice, at 10 a. m., in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Austin, and Hickenlooper.

Also present: Dr. Edward U. Condon, scientific adviser to the special committee; James R. Newman, special counsel; and Christopher T. Boland, staff director.

The CHAIRMAN. Mrs. Stone is appearing for the League of Women Voters.

STATEMENT OF MRS. HAROLD A. STONE, DIRECTOR, NATIONAL LEAGUE OF WOMEN VOTERS

Mrs. STONE. I have with me Mrs. Allan C. G. Mitchell, director in charge of foreign policy for the League of Women Voters, and I would like her to present a brief portion of the testimony. I am Mrs. Harold A. Stone, a director of the National League of Women Voters.

In appearing before the Special Committee on Atomic Energy, the League of Women Voters would like to divide its testimony into three parts. First, we believe that we should express our preference for putting the new agency for the control of atomic energy under a single head and within the regular framework of the executive branch. Second, we should like to express our approval of many features of the McMahon bill, although pointing up several provisions which the League would like to see changed; and, third, we should like to state our opposition to the May-Johnson bill.

The league believes that the drama of atomic energy has confused both the leaders and the people of the Nation and caused them to overlook the tested and familiar pattern created by our Constitution for holding the administration of the most important aspects of government within the immediate framework of the executive.

Finding suddenly a new and infinitely greater kind of power in the possession of our Government, we have cast about frantically for some mechanism and some omniscience to assure its proper use. We have longed for some social invention, and wished for some supermen to assume this staggering new responsibility, which has seemed too much for ordinary mortals and mortal institutions to cope with.

We have no new institution. We have no supermen. Several months of sobering reflection have led us back to what we have. We have a representative government with a legislative and an executive. These two branches have mutual responsibilities for the conduct of our Government. The legislative branch enacts the laws. The executive branch administers them.

The League of Women Voters believes that atomic energy should be controlled by our Government in the public interest and its benefits developed as rapidly as possible. It recognizes the immensity of the administrative problem involved in controlling the production of atomic energy, already a $2,000,000,000 project, already functioning, daily adding to our supply of a vast new source of energy. We recognize that this is indeed something new—that never before has our Government held the responsibility from the beginning for a new source of power, which promises intimately to affect the daily lives of all of us within a few years.

The League of Women Voters believes that the situation calls for administrative skill of the highest order, that we should apply the best of our knowledge of public administration in setting up the new agency. We believe that authority and responsibility should be direct and simple, visible to the citizen. This can be done best, we believe, by placing the agency under the direction of a single head, appointed by the President with the advice and consent of the Senate. The importance of the agency would probably command for its head a position in the President's Cabinet. The League of Women Voters believes it of great importance that the work of the new agency be coordinated with the work of other Federal agencies through the already established executive organization. The ramifications of atomic energy will not be confined, but will inevitably reach out and affect the work of every major department of the Government. The league, therefore, believes that the new agency must be directly responsible to the President, who is in turn responsible to all of the citizens. It is the President, in our system of government, who alone can coordinate the work of the various executive agencies. To limit the authority of the President over the new agency for the control of atomic energy, would make it difficult, and might eventually make it impossible, for him to discharge his constitutional duty as Chief Executive.

The league believes that we should not place this great new function apart from the executive in the "headless fourth branch of government," responsible to no one and impossible of coordination with the general policies and work of the Government. Atomic energy is not something which may be kept apart, unsullied by the many other aspects of government with which it will inevitably be interrelated. That it is fraught with such significance to our citizens, is all the greater reason why the new agency should be directly responsible to our duly elected Chief Executive. We believe, therefore, that the Congress should create a new agency, with a single head, responsible to the President.

Because there are many new and unknown aspects of atomic energy, the league believes that the law should provide for a small advisory commission to assist the Administrator. This would be composed of eminent civilians serving on a part-time basis.

The CHAIRMAN. Pardon me a minute. Would you advise that the one-man administrator be a civilian or a military man?

Mrs. STONE. A civilian. I will come to that again.

Even though we differ with the basic structure, preferring a single administrator rather than a commission, the League of Women Voters believes other provisions of the McMahon bill are excellent and should be incorporated in whatever final legislation your committee recommends. The league agrees that control of atomic energy should be vested with the Government, and that it should be under civilian control. We believe that the provisions for licensing and control are excellent, retaining, as they do, national control over production of atomic energy, while allowing private-enterprise ownership of source materials, byproducts, and devices for the application of atomic energy.

The provisions for the free development of scientific research, with adequate safeguards of technical data where it relates to national defense, we believe to be good. It is wise that the new agency carry on research but have no monopoly on research. The provisions for inspection and for safeguarding health are also adequate.

Because of the league's deep interest in international cooperation we note with special approval the provisions which would assure that our domestic policies for atomic energy not conflict with our international policies. We are also especially glad to note in previous testimony preponderant agreement that the agency should be a civilian agency. We are pleased that the bill so provides.

The league believes that it is an extremely wise provision that the quantities of fissionable material to be produced should be determined by the President, and that the President should specify what atomic weapons are to be used by the armed forces.

With the provisions for the internal organization of the Commission, the league must differ emphatically. Divisions of the agency should not be specified by statute, nor should their heads be appointed by the President with the advice and consent of the Senate. We believe that it will not help the President to give him the power to appoint such division heads. Such appointments threaten the unity of an organization, and make it difficult for the head of the agency to be held responsible by the President. Such provisions do not make for good administration. They foul lines of authority and responsibility and make for confusion, buck-passing, and stalemates when important decisions are at stake. Specifying the internal arrangement of the organization makes for a rigid rather than a flexible organization.

The league believes that if the Congress does create a commission, a general manager should be provided and that the heads of divisions should be appointed by and be responsible to him, in order that he may in turn be held responsible by the Commission.

The CHAIRMAN. Mrs. Stone, theoretically there might be something to be said for your observation about making it too rigid. I have in mind, for instance, the Department of Justice, with which I used to be associated. The five Assistant Attorneys General are nominated by the President and confirmed by the Senate. As a matter of practice, the Attorney General nominates them.

Mrs. STONE. I realize that, and there is, of course, the possibility that it would work out that way.

Now, I would like to comment briefly on the May-Johnson bill. The League of Women Voters is opposed to the May-Johnson bill. We believe it unwise to create a large and unwieldy commission over which the President of the United States would have so little authority. We believe that the bill emphasizes military security, rather than the development of atomic energy for peacetime uses. We disapprove of the broad powers granted the Commission, particularly because of their implications for our foreign policy. It would be possible for the Commission proposed in the May-Johnson bill to cripple or run contrary to the foreign policy of the President and State Department, since it would have the power to determine the quantities of fissionable material to be produced, and how much should be made into bombs. We believe that to give the Commission power to issue restrictive regulations on the dissemination of scientific information might result in the hampering and restricting of the development of science. Finally, we believe that the Government must be the sole owner and producer of fissionable material, and that the provisions of the May-Johnson bill which would permit private ownership of such materials are loosely and dangerously drawn.

We should like to comment on another aspect and that is whether or not the proposed legislation would fall under the Reorganization Act of December 1945.

The league has followed with great interest the law providing for the reorganization of the executive establishments, which Congress so wisely passed in December 1945. We believe that the new agency for the control of atomic energy should not be exempted from the provisions of the Reorganization Act.

In summary, we wish to make it clear that the League of Women Voters is opposed to the May-Johnson bill. We support the McMahon bill in all of its important provisions for the control of atomic energy, although we should prefer to see the agency headed by a single individual, responsible to the President, rather than by a commission.

With me is Mrs. Mitchell who has a brief statement on the international aspects, and if it is possible, she would like to read that.

The CHAIRMAN. Thank you very much, Mrs. Stone. Of course, we are directing our attention now to the domestic aspects, but I am sure we would be glad to hear Mrs. Mitchell.

STATEMENT OF MRS. ALLAN C. G. MITCHELL, DIRECTOR, NATIONAL LEAGUE OF WOMEN VOTERS

Mrs. MITCHELL. Senator, we realize that these hearings are on the domestic legislation. However, we feel that the two aspects of the problem will ultimately be closely tied, and we support the provisions in the McMahon bill so wholeheartedly because they seem adequate to enable the correlation between the domestic legislation and eventual international agreements. I have just a few words about the general philosophy of the international arrangements, when they come.

The league feels very keenly that the international program for the control of atomic energy must always be considered in the light of the pledges which the United States and other United Nations have made for the establishment of a collective security system.

We feel that the whole success of the collective security system will to a large extent depend on the ability of the United Nations to devise a workable program for the control and reduction of armaments. I think it is quite obvious that any excessive or uncontrolled armament on the part of any of the United Nations, particularly a great power, would be a constant threat to United Nations system of joint defense. Therefore, the problem of the control of atomic weapons is a part of this larger United Nations problem of the control and reduction of arms as a foundation for the new world system of joint responsibility for security.

The League of Women Voters believes that the United States, as a permanent member of the Security Council and at present the sole producer of the bomb, should take the lead in bringing about United Nations agreement to reduce and regulate arms. In order to assure adequate control of atomic weapons—because that does, of course, present a very difficult technical problem—the Security Council should be responsible for supervising the production and use of atomic power.

The Security Council should control weapons derived from atomic energy as part of an international program of arms control under which all nations would submit to such agreed-upon controls as exchange of information, registration, inspection, and licensing.

The CHAIRMAN. Thank you very much, Mrs. Mitchell and Mrs. Stone.

Mr. John Parker, will you come forward?

It is nice to have you with us this morning, Mr. Parker.

You are vice president of the Consolidated Edison Co. of New York?

Mr. PARKER. I am.

The CHAIRMAN. You have a prepared statement?

Mr. PARKER. I have, sir.

The CHAIRMAN. Will you go ahead, Mr. Parker.

STATEMENT OF JOHN C. PARKER, REPRESENTING THE ASSOCIATION OF EDISON ILLUMINATING COMPANIES

Mr. PARKER. My name is John C. Parker. I am speaking for the Association of Edison Illuminating Companies. I am a member of the executive committee of the association and chairman of its special committee on appraisal of atomic energy as a source of electricity supply.

The association is very glad, responsively to your request, to present before your committee a prepared statement authorized by the association, a 60-year-old association made up of operating companies serving the majority of the customers of the light-and-power industry.

The association was, as I have said, founded a little over 60 years ago and is made up of member companies who, since the beginning of the electric light and power industry, have served communities widely scattered throughout the country. The association is devoted to the advancement of electric service to the public for light, heat and power. It has consistently throughout its existence operated primarily as a conference of executives with the assistance of the technical and commercial personnel of the member companies for the purpose of interchange of ideas and information looking toward high standards of dependability and flexibility in service and to the enhancement of operating economies and progressively and consistently lower charges to the consumers. Its member companies are not manufacturers of equipment.

That the association regards very seriously the possibilities of atomic energy in the field of electrical energy production and its responsibility to help in its development is evidenced by the fact that this is the first time in its long history, to my best knowledge and belief, that the association ever has made an appearance before a legislative or administrative body. It is now doing so through a special committee whom I represent, and which has been set up to explore and appraise both the favorable possibilities and the limitations that may affect the use of atomic energy in the field of electric power supply.

The committee consists of five members, all engineers and executives, each in one of the important utility enterprises of the country.

The membership of the committee is:

Alex D. Bailey, executive vice president of the Commonwealth Edison Co. of Chicago, formerly president of the American Society of Mechanical Engineers.

Kilshaw M. Urwin, who is present this morning, manager of the engineering department, Philadelphia Electric Co., formerly vice president of the American Society of Mechanical Engineers. For nearly 6 months during hostilities in Europe Mr. Irwin was in England and on the Continent serving as executive director of the London staff of the Public Utilities Committee of the Combined Production and Resources Board. He is at present chairman of the power generation committee of the association.

James W. Parker, president, the Detroit Edison Co., formerly president of the American Society of Mechanical Engineers.

John C. Parker, formerly president, Brooklyn Edison Co., Inc., more recently vice president, Consolidated Edison Co. of New York, Inc. (in charge of planning, development, and research), formerly president, American Institute of Electrical Engineers.

Philip Sporn, executive vice president, American Gas & Electric Service Corp., the recipient of the Edison Medal of the American Institute of Electrical Engineers for 1946.

Each of these men, during the war period, served as consultant to one or more of the defense offices, including the War Production Board and its predecessors, Foreign Economic Administration and War Manpower Commission.

The secretary of the committee, Ward F. Davidson, who also is present this morning, research engineer of Consolidated Edison Co. of New York, Inc., has devoted practically all of his time since early in 1942 to the work of the Office of Scientific Research and Development and is at the present time Deputy Executive Officer of the National Defense Research Committee thereof.

It is believed that the men who comprise this committee are (1) of such a character that they are able to appraise technical possibilities and at the same time to measure the economic and social results that can be obtained in a new technique; (2) well grounded in the tradition of the utility industry which continuously has sought to advance the results of scientific development into practical realization through stimulating manufacturers to produce equipment embodying the latest scientific developments, through the assembly of such equipment into generating and transmission systems, and through the persistent supervision of its operation into successful realization; (3) well fitted to contribute to the development of atomic energy along engineering or practical lines and to guide the work of others so that, to the extent that atomic energy can be developed in the electro-power field on a practical basis, it will be done with a minimum of waste and in the shortest time.

The instruction under which this committee is acting is to be utterly objective in its appraisal and not to approach the multitude of difficult problems involved with any predetermination arising from any conception of any industry policy other than the exploration of the probabilities of a better service to the community.

Neither this committee nor the Edison Association seeks to probe into matters which both freely recognize must, for the moment at least, be restricted from general dissemination. More specifically the committee proposes to avoid inquiry into the specific technique of the processing of fissionable materials or their utilization in fields other than that of heavy power generation. It goes without saying, however, that the committee of appraisal would be immeasurably aided in its work by such knowledge of the economic factors surrounding the materials involved in energy production by atomic fission as can properly be made available to it. Indeed such knowledge, which we do not now possess in more than the most rudimentary degree, is quite essential to any competent appraisal of the possibilities.

With that in mind and subject to a clear understanding with them that the committee does not seek to go beyond the limits of propriety, the members of the committee are conducting conversations with various scientists and engineers who are believed to have knowledge in this new field. The committee fully believes that such conversations, carried out under appropriate restrictions, are conducive to the advancement of the national welfare.

The mere technique of utilization poses questions of the first magnitude. The ability to transform nuclear energy into heat in unconventional boilers—which, with quite incomplete knowledge on the committee's part, seems to be the most probable process—and to do that without risk either to plant personnel or to the general public; to develop efficient systems of control; to find the materials most suited to such operations and to carry them through engineering development and construction will require a high degree of collaboration extending well beyond the abilities and the available time of any committee of five men. The committee therefore will seek, subject to their approval and willingness to cooperate, the assistance and advice not only of scientists and engineers but of the departments of government so far as it appropriately may be extended. It will also seek to enlist the design and other technical talent of manufacturers.

The CHAIRMAN. Mr. Parker, as far as your committee has gone now in its studies, have you been handicapped very much by the restrictions on the dissemination of information?

Mr. PARKER. Categorically, I would say "No," sir. Possibly that is because we have been at great pains not to probe more deeply than propriety had indicated. There have been no official barriers placed in our way so far. On the contrary, we have met a very understanding spirit of cooperation.

The CHAIRMAN. Are there some things that you would like to know in order to continue your studies that you thought you had better not inquire about at this time?

Mr. PARKER. We have not as yet undertaken to explore one question which is of the very essence of practicality, and that is the economics of procurement of fissionable materials.

The CHAIRMAN. Cost of production?

Mr. PARKER. Cost of production. That, sir, I think we have stayed away from on the assumption that first we would better determine the technical feasibility and then come to that later when the cost facts probably are known to the people who are most closely related to production.

The CHAIRMAN. Thank you.

Mr. PARKER. Returning to my prepared statement:

It appears now that the two most likely fields of energy utilization are to be found in marine propulsion and in large land power plants. The committee, therefore, proposes to offer to the United States Navy such collaboration as the Navy finds to be consistent with the purposes of national security. There is no doubt that such collaboration would make available to the committee important technical information. On the other hand, it is believed that the committee can, through its familiarity with the problem of power-plant design, construction and operation, be of some appreciable service to the naval authorities. It is quite possible, as was the case with higher-pressure and higher-temperature steam development, that large land installations may afford an excellent proving-ground for the exacting requirements of the naval service.

The Senators are aware, of course, that not only the operating costs but the investment in new types of boiler equipment are important to the successful service of the public. It will be necessary, therefore, for the committee to estimate the minimal costs at which equipment may be provided for transforming nuclear energy into the heat in steam or perhaps other media for use in heat engines.

Beyond this there is a remote possibility that, at some future date, some fraction of the energy available within the atom may be released directly in the form of electrical energy with the intervention of equipment other than heat engines. This and the way in which such direct transformation may be correlated with thermal processes require open-minded investigation.

However, regardless of the route by which it is achieved, anything that will reduce the cost of production of electrical energy is none the less of benefit to the national economy, and will become an object of assiduous research and investigation by this committee. It is proper to point out, however, that zealously though the industry will seek to develop the possibilities, revolutionary results in the cost of supplying the public are not to be expected but rather sober, level-headed betterment. The reason for that is worth pointing out.

Most of the investment and much of the operating cost of present systems lie outside the generating plants—for example, in the distributing systems and in the multifarious services to customers. There is no present indication that atomic energy will relieve that major element in cost. Much of the investment in generating stations will remain as at present. At present it seems probable that steam turbo-generators and their extensive auxiliary equipment, the electrical switchgear and the housing of this equipment will be retained, that the boiler plants of some parts of the stations will be retired, and be replaced by a new type of boiler involving some probably heavy investment and using a possibly—hopefully—cheaper fuel than is now available.

It is evident, if this preliminary hypothesis proves correct, that the primary advantage to the national economy through such use of nuclear energy will be in the service of that part of the utility load in which fuel costs play the relatively biggest parts, namely, industrial and heavy traction load, and that the economies here will probably be not much greater than the difference in fuel cost.

Limited though those economies may be, the committee and the Edison Association which it represents believe them to be of importance to the industrial development of the country. They believe that whatever body is set up to administer the distribution of fissionable materials well might require that such economies be passed on to the consumers conformably with the determinations of the local regulatory authority. Such economies, of course, should be the net economies giving due weight to new investment occasioned by a new type of boiler or other conversion equipment.

There has been some popular misconception as to the amount of energy that would become available through atomic processes. A clear perspective in this matter is to be had from a realization that never at any time has the country suffered from a deficiency in the amount of power available. Indeed it seems clear that the ultimate supply of energy available from coal and from water power is more than sufficient for all the probable needs of the country for centuries to come. All that is necessary vastly to expand the availability of electrical power is the construction of plants, transmission and distribution systems. Even more significant, however, are the much more expensive plants and devices for utilization. All this will be the case whether the source of energy is the newly understood atom or the more conventional sources. It is true that some expansion of electric energy use may result from the development of atomic energy insofar as such development brings about a reduction in cost of generation, and therefore makes possible the electrification of certain large-scale chemical or metallurgical processes now carried out on a directly thermal basis. But that, if at all, will occur only after an extended period of time and as it proves economical.

Another popular misconception which must be mentioned in order to make clear the attitude of the public utilities is the thought that they might be unduly apprehensive of the incipient obsolescence of their plant and property by a new technique. If the present probabilities develop, namely, that nuclear energy will be used in the production of steam for high-temperature turbines, the process will be highly analogous to a current one quite common to the light and power industry, namely, the use of so-called topping turbines. When new and more efficient heat cycles, using much higher steam pressures and temperatures, became available, the utility companies recognized the possibility of removing some or all of their older boilers, of producing steam at high temperature and high pressure and then, in new turbogenerator sets, while doing useful work, degrading it to the level formerly produced in the lower-pressure, lower-temperature boilers and further using it in the existing turbines. A strictly analogous process seems quite probable when and if the technical and economic problems of atomic energy utilization are worked out. Old boiler-plant and combustion equipment may be removed, giving place to the newer type of boiler, with or without its own high-pressure, high-temperature turbine. Thus steam would be produced for use in the present turbo-generators either directly or through the intervention of an atomic Topping turbine.

Even should some appreciable part of the atomic energy ultimately be found capable of direct conversion to the electrical form it would work as one horse of a two animal team, the other being the heat process, both in parallel supplying power to central station bus bars. But this prospect does not appall either the committee or the industry. On the contrary, the industry will welcome and seeks to aid the development of any attractive possibilities in nuclear power production quite as it has the development of improved combustion processes and more favorable steam cycles.

When it becomes reasonably certain that sound economic advantage will result from atomic sources it is fully expected that the rate of increase of central station energy utilization will make possible the introduction of atomic "toppers" for base load purposes, that is for energy production round the clock so that the fullest operating advantage may be had from the replacement of the current conventional practices. On the other hand it seems equally probable that the cost of new equipment will not be warranted or if so only in lesser degree by that part of the load which is of short duration. Thus, much of the unconverted present conventional equipment will represent the most realistically economical method of meeting the requirements of the community and will therefore have an undisturbed usefulness throughout its natural physical life.

For these reasons combined with the necessity for continuing our present and highly significant systems of transmission and distribution there is no reason why the industry should be alarmed by any considerations of obsolescence. Indeed, were the economic attractions of atomic energy in the course of time to prove so great that even peak load and reserve equipment would be forced into the scrap heap, that fact in itself would say that there were advantages sufficient to warrant—indeed to make welcome—the processes of supersession. The committee thus feels that there are no obstacles, tangible or otherwise, to its full and open-minded exploration of the possibilities inherent in atomic energy to develop a more economical system of electric energy supply and more widespread use of electrical energy to enhance and stimulate the national economy.

In this connection the public-utility industry of the country has only one reservation and that is that atomic materials should be available for industrial use without differentiation as to the type of utility to which it is made available and with the single collateral requirement that any resultant net economies be passed on to the consumers under the supervision of regulatory authorities on the local level.

As an association we completely endorse the theory that the processing of such materials for use must be under the control of some such commission as it is proposed in the bill (S. 1717) under discussion. The possibilities of misuse under any other scheme of production are too ghastly to be contemplated. As a collateral of such control, licenses for use seem quite inevitable. Such licenses for all uses whatsoever obviously must be surrounded by safeguards against injury to life and health. These safeguards quite clearly must be uniform and effective. The greatest measure of effectiveness is, in our judgment, in the denial of release of materials to those who do not comply with the prescriptions.

The Association of Edison Illuminating Companies regards as of distinctly minor significance any question of patent rights that may result from the studies of this committee or subsequent development committees. It is none the less speaking for itself as an association, very glad to say here that all of the results of the association's developmental work will be widely disseminated. Insofar as they are reflected by any patents granted, they will be made available to others on a reasonable, nonexclusive licensing basis. It would consider it proper, and would be glad to agree, that such licensing processes and fees be regulated by an appropriately constituted governmental agency. In making this declaration of policy the association does not, of course, assume to control the otherwise legal conduct of individuals, particularly those engaged in the manufacture of apparatus and machinery.

In brief summary, the industry, for whose oldest association I speak, is keenly and constructively interested in the peaceful uses of atomic energy for the benefits of the users of electrical power throughout the country whether on the systems of its member companies or otherwise; is at the present time, like most of the American public, not sufficiently informed of the basic facts to be able to make any sound forecasts; seeks such fuller knowledge as may properly come to it; and is committed to the aggressive prosecution of all favorable possibilities by the application of its technical and economic resources.

The association does not at the present time offer comment on minor details of the bill before you which it assumes will somewhat be modified, but regards the general structure of the bill as being most favorable to the orderly development of peaceful uses of a new technique which can be of great service to mankind.

Senator AUSTIN. I wish you would explain what you mean specifically by "topping."

Mr. PARKER. When the metallurgic arts and the art of design became such that it was possible to build steam turbines with their associated generators operating at temperatures of the order of magnitude of 950° to 1,000°, and at pressures running up to 2,500 pounds to the square inch, relatively small turbines of that character were produced which, after having done useful work in driving the electrical generators, exhausted their steam at more moderate pressures and temperatures, generally at the temperatures and pressures previously used in the stations into which these new turbines were to be installed. These turbines were high-speed, relatively small units with their boilers, and where they were installed did about half of the useful work of making electrical energy, discharged their steam—still capable of doing a great deal of useful work—into the older equipment which didn't any more have boilers for supplying them directly, and then roughly an equal amount of work was done in those lower-pressure, lower-temperature turbogenerators.

Senator AUSTIN. Does that process correspond to the superheater engine found on locomotives?

Mr. PARKER. To some degree, sir, yes; though not in technical detail. The superheat engines used on locomotives are designed as these Topping turbines are, to use a considerably more efficient cycle of heat conversion. In that respect they are similar but in more minute technical respects quite dissimilar.

Senator AUSTIN. I wish you would define "supersession" as you have used it.

Mr. PARKER. "Supersession," as we conceive it, is the process by which older equipment must be replaced when the advancement of the arts of design or of material production makes possible more efficient processes under which the operating costs are reduced to the point warranting discarding the old equipment.

Senator AUSTIN. Thank you, sir.

Senator HICKENLOOPER. Mr. Parker, do I understand correctly your association you are representing here this morning is something in the nature of a research association or a study association to study new methods or to explore new fields, and that you are not as an association directly interested in sales or the promotion of any specific type or kind of electrical energy, power, or equipment?

Mr. PARKER. As to equipment, we are not directly interested or even indirectly interested in the promotion of any specific type. The association is a conference of executives, which, during its existence, has sought to explore all of those things which would be beneficial to the industry and our member companies, frankly, sir, but also in that process to the customers of the member companies. That necessarily means that the association has been quite interested in exploring the possibilities of improved methods of utilization of electricity after it is delivered to the consumer.

Notably, for instance, it has done a great deal throughout its life collaborating with the manufacturers to bring about a better standard of efficiency and life for the simple incandescent lamp. That has been one of its major activities in its earlier years, the promotion of more efficient and better standards of lamp manufacture and the utilization of illumination.

Similarly, it has devoted itself to stimulating the production of more efficient motors. Primarily, I should say, however, through such committees as that of which Mr. Irwin is chairman, it has sought to study collaboratively among the members and with the manufacturers the methods of producing more efficient production apparatus.

Senator HICKENLOOPER. I see that the comic strips have now developed an atomic light. I don't presume that you have gone into that field yet.

Mr. PARKER. We haven't yet, sir.

Senator HICKENLOOPER. I merely wanted to be certain that your association was really an over-all study group that takes in the entire field and is not devoted to special promotion, primary promotion, of either equipment or service.

Mr. PARKER. That is quite right, sir. I think we are entirely objective in that respect.

The CHAIRMAN. I was especially interested, Mr. Parker, in the forthright endorsement of the proposition that the Government should produce this fissionable material. I believe you said in your statement that the consequences might be pretty horrible to contemplate if that was not done. Would you care to develop that, sir?

Mr. PARKER. Fundamentally, sir, it seems perfectly clear to me—I cannot say that the association has explored this minutely, but it has arrived at the conclusion that you have stated, that for any body of individual citizens without the most compelling restraints to have possession of the processes of production of materials which have demonstrated their capacity to two Japanese towns just would be a complete subversion of every element of public safety.

That would be the first thing. The second thing is that the large-scale technique of promotion of the scientific knowledge that already was under way had been at the expense of the people of the country as a whole. Two billion dollars of the resources of the country have been put into this thing. Now, it does seem perfectly clear that whatever may be the active agent in the further production of fissionable material, the control of a thing created by the people of the Nation must rest in the people of the Nation.

The CHAIRMAN. Thank you very much, sir.

Senator HICKENLOOPER. Would you envision the possibility in the future that private industry in some capacity might, under very rigid license and supervision, be permitted to produce at least up to the point of power production in this field, or do you at the present time think that it is more probable that the Government should produce this alone at all foreseeable times in the future?

Mr. PARKER. May I reply to that as an individual, and not speaking for the association?

Senator HICKENLOOPER. Surely.

Mr. PARKER. In response to the chairman's question, I spoke of controls by government. I think it would be most desirable that as much as possible in the active production be done under the thing that—for want of a better phrase—we call the free-enterprise system and by a plurality of producers, but subject to the most extremely tight controls.

Senator HICKENLOOPER. Mr. Parker, at this moment, I am in thorough accord with various expressed opinions that the Government should rigidly take this matter until they can see what the future holds for it. I am not advocating, nor do I believe we should turn it loose to private investigation at the moment.

When you start to make a bomb, the first 75 percent is the production of the material, and the remaining 25 percent is the technical production of the bomb. It was that division that prompted my question as to whether or not sometime in the future it might be possible to permit the experimentation and the development of that first 75 percent by private industry under rigid controls, but of course not permitting any private individuals to go the other 25 percent and tinker with the making of a bomb.

I presume that is not beyond possibility, nor beyond reason and probably would be desirable if proper safeguards could be worked out.

Mr. PARKER. To me it seems intensely desirable for the further purpose of getting a diversity of minds and philosophies at work and stimulating the competitive zeal of the different producers.

Senator HICKENLOOPER. In other words, it would be the same argument, I take it from your answer, as the scientists use when they say they must have friction of the mind in science and therefore freedom in order to develop. It would be desirable to have that same friction of the mind and friction of competition, for instance in free enterprise, providing safeguards could be established for the control and the production of large quantities of this material.

Mr. PARKER. I feel that very fully, sir.

The CHAIRMAN. Thank you very much indeed, Mr. Parker, for coming down.

Mr. PARKER. Thank you, sir, for the privilege of being here.

The CHAIRMAN. This will adjourn the hearing for today.

The projected last hearing of this series of hearings will be at 10:30 a. m., tomorrow morning, and at that time, unless some other Senator has a definite witness that he wants to hear—and I think that possibility has been pretty well exhausted—we shall close the hearings tomorrow on the domestic phase of the question and go into executive session and resume on the international phase of it a little later.

(Whereupon, at 11:40 a. m., an adjournment was taken until 10:30 a. m., Tuesday, February 19, 1946.)

ATOMIC ENERGY ACT OF 1946

TUESDAY, FEBRUARY 19, 1946

UNITED STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to adjournment, at 10:30 a. m. in room 312, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon, Johnson, and Hickenlooper.

Also present: Dr. Edward U. Condon, scientific adviser to the special committee; James R. Newman, special counsel; and Christopher T. Boland, staff director.

The CHAIRMAN. The hearing will come to order.

Dr. McDonald, you may proceed.

STATEMENT OF DR. RALPH McDONALD, EXECUTIVE SECRETARY, DEPARTMENT OF HIGHER EDUCATION, NATIONAL EDUCATION ASSOCIATION OF THE UNITED STATES.

DR. McDONALD. Mr. Chairman, I am Ralph McDonald, appearing before your committee as the authorized representative of the Department of Higher Education of the National Education Association. The National Education Association is the voluntary professional organization of educators in the United States and its Territories. It is composed of the 48 State education associations and 1,425 local education associations throughout the Nation, having a total dues-paying membership of 733,409, or more than 70 percent of all persons professionally engaged in education in the Nation and its Territories. In addition to this membership affiliated through its constituent associations, the National Education Association has 331,605 direct dues-paying members. Membership of the National Association extends into every State, Territory, city, and county, and into practically every school, college, and university in America. Founded in 1857, the Association has as its purpose the advancement of the cause of education. The department of higher education is composed of the members of the National Education Association who are engaged in teaching or administration in colleges and universities.

On behalf of our members I should like to thank the chairman and members of this committee for the epochal service you are rendering not only to our Nation but to the world. By your earnest and intelligent approach to the foremost fact of our times you have succeeded in removing the consideration of atomic energy from a narrow and fearsome military atmosphere to the broader and more constructive realm of science and public welfare.

The CHAIRMAN. Under some difficulties, Doctor.

Dr. McDONALD. You have conducted one of the most thoroughgoing and open-minded studies ever made by a congressional committee, driven by a realization that the action taken by this Nation with respect to atomic energy may determine the future for all mankind. As educators we have admiration for your procedures; as citizens we are deeply grateful to you.

There are two major areas of your committee's subject matter on which we do not care at this time to offer any comment, feeling that discussion of those areas on our part is unnecessary.

First, this statement will not deal with those questions on which there has developed no major controversy, as, for example, the question of whether there should be a Commission on Atomic Energy, or the question of whether there should be through the United Nations Organization a world policy to prevent atomic warfare.

With respect to these broad areas of general enlightened agreement I should like, however, to go on record as endorsing the provisions and the implications of S. 1717.

Second, this statement will not deal with the details of administration or policy which must, in the final analysis, be worked out carefully by the committee with its experts and later with the Atomic Energy Commission and its experts, giving due consideration to the recommendations of those most competent to testify with reference to the various matters involved. Examples of what I have in mind are: Detailed administration and policy on patents; internal organization of the work of the Atomic Energy Commission; other matters of similar level.

In order to keep within the proper sphere of competent interest for educators and to be as helpful to the committee as possible, this statement will go directly to some of the fundamental issues which we deem of great importance.

For convenience and clarity, I shall discuss these issues in the order with which they are dealt in S. 1717, the Atomic Energy Act of 1946.

Section 1 of S. 1717 meets with our strong endorsement. Because of the manner in which atomic energy first became generally known to the world on August 6, most of us are still inclined to recognize only the destructive possibilities of atomic energy. The statement of purposes contained in the bill gives complete recognition to the necessity for control to protect the national security, but it goes further and proposes a constructive program pointing to the development of atomic energy as a source of great good for mankind.

It is clear to us that atomic energy holds the awful threat of utter human destruction. It is also clear that, with decent and enlightened direction, atomic energy holds the promise of vast new developments which can lift the lives of people everywhere to a high and hitherto unimagined level.

We endorse the establishment of a Commission as set forth in section 2 of S. 1717.

While the Commission will have both policy and administration functions, it is clear that the most crucial responsibilities of the members of the Commission themselves will be in regard to policy. According to the terms of the bill, the Commission is fully authorized to employ expert administrators for the various activities which they will direct.

The tremendous import of atomic energy makes it unthinkable that one Administrator with an advisory committee be put in charge of our national policy respecting it. Mr. Harold Smith, Director of the Budget, was probably right in suggesting that there be a single administrative head for the production and other administrative machinery, but such a central administrator should be, in my judgment, appointed by the Commission and be responsible to it.

I believe Mr. Smith pointed out that probably the administrative heads ought to be directly responsible to the Commission, which in turn would be responsible to the Congress, rather than by creating a division of authority there by having them directly responsible to the President.

As to whether the membership of the Commission should be three, five, or seven—either number would seem acceptable.

It has been suggested that the best men might not be obtainable at the salaries specified, $15,000 a year for other members and $20,000 for the chairman. This argument is based on a misconception of the motives which govern the actions of men of principle and competence. Men of the type to whom the tremendous responsibilities of this act should be entrusted would not be concerned about personal income above the level specified. Certainly, there could be no objection to higher compensation as a matter of right, but it would be a tragedy for any person to hold such a post if he were for one moment concerned over financial compensation beyond the requirements for maintaining a satisfactory economic standard for his family. The universities of the Nation have literally thousands of men who have deliberately chosen their present careers in preference to positions which would have paid them much more money. Up to the income level necessary for maintaining an adequate standard of living and security, compensation is vitally important to anyone. Beyond that point, financial compensation would be relatively unimportant to any person of the caliber who should even be considered for an appointment to the Atomic Energy Commission.

The CHAIRMAN. Doctor, I am very grateful for your statement in one paragraph where you express what I have felt about the objections that have been made that we couldn't get the right caliber of men for this Commission. I am grateful to you, at least personally grateful, for having put the argument so succinctly.

Dr. McDONALD. There are so many examples that fall within the observation of all of us to indicate that the men of the type of whom the responsibilities of this Commission should be entrusted are not primarily concerned with building up large estates for themselves beyond what would be necessary for security and satisfactory standards for their families, in my judgment.

Senator HICKENLOOPER. Doctor, at that point may I explore that with you? It is my impression—and I don't know that anyone has testified here that any appointee would want to make money out of this as a commercial proposition—that the testimony has mostly gone to this point: First, people of the caliber that you want to get will have established their economic standard of living which because of their past means that they would require for their peace of mind, comfort, and family responsibilities a substantial salary, the amount being subject to argument within reasonable limits.

But this question was raised the other day, that on a full-time basis no salary would command certain men who might be very desirable to have on this job; that is, there are many men in the country who have a tremendous capacity, but who have some other field of general advancement that would preclude their accepting exclusive employment on this Commission, regardless of salary. That was advanced by one witness, I believe, in supporting his argument that we might well consider a rather mixed Commission; that is, provide for certain men on a part-time basis who would devote all the time that would be necessary on their part, but who would not want to leave entirely other fields of activity that they had spent their lives in building up. There are other individuals who would be willing to devote their entire time as members of this Commission.

I am frank to say that that is an intriguing argument to me because it would open up the field for the acquisition of the best possible men in this country, regardless of salary or anything else, if you could get one or two of them on a part-time basis or on a voluntary basis, you might say.

Dr. McDONALD. That is one of the features, Senator, that I like particularly about S. 1717, in that while the main responsibility would rest in the hands of those Commission members who are full time—and that seems to me to be essential—at the same time, through the machinery of advisory boards, such persons as you have indicated could give their fullest and most advantageous service to the Government in that relationship.

Senator HICKENLOOPER. This goes a little beyond that. The thought behind my suggestion was that these part-time people would have equal authority with the full-time people on any decisions of policy, but some provision where we might gain their cooperation and the advantage of their experience and judgment might well be worked out.

Dr. McDONALD. I should think, Senator, that with a force that is potentially so free and that actually, even according to its present stage of development, is so fraught with possibilities of destruction that it would be absolutely essential for at least as many as three persons to be completely disassociated from any other major and dividing interest that would require the use of some of their time and effort in order that they might devote their full time. I think it would require not only their full time in terms of regular office practice, but I think probably the proper type of men would be studying about this thing night and day, as no doubt the members of this committee are at the present time, using the major portion of their time in the consideration of this very matter. In the long run it would seem to me that it would be absolutely essential to have people who could concentrate their interest exclusively.

Senator HICKENLOOPER. I think I agree with that, at least at this moment, that it is essential to have at least a portion of the Commission—the percentage is more or less immaterial—that is full time, devoted exclusively to this, but I am rather intrigued with the suggestion that, in addition to that, some people with equal authority as members of the Commission might be available for part-time service. I haven't made up my mind on it finally at all.

Dr. McDONALD. My fear in that connection, Senator, would be that the time for decision on a very important matter might arrive, and that the persons who would make that decision would of necessity have to have complete and full and thorough understanding of all other matters related to it; if part-time people in such an instance had given only a part of their time, they probably would not have had opportunity to have full and complete understanding, and consequently the votes of such people in a close vote in the Commission might actually turn the decision of the Commission one way or the other, whereas it would not be a lack of capacity to judge on their part, but a lack of full, complete, and detailed information.

Senator HICKENLOOPER. Of course, there is that phase of it. My thought on the other side, however, would be that any part-time individual who might be chosen as a member of this Commission should be of such caliber and capacity that he would not only realize his own reservations of possibility in this field, but would be of such capacity to devote all time to completely familiarize himself. I think there are many such men in the country. I don't know what the committee will decide on the matter.

Dr. McDONALD. I can see very well the point that there may be individuals who could make a real contribution to our national thinking and to our national policy on this important subject who might not be free to disassociate themselves completely in every other undertaking and devote full time to it; but I should think that there are such men you would be able to find equal in mental ability, in background and experience, who would be able to disassociate themselves completely, in which case you could use the full-time available man as the decision-making member of your Commission, and use your other individuals as members of an advisory committee or board, which would give you the full advantage, it seems to me, of both minds.

Senator HICKENLOOPER. Thank you.

The CHAIRMAN. Well, the answer to that, Doctor, that has been made is this: That the man who is selected as a full-time member becomes, shall we say, bureaucratic; and the advisory member who is the fullest, maybe, of some wisdom and light on a specific proposition is disregarded by these "bureaucrats" who go ahead and disregard the advice of the advisory board. That has been the argument that has been made against that.

Dr. McDONALD. I think definitely there is a danger of the development of bureaucratic ideas and attitudes on the part of the members of any commission which is given charge of the vast enterprise that will be involved here; but it seems to me that there are safeguards proposed in S. 1717, and also suggested by other persons other than the authors of this bill, that would permit some check against that bureaucratic attitude. For example, the members of the Commission are removable at the will of the President. Not only that, but there is a requirement that the Commission quarterly make complete and detailed reports to committees of Congress.

It would seem to me that the tendencies toward bureaucracy would be curbed much more effectively for this Commission than is the case in usual government commissions. I do think that is a very real danger, and I think it should be guarded against. I have a feeling it is guarded against by the provisions suggested in S. 1717.

S. 1717 in a subsequent section provides for the establishment of advisory boards to the Commission. Through such boards the Commission would make use of the very type of people who are suggested for a part-time advisory committee to a single all-powerful administrator. I should like to make this comment in relation particularly to the point which was made just a moment ago, that as between the establishment of a single all-powerful administrator and the establishment of a board which would be composed of some part-time members and some full-time members, it seems to me the board would be far to be preferred above the single administrator.

Senator HICKENLOOPER. Now, would you care to express yourself on this? Manifestly I think in any activity of this kind there should be somebody to run it. Five or six people cannot run it; they have to have a general manager, or something of that sort, and manifestly with considerable leeway to carry out the policies of the board.

Now, do you think it would be advisable to have that administrator or general superintendent, or whatever you want to call him, appointed by the President or selected by the board, which in turn will be appointed by the President?

Dr. McDONALD. I think I would agree with the suggestion of Mr. Smith that that administrator should be responsible to the board. He should be appointed by the Commission, and his responsibility to the governing head of the Nation, it seems to me, will be taken care of by the fact that they in turn are responsible to the President, particularly since they are removable at the will of the President.

Senator HICKENLOOPER. In other words, if a general administrator is appointed by the President, he holds his appointment by the President and not from the board. He holds himself primarily responsible to the President and not to the board, and the board in turn is responsible to the President, but it gives a division of authority.

Dr. McDONALD. A division of authority; yes; I should think that would be the case.

Members of the policy-making Commission itself should by all means be full-time, paid servants of the Government, with no distracting or dividing interests whatever. The magnitude of the ultimate consequences of their action would impose upon the members of the Commission the heaviest conceivable burdens of study and decision, which would certainly occupy their full time. We hope that they may not only be full-time, but that they may be also the brainiest, most resourceful, and most public-spirited men who can be found in America.

Section 3 of S. 1717 provides a sound and productive policy for promoting the advancement of scientific knowledge.

Effective scientific knowledge can be carried on only under a policy which (1) makes widely available the equipment, materials, and other resources for endless experimentation, (2) gives complete freedom of study and experimentation to researchers, and (3) provides for full and unimpeded flow of scientific knowledge.

To assume that scientific knowledge can be advanced under conditions of secrecy is unrealistic. The advancement of knowledge is directly proportionate to the volume and efficiency of communication from mind to mind, from laboratory to laboratory, from nation to nation.

In the field of atomic energy we are dealing with a force potentially so destructive that secrecy would seem desirable with respect to every aspect which can be kept secret, especially when there exist powerful national governments which are not responsive to the will of the people they rule. The fact is that in the long run there is probably very little, if anything in the area of theoretical scientific information which is or can be kept secret; our scientists testify almost unanimously to this fact.

American scientists desire only that a free flow of such basic scientific information as in its very nature is not and cannot be secret be promoted among our own scientists. My personal opinion is that knowledge of atomic energy in the hands of any government which is totalitarian and not fully responsible to its own people is dangerous to all mankind. Such knowledge in the realm of scientific theory is not and cannot be withheld, however,.

Our wisest course, it seems to me, is to promote the widest dissemination among American scientists of such basic scientific information as the Commission may determine not to be dangerous to our national security. Granting that the free flow of such information among American scientists will permit a totalitarian power to acquire such knowledge, our best safeguard against such a nation in the event of an atomic war would be through the great progress our own scientists would make by continuous effective experimentation. If we do not have such wide dissemination of scientific knowledge, our own progress in atomic energy protection will be much less. The result would be that our very effort to maintain secrecy might permit an aggressive nation to go miles ahead of us in experimentation and development.

The CHAIRMAN. Doctor, I will make an argument now against a theory which you stated, which I believe in. Let's assume that through further experimentation we can develop an explosive releasing 5,000 times as much energy; you might say 4,900 or take any figure you please—but tremendously greater.

Senator HICKENLOOPER. I don't like to have you mention such things, Mr. Chairman; it scares me to death.

The CHAIRMAN. Take any figure you want that would show an advance. Now, if any other country reaches the point of having the Nagasaki bomb, what good is the fact that you have improved your bomb by any multiple that you want? What good does it do you? Do you follow my thought, Doctor?

Dr. McDONALD. If you are not here, the Congress is not here, the President is not here, and the military leadership of the Nation are not here by virtue of some explosion that took place before we realized we were about to get into war, I doubt whether our possession of those things would be of much value to us. They might permit us to cause a greater destruction to the enemy, and ultimately give to those people who remain in America after the destruction has been wrought all over the earth a better opportunity, we will say, to have a dominant voice in whatever remains of humanity. I do think that it would be advantageous for us to possess the most modern and the best knowledge that is possessed anywhere in this area, though I can see that there is only one real safeguard against ultimate human destruction, and that is for us to learn somehow either to live without war—which is really the only ultimate possibility—or certainly to remove completely from the realm of such wars as may be permitted to go on, like the one in China, the use of atomic weapons.

The second course seems to me to be very largely wishful thinking.

Senator HICKENLOOPER. How are you going to prevent countries from using every last weapon they can get their hands on when it is a question of national destruction or national survival?

Dr. McDONALD. Frankly, Senator, I don't think you can prevent that and I think it is wishful thinking to assume that this Nation or any other nation could come through an atomic war with anything that is really worth having.

Senator HICKENLOOPER. In other words, there won't be any future wars fought by Marquis of Queensberry rules. They will use every method and means they can get hold of.

Dr. McDONALD. I think at the present time—and I am not just one of these boasting Americans, I hope—there is no nation on earth that is composed of more enlightened and humanitarian people on such things than the United States, and we did use the atomic bomb, so it would seem to me that a discussion of the possibility of having wars between great nations without their use of, as you say, the ultimate in weapons that they know about is just wishful thinking.

Senator HICKENLOOPER. Well, it is human nature when you get into war to lick the other fellow as quickly as you can.

Dr. McDONALD. When you realize you are going to be destroyed, then it is human nature to cause as much destruction to your enemy as you can before you are finally put out of existence.

Senator HICKENLOOPER. It is a very confusing situation.

Dr. McDONALD. I see no possible solution to this problem internationally except for the nations of the world to find out somehow how they can live without war. It is absolutely essential, and it seems to me that it is within the realm of possibility. I think this is, of course, the fundamental issue before all of us.

The CHAIRMAN. Doctor, I don't want to hold you too long, but if you believe that no other nation could develop the present-type bomb in any given period of time—I have concluded it is more or less anybody's guess. You can guess 2 years, you can guess 10 years, and of all the witnesses who have come and testified before this committee there hasn't been one of them that has really been able to substantiate their estimate with any facts; it is a guess.

Now, if it were to be impossible for any other country to duplicate our present-type bomb, you could make out quite a case for locking it up—that is, locking science up so that there would be no possible exchange of any scientific information. Isn't that the basic theory under which the people who want to restrict scientific investigation are proceeding, namely, the fallacy that it cannot be reproduced anywhere else, when I think the better judgment is that it can. Now, just how soon neither you nor I nor anybody else that has testified before this committee knows.

Dr. McDONALD. I think that is correct, Senator McMahon. It is utterly impossible for the basic scientific information which made it possible for our engineers to develop the bomb to be kept secret. That is a matter of utter impossibility. As a matter of fact, the knowledge did not develop even primarily in this Nation.

Senator HICKENLOOPER. Every nation knows it now, don't they, in your opinion?

Dr. McDONALD. Yes; as a matter of fact, they had access to the information beforehand.

Senator HICKENLOOPER. The basic knowledge?

Dr. MCDONALD. The basic research. Now, with respect to the devices and the machinery by means of which you take this basic scientific information and convert it into a destructive device, it may be that within that area—and I think undoubtedly in that area at the present time—the United States may have certain processes that are not fully and completely known. I think that with respect to those things, Mr. Chairman, the problem is simply one of time during which the other nations will develop their own devices. They may not correspond to ours at all, but when the basic scientific information is known, then human ingenuity in any major area is such that it is just a matter of time until, if they desire to do it, they will convert that scientific information into devices and instruments of destruction. So I think these items of knowledge which may be possessed at the present time by our engineers and scientists are of such a nature that it is inevitable that in other nations they will produce comparable devices and techniques, though they may be different. They might even be better. The probability is they will not be so good, but they will—so far as turning out bombs is concerned—be just as effective in the final analysis.

It would seem to me that the only area in which we would be justified at all in thinking in terms of the possibility of having secrets is in the area of processes and techniques and devices for the manufacture of any particular instrument of destruction, and in that area it would seem to me that the Commission, as suggested in S. 1717, would have full authority to maintain whatever elements of secrecy exist.

Of course, there is a danger there and that is that the very fact that we demonstrate to the world by our efforts to maintain secrecy that we have something which we think is important in the way of destruction makes it inevitable that a network of spies will infest our country from any nation that might be in fear of us; and if we kill off a hundred or two, then that will not stop the process. There will be another network, because they, having been thrown into an attitude of fear, do not know what it is that we are holding by means of which we might destroy them, will take the only course open to them, namely, to send their own citizens or employees, or if they can get citizens of other nations, employ them to try to uncover these secrets, which in the long run would have great disadvantages.

I do think, however, that in the present situation of world insecurity, until this Nation primarily can take a leadership, and a meaningful leadership for peace, the Commission on Atomic Energy would be justified in drawing that line as sharply as it can. It seems to me that for the present, that should be done; but I do not think in the field of basic scientific theory there is anything that can possibly be kept secret.

Basic research, as contrasted with applied research and technology, is rarely remunerative to a scientist. Yet it is upon such basic research that practically all scientific advance rests. Therefore, the Atomic Energy Commission, as directed in S. 1717, should liberally subsidize research and developmental activities in colleges and universities, in laboratories and engineering establishments, and elsewhere.

Particularly appropriate and necessary is the promotion, through subsidies, grants, and loans, of studies in the field of social, political, and economic effects of atomic energy.

With respect to this dissemination of information by means of which experimentation may be encouraged, it seems to me that is fundamental even to the military defense of our Nation, because I do believe we have in the United States the brains which, if they are freed and given the opportunity, will give to this Nation as rapid advancement of its knowledge in this area as can be obtained anywhere, but they cannot do that if they are not free. It seems to me, for example, that in this whole area of the finding of devices by means of which we might protect ourselves from the bomb, that if we make research as free and widespread as possible we are in much better position to hope that at least some element of safety might be upturned in this process of research. It would seem to me the most dangerous thing for us to do in terms of our own future national safety would be to bottle this thing up and keep our own scientific minds from working on it fully, freely, and as completely as they will.

The CHAIRMAN. Doctor, it has been stated by every authority on this subject that there is no defense to the atomic bomb. It is pretty hard to foresee one. Do you think there would be any possibility in the nature of things of inventing one if you pursued a policy of smothering scientific investigation and research?

Dr. McDONALD. It seems to me that it would be impossible under such conditions ever to hope to achieve defenses against it. I do think, however, as I have talked to a great number of these scientists, I have gathered this as being their opinion: They do not know now of any defense, and they cannot, on the basis of their present knowledge, conceive of an adequate defense; but it certainly was true of me, and it was probably true of a great many Americans in 1940, that we had no way of conceiving the atomic bomb. I do feel that we ought to open the doors to the widest possible research in the hope that these brains which I know we possess in this Nation, freed and even inspired by the desire to do something about this thing, might find some means at least to reduce the ultimate damage that it could cause.

But I think if we establish a pattern of secrecy around this thing, build walls around it, it will be utterly impossible for those results to be accomplished.

Sections 4, 5, 7, and 8 of S. 1717 would seem to establish the Commission in complete control of all materials, devices, sources, and property having a direct relation to atomic energy.

We share the desire expressed by Henry Wallace and others that the restrictions of the Commission not be carried to the point of the trivial and unessential. We share also the wish expressed by certain leaders of industry that the greatest possible encouragement consistent with national security be given to private enterprise in the development and production of devices and applications.

Senator HICKENLOOPER. In other words, I take it you believe that there is as much advantage to be gained in that field of competition and section of the mind as the scientists believe to be gained in what they call the section of the minds of the scientists in that field?

Dr. McDONALD. Yes, and I think in each instance the line would have to be drawn in terms of the most intelligent policy of national safety that can be worked out.

Senator HICKENLOOPER. With adequate controls and safeguards?

Dr. McDONALD. Yes, sir. These desirable aims are secondary, however, to the absolute necessity of controlling atomic energy developments so as to insure national safety and promote world peace. If we are to implement effectively any international agreement on atomic energy, it would seem essential that all aspects and facets of atomic energy production be placed under the undisputed control of the Atomic Energy Commission. We dare not do less with a force so gigantic. Direct Government ownership and the right of seizure are strong measures, but there is no other safe course, it seems to me.

Perhaps as our knowledge of atomic energy is extended it may be possible to relax some of the strict controls proposed under S. 1717. For the present, however, complete and strict control is imperative, and I do not want to be understood as passing judgment with respect to details in that area. It is only on the principles that I think I in any sense would be considered a competent witness.

Section 6 of S. 1717 provides that the Commission shall have charge of all atomic weapon production facilities and shall conduct research and developmental work in the military application of atomic power.

A close liaison with the military branches of the Government would seem to be necessary in these matters. Such a close liaison is clearly practicable under S. 1717. The Director of the Division of Military Application could, if the President desired, be a military man. Certainly, through the Division the fullest kind of cooperation and integration with military plans would be possible.

Of course, if the committee were to amend this act in line with the corrections of Budget Director Smith and others giving to the Commission the authority to designate its administrative head, then that decision would be with the Commission rather than the President as to whether a military man would head this Commission.

A safeguard against unwise action of the Commission in military matters is afforded not only by the fact that Commission members would be removable by the President, but also by the fact that the direction of the President is specifically required in the manufacture and delivery of atomic weapons.

We concur with the opinion expressed by the scientists, implied by President Truman, and concurred in by Secretary of War Patterson, that the Commission should not be composed of professional military men. It is an error to assume that the military high command developed and perfected the atomic bomb. When the financial expenditures incident to the project became too great to be met from President Roosevelt's contingency funds, the money was channeled to the project through Army appropriations. Army supervision over the personnel was established to insure national security.

Civilian control—real civilian control, not generals in civilian clothes—is absolutely essential.

For atomic energy control to be placed in the hands of military authorities by the United States would, in my opinion, produce an atomic bomb race between nations and would at the same time probably hinder scientific advance in the improvement of the bomb itself.

The training of the orthodox military man is the antithesis of the training of a scientist. A general who has been successfully educated as a military leader would be unlikely by virtue of that training to possess the point of view necessary to consider scientific problems sympathetically.

The trained military mind deals in fixed ideas; it is schooled to rest upon authority. The scientific mind is continuously fluid and questioning; it is schooled to critical examination of every dictum and datum.

Military training seeks to make soldiers think alike, act alike, so that many respond as a unit instantaneously and mechanically. Scientific training seeks to make the mind independent, exploratory, inquiring.

If atomic energy developments are subjected to military control, progress in scientific knowledge is less likely to result than is a vast secret production of more and bigger bombs of the type we know about.

We must recognize the possibility of war, and the fullest application of scientific discoveries should be made in the military field. It seems probable that greater advancement in military applications will be made if research is promoted by a civilian commission, with a military division operating under the Commission in liaison with military authorities.

It is my understanding that our atomic energy activities are now under military control, and that our plants are probably even now manufacturing more atomic bombs secretly. If that is the case, then immediate passage of a measure such as S. 1717 is urgently needed to establish a sound national policy on atomic energy.

One of the most admirable features of S. 1717 is its provision for wide dissemination of basic scientific information. By drawing a sharp distinction between such basic scientific information on the one hand and techniques and processes on the other, the bill would encourage the flow of useful knowledge and at the same time safeguard completely everything in the way of secrets which the United States now has or might later acquire, particularly of a military nature.

One of the most important agencies of the Commission would be the Board of Atomic Information, as proposed in section 9 (b). We are literally being ushered into a new age by the impact of atomic energy upon our society. As President Truman truly said, "In international relations, as in domestic affairs, the release of atomic energy constitutes a new force too revolutionary to consider in the framework of old ideas." To enable the people of the United States to adapt the framework of their ideas to this revolutionary force it will be necessary for an unprecedented job to be done in education, particularly in science. The Board of Atomic Information will have the resources and the responsibility for encouraging and hastening that education.

Section 13, requiring quarterly Commission reports of a very comprehensive and revealing nature, is one of the fundamentals of legislation in this field.

The best safeguard the people can have against the monstrous damage which might come from misuse of atomic energy is to establish complete control in the Atomic Energy Commission and make the Commission fully responsible and responsive to the President and Congress. Reports should be regular and complete, with no reservations whatever unless dictated by the President and the appropriate committee of Congress for reasons of national security.

Certain amendments could be made to S. 1717 which would strengthen or clarify some of the more important provisions.

The atomic scientists have suggested an amendment which we consider sound and desirable, namely, that a general section be added making it clear and specific that international agreements would supersede any conflicting provisions of the domestic act.

Another amendment proposed by Secretary Patterson would require rather than simply permit close liaison between the Commission and the military branches of the Government. For obvious reasons national security must be the most compelling immediate objective of our policy. Therefore, the Patterson amendment—to require rather than permit—seems to be sound, provided that such required liaison does not weaken the civilian control of our national policy on atomic energy.

We should like to call your attention to the relation which will exist between the work of the Atomic Energy Commission and the activities of the proposed National Science Foundation and those of the United Nations Educational, Scientific, and Cultural Organization recently established at London. Amendments may be necessary to insure liaison and cooperation in the work of these agencies.

The National Education Association takes an official stand on specific legislation only by action of its delegate assembly which met last in Pittsburgh in 1944 and will convene next in Buffalo July 2, 1946. No interim official position has been taken on the specific bills before this committee by the executive committee of the NEA. Such a position has, however, been taken by the executive committee of the department of higher education.

In presenting this statement I have appeared by general authority of the executive committee of the department of higher education and with the approval of Willard E. Givens, executive secretary of the entire National Education Association. The views presented represent not only the official position of the department of higher education but my best effort as an official of the NEA to bring to your committee the opinions of our leaders and membership as I am able to judge them.

Recognizing the experimental and fluid character of any legislation on atomic energy which may be enacted at this time, and recognizing also the urgent necessity of the immediate adoption of a sound initial national policy on this subject, I should like to urge the passage of a measure which fulfills as nearly as possible the purposes indicated by President Truman in his message of October 3, 1945—and emphasized in his letter of February 1, 1946—and as conceived in the statement of general purposes contained in section 1 of S. 1717. Above all, I hope that legislation in this critical interim period may be such as to provide the greatest possible safeguards for our national security while at the same time stimulating further research and promoting the movement toward world peace.

The CHAIRMAN. Doctor, I want to thank you very much indeed.

Dr. McDONALD. We are very grateful to this committee.

Senator HICKENLOOPER. That is a very fine statement. We could probably visit with you a whole day on these things.

Dr. McDONALD. I am at your service, Senator.

The CHAIRMAN. Mrs. Sibley.

STATEMENT OF MRS. HARPER SIBLEY, PRESIDENT, UNITED COUNCIL OF CHURCH WOMEN

Mrs. SIBLEY. I am here, Senator McMahon, not as an expert on the details of governmental organization, nor as a scientist; you have already heard from both those groups. I am here as president of the United Council of Church Women, acting under a resolution passed by their national board meeting in Washington October 23 to 25—and you may perhaps remember that we were in your office that day, which was the day you received your appointment, Senator—and representing the moral conscience of great groups of Christian women organized in over 11,000 communities in the United States.

For the record, I will quote their resolution:

> We reaffirm the principles involved in freedom of scientific research relative to peacetime uses of atomic energy. We oppose the May-Johnson bill (S. 1463) which forfeits democratic control of a power which should be used for the good of mankind. The May-Johnson bill makes it possible for a powerful administrator to gain control of atomic energy and the production of atomic bombs and not be removable even by the President. This could lead to complete military control.
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> We urge Congress to hold full public hearings so that people understand the issues before legislation is adopted on atomic energy.

On July 16, 1945, an atom—that tiny measure of the universe—was shattered, and at that moment history was split in two, so that old patterns lost their meaning; so that old men who would say that marching boys could save us from the bomb have failed to measure what happened that day in New Mexico.

In case you have forgotten, let me quote to you from the War Department's official release of the New Mexico test, July 16, 1945:[1]

> Mankind's successful transition to a new age, the atomic age, was ushered in July 16, 1945, before the eyes of a tense group of renowned scientists and military men gathered in the desert lands of New Mexico to witness the first end results of their $2,000,000,000 effort. Here in a remote section of the Alamogordo Air Base, 120 miles southeast of Albuquerque, the first man-made atomic explosion, the outstanding achievement of nuclear science, was achieved at 5:30 a. m. of that day. Darkening heavens pouring forth rain and lightning immediately up to the zero hour heightened the drama.
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> Mounted on a steel tower, a revolutionary weapon destined to change war as we know it or which may even be the instrumentality to end all major wars was set off with an impact which signalized man's entrance into a new physical world. Success was greater than the most ambitious estimates. A small amount of matter, the product of a chain of huge specially constructed industrial plants, was made to release the energy of the universe locked up within the atom from the beginning of time. A fabulous achievement had been reached. Speculative theory, barely established in prewar laboratories, had been projected into practicality.
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> The entire cost of the project, representing the erection of whole cities and radically new plants spread over many miles of countryside, plus unprecedented experimentation, was represented in the pilot bomb and in its parts. Here was the focal point of the venture. No other country in the world had been capable of such an outlay in brains and technical effort.
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> Gen. Farrell's impressions are: "* * * We were reaching into the unknown and we did not know what might come of it."

[1] First Test Conducted in New Mexico, official press release by the War Department, issued August 6, 1945

It can safely be said that most of these present were praying—and praying harder than they had ever prayed before. [Continues reading:]

"If the shot were successful, it was a justification of the several years of intensive effort of tens of thousands of people—statesmen, scientists, engineers, manufacturers, soldiers, and many others in every walk of life.

"In that brief instant in the remote New Mexico desert, the tremendous effort of the brains and brawn of all these people came suddenly and startlingly to the fullest fruition. Dr. Oppenheimer, on whom had rested a very heavy burden, grew tenser as the last seconds ticked off. He scarcely breathed. He held on to a post to steady himself. For the last few seconds, he stared directly ahead and then when the announcer shouted "Now" and there came a tremendous burst of light followed shortly thereafter by the deep growling roar of the explosion, his face relaxed into an expression of tremendous relief. Several of the observers standing back of the shelter to watch the lighting effects were knocked flat by the blast.

"The tension in the room let up and all started congratulating each other. Everyone sensed 'This is it.' No matter what might happen now all knew that the impossible scientific job had been done. Atomic fission would no longer be hidden in the cloisters of the theoretical physicists' dreams. It was almost full grown at birth. It was a great new force to be used for good or for evil. There was a feeling in that shelter that those concerned with its nativity should dedicate their lives to the mission that it would always be used for good and never for evil.

"Dr. Kistiakowsky threw his arms around Dr. Oppenheimer and embraced him with shouts of glee. Others were equally enthusiastic. All the pent-up emotions were released in those few minutes and all seemed to sense immediately that the explosion had far exceeded the most optimistic expectations and wildest hopes of the scientists. All seemed to feel that they had been present at the birth of a new age, the age of atomic energy, and felt their profound responsibility to help in guiding into right channels the tremendous forces which had been unlocked for the first time in history.

"As to the present war, there was a feeling that no matter what else might happen, we now had the means to insure its speedy conclusion and save thousands of American lives. As to the future, there had been brought into being something big and something new that would prove to be immeasurably more important than the discovery of electricity or any of the other great discoveries which have so affected our existence.

"The effects could well be called unprecedented, magnificent, beautiful, stupendous and terrifying. No man-made phenomenon of such tremendous power had ever occurred before. The lighting effects beggared description. The whole country was lighted by a searing light with the intensity many times that of the midday sun. It was golden, purple, violet, gray, and blue. It lighted every peak, crevasse and ridge of the nearby mountain range with a clarity and beauty that cannot be described but must be seen to be imagined. It was that beauty the great poets dream about but describe most poorly and inadequately. Thirty seconds after the explosion came first, the air blast pressing hard against the people and things, to be followed almost immediately by the strong, sustained, awesome roar"—

which warned of doomsday and made us feel that we puny things were blasphemous to dare tamper with the forces heretofore reserved to the Almighty. [Continues reading:]

"Words are inadequate tools for the job of acquainting those not present with the physical, mental, and psychological effects. It had to be witnessed to be realized."

Shall we add to their blasphemy by daring to try to keep for ourselves the results of this revelation for good or for evil and thereby endanger through suspicion our very survival?

We seem to be indulging in a state of psychological bigamy. We are entering into a new relationship of the most intimate and responsible nature with the rest of the world through the United Nations Organization, while at the same time attempting to preserve a defensive nationalism by retaining exclusive control of this new powerful source of energy.

During the last quarter century and especially during the iron years of war the United States has achieved, or had thrust upon it, primary responsibility for world leadership. Rich, powerful, progressive, enlightened, relatively unscathed by war, the oldest republic, the oldest democracy, with long traditions of peace, federalism, and international morality, we, better than any other nation, are in a position to furnish that leadership. It is a responsibility we cannot evade.

Let us recall now and take to heart, Lincoln's admonition in an earlier crisis:

> We, even we here, hold the power and bear the responsibility. * * * We shall nobly save or meanly lose the last best hope of earth. * * * The way is plain, peaceful, generous, just—a way which if followed the world will forever applaud and God must forever bless.

In addition, we quote from him:

> Fellow citizens, we cannot escape history. We of this Congress and this administration will be remembered in spite of ourselves. No personal significance or insignificance can spare one or another of us. The fiery trial through which we pass will light us down, in honor or dishonor, to the latest generation. We, even we here, hold the power and bear the responsibility.

In closing, I have been given the privilege of reading a telegram which has just come from the Midwest Conference of Atomic Scientists and Religious Leaders:

> The Midwest Conference of Atomic Scientists and Religious Leaders, representing churchmen and religious leaders from the Catholic, Protestant, and Jewish faiths, as well as natural scientists and social scientists who have given serious study to the problems arising out of the discovery of atomic fission, urges the prompt enactment into law of the principal provisions of S. 1717, known as the McMahon bill. We call attention to the following four principles which we earnestly hope will guide the policy of the Government of the United States:
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> 1. That the production of atomic bombs and the control of the development of atomic energy be promptly placed under international regulations.
> 2. That the domestic development of atomic energy and the control of fissionable materials be placed in governmental rather than in private hands, so that it may be used in the public interest.
> 3. That the subject of atomic energy and its development shall be divested of the atmosphere of secrecy which hampers research and breeds international suspicion, and tension, and that there shall be adequate opportunity for public scrutiny of the action and policies of national and international agencies entrusted with the control of atomic energy.
> 4. That the agency to be created for the development and control of atomic energy shall be composed of civilians rather than military personnel.
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> Since the McMahon bill embodies these principles, we urge its passage and express our opposition to such amendments as are designed to undermine or vitiate these principles.
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> Rabbi Jerome P. Folkman, Rabbi Jacob J. Weinstein, Dr. Charles O'Neil, Dr. Leo R. Ward, Dean Charles W. Gilkey, Dr. Bernard Bell, K. S. Kole, Warren C. Johnson, R. J. Moon, J. E. Rose, K. Way, Louis Wirth.

The United Council of Church Women of the United States associates itself with this statement.

The CHAIRMAN. Thank you very much, Mrs. Sibley.

Senator HICKENLOOPER. May I ask Mrs. Sibley a question, Mr. Chairman?

The CHAIRMAN. Certainly.

Senator HICKENLOOPER. I am not quite clear from your statement, Mrs. Sibley, whether your association or organization advocates the immediate disclosure to other nations, or the United Nations Organization, of all of the techniques of the atomic bomb before we get any reliable assurance that other nations will not use it.

Mrs. SIBLEY. We never had a referendum on that point. We are a very large organization, and we would not urge that the second steps be taken before the first; but we urge that that be the direction—that international control and sharing of secrets be the direction in which we progress.

Senator HICKENLOOPER. We have a problem facing us now as to what policy the legislation should take as to whether or not we should disclose fully to other nations before any reliable agreements for the maintenance of peace are reached, or whether we should keep our major secrets of atomic explosion, at least.

Mrs. SIBLEY. I can speak now only for myself, because we have had no referendum on that subject. But I ask which is cause and which is effect, and whether it is possible to create these assurances in an atmosphere of suspicion which secrecy engenders—as, for example, in our current handling of the Canadian situation. My own hope is that it will be made a part of the international knowledge as soon as possible.

Senator HICKENLOOPER. Yes; I think that is a desirable goal; but still my question is, and I don't care to have you embarrass yourself, do you as an individual, perhaps, not speaking for your organization, believe that we should now, under present existing conditions, disclose all of the secrets about the atomic bomb?

Mrs. SIBLEY. I do. Period.

Senator HICKENLOOPER. Before we get any reliable assurances of peace?

Mrs. SIBLEY. I think it is the basis of those. I don't think you can bargain with a thing like that in your pocket and expect any kind of assurances, because you are not keeping faith with the thing that you are trying to assure.

Senator HICKENLOOPER. I think history shows that we have kept a lot of faith in this country with peace and humanitarianism.

Mrs. SIBLEY. Not enough. You will remember, Senator, if I am not out of order, that after the last war you promised many things and the Senate prevented some of those things from happening.

I was in the League of Nations when the Germans were admitted. I was in Manchuria at the time the Lytton Commission was making its study. I was in Shanghai at the time of the first Shanghai incident, and I was in Berlin as the guest of Mr. Goebbels at the International Chamber of Commerce at the time the thing was building, and the fact that the United States was not a part of a great international organization at the time allowed those things to happen, allowed things to go on in both Manchuria and western Europe.

Senator HICKENLOOPER. That is a question of serious disagreement.

Mrs. SIBLEY. Granted, but it is our conviction.

Senator HICKENLOOPER. I wanted to get your opinion.

Mrs. SIBLEY. Thank you, Senator.

The CHAIRMAN. Commander Brunauer.

STATEMENT OF COMMANDER STEPHEN BRUNAUER. UNITED STATES NAVAL RESERVE

Commander BRUNAUER. My name is Stephen Brunauer. Prior to my entering the Navy I was a research chemist in the Department of Agriculture. In the last 3 years I have been in charge of explosives research and development in the Navy Bureau of Ordnance. Perhaps it is obvious and unnecessary to state that I am not testifying here for the Navy; I believe that Secretary Forrestal, who appeared before you, gave you the official views of the Navy on atomic energy legislation. I testify here in the first place as a citizen of the United States, vitally interested in the fate of my adopted country and the native country of my children. In the second place, I speak as an officer of the Naval Reserve interested in preserving the military strength of my country, because I believe that that is the best safeguard for the peace of the United States and of the world.

Finally, I wish to speak as a research man, interested in the fate of science, because I believe that science if properly handled is capable of providing the foundation for greater spiritual and material welfare or my fellow citizens and for all mankind.

The views I advance here are my own views, but they represent not my views alone—otherwise I would not have had the courage to appear before you. I have discussed them with a considerable number of scientists, atomic and otherwise, with Navy officers and with friends in other occupations, including some Members of Congress, and the response I received made me feel that even if I may be wrong in some of the things I believe in, I cannot be wrong in all of them.

I do not intend to discuss here the international aspects of the problem. I am fully convinced that it is more important than the domestic legislation, but this tremendous problem cannot be solved by the United States alone, it has to be worked out together with the other nations in the United Nations Organization. One of the great contributions this Nation can make to the solution is to enact far-sighted domestic legislation that will serve as a model to all other nations which in the future will also produce atomic energy for peaceful and for military purposes. I further believe that I could not say anything on the international problem that has not been said here before by men better qualified to discuss this matter than I am, and I am convinced that any one of you gentlemen could give me far better counsel on the subject that I could give you.

I have studied all the bills introduced on the control of atomic energy, but I shall discuss only certain phases of three of them: the Johnson-May bill (S. 1463), the Ball bill (S. 1557), and the McMahon bill (S. 1717).

Although I believe that I can make a contribution of some value primarily on the part of the legislation that deals with the military applications of atomic power, nevertheless I shall take the liberty of expressing my opinion first on three other points: the composition of the proposed Atomic Energy Commission, the attitude to be adopted toward fundamental research, and the provisions regarding patents on the utilization of atomic energy for peaceful purposes.

COMPOSITION OF THE COMMISSION

Regarding the composition of the Commission, it seems to me that the Ball bill proposes the best system for carrying out the great task that confronts that body. It is a compromise between the Johnson-May bill which proposes nine members, each to serve for 9 years, and the original McMahon bill (S. 1359), which made up the Commission almost entirely from members of the President's Cabinet.

The Ball bill proposes five secretaries and four other members, the latter to serve for 6 years.

The new McMahon bill (S. 1717) proposes five full-time Commission members to serve at the pleasure of the President.

It seems to me that changing the entire membership of the Commission with every change of administration would be apt to disrupt the work of the Commission. The provisions of the Ball bill would insure continuity, since four of the members would remain in office. The objection that the task is so great that full-time members are needed for the Commission is solved in the Ball bill by appointing full-time assistants for each member of the Commission, whose principal duty is to keep each member fully informed on all atomic energy problems. These assistants are not to be appointed by each member individually, but by the Commission as a whole, and their appointment would not terminate with a change of administration. I look upon the Commission as a top policy-forming body, and believe that its prestige would be tremendously enhanced by the presence of members of the President's Cabinet. At the same time this would insure a close integration between the problems of the Commission, and all other important problems that face the Nation. I should like to touch on one other point in this connection, namely, the frequency of reports by the Commission to the President and to the Congress.

The McMahon bill proposes four reports per year. This provision, if enacted, might leave the Commission little time for anything except writing reports. The Johnson-May bill and the Ball bill propose annual reports, which would probably prove entirely satisfactory.

Incidentally, I haven't seen that any of the bills suggest military control, a Commission which would be composed of military men. As far as I can see, in all the bills the control would be in the hands of civilians, and in the case of the Ball bill it would consist of nine civilian members, and the armed forces would be represented only by the Secretary of the Navy and the Secretary of War, who would, of course, constitute a minority in a Commission of nine members.

FUNDAMENTAL RESEARCH

The Johnson-May bill established very severe security restrictions for fundamental research: the bill as reported out of the Military Affairs Committee of the House of Representatives toned down somewhat the severity of these restrictions. The Ball bill and the McMahon bill insure full freedom of fundamental research.

I believe, together with all my scientist friends with whom I have discussed this problem, that fundamental research should be free and unfettered. No scientist should need the permission of any agency to investigate nuclear reactions, or to publish his findings. There is a tendency on the part of scientists to flock into the most promising field automatically. It is certain that a large and continually increasing fraction of physicists and chemists will work on nuclear physics and chemistry in the coming years and decades, and that tremendous progress will be made—if the field remains free. If, on the other hand, a scientist faces a jail sentence for discussing his research with another scientists who is "not entitled to receive" such information, the result will be that scientists will leave the field and progress will be stifled.

And yet, gentlemen, for all that, the problem is not as simple as it appears on the surface. When Hahn and Strassman discovered nuclear fission 7 years ago, some scientists began to see dimly the atomic bomb, and when shortly thereafter Fermi and Szilard discovered the chain reaction, some began to feel that the atomic bomb was in the bag. Three of these scientists, the three initiators of the atomic bomb project in this country, Szilard, Wigner, and Teller, testified already before you gentlemen.

The papers I mentioned were published freely in scientific journals, and these publications resulted in the atomic bomb projects in the United States, the United Kingdom, in Germany, and elsewhere.

It is quite certain that there will be fundamental scientific discoveries in the future that will have far-reaching military implications, and if there is some way to keep these out of open publications, they should be kept out as military secrets. I do not know how to solve this difficulty, but I am firmly convinced that much more harm would come from restricting research than from freedom of research. If there is no satisfactory way to solve this problem, I believe that we should accept the provisions of the Ball bill or the McMahon bill.

UTILIZATION OF ATOMIC ENERGY FOR PEACEFUL PURPOSES

I should like to make only one remark on this extremely complicated subject, namely, regarding patent rights. The McMahon bill makes all patents the property of the Government, giving just compensation to the inventor. I am afraid that this system would result in very slow progress in the development of atomic energy for peaceful utilization. Our big industrial organizations are not used to conduct research and development on the basis proposed by the McMahon bill, except in time of war, and I am afraid that their attitude would be lukewarm toward such nonprofit proposition in time of peace. On the other hand, I believe that great advances can be expected if our industrial organizations are allowed to develop freely their processes, patent them, produce them, and draw profit on them. The Johnson-May bill and the Ball bill both establish the policy of widespread distribution of licenses on equal terms to all qualified organizations, and discouraging the growth of monopoly, restraint of trade, and unlawful competition. Perhaps, if this policy is followed, the industrial corporations can be permitted to possess patent rights. What I said here is purely a layman's view, but I had a good deal of contact with the research organizations of the industries during the war, and I have some idea how their minds work.

MILITARY UTILIZATION OF ATOMIC ENERGY

I am coming now to the last subject, about which I should like to talk to you in somewhat more detail, because I feel that I know more about it and perhaps can say something that has not been said here before. I believe that military research, development, and utilization of atomic energy is vitally important; it may determine the continued rise or a cataclysmic fall of our country and of the type of civilization we believe in. A wise solution of this problem is essential. I believe that a simple and workable solution is on hand; it has been tried during the war, and it worked, and I believe it would work in peace.

The three bills I am discussing here present three different solutions of the problem. The McMahon bill proposes that all military research and development be conducted by the Commission and thus excludes completely the armed services from such activities, except I understand full well that liaison would be permitted.

The Johnson-May bill gives the authority over all military research and development to the Commission, but the Commission can authorize the Army and Navy to perform research and development. Indeed, this bill lays down the policy of utilizing existing research institutions to conduct experimentation in the field, and if this policy is followed, the research laboratories of the Army and Navy would probably be utilized. The Ball bill gives military research and development jointly to the Army, the Navy, and the Commission. This is the system that has been tried and found workable, and I shall attempt now to give you my reasons why I believe that it is vital that this sytem be adopted by Congress in preference to the others proposed.

To start with, I do not need to emphasize what disastrous effects another world war, fought with atomic weapons, would bring upon the United States and on the rest of the world. This has been emphasized here and elsewhere by outstanding scientists, men of public affairs and others, equally well or better qualified than I am to discuss that subject. I can only repeat on the basis of what I know that what they said was true. I can only add my firm conviction that the best safeguard to avoid a disastrous war is the military strength of the United States. This strength, combined with wisdom in handling the international problem, will give time and opportunity to the United Nations Organization to work out the infinitely varied and complicated problems of the nations and to lead us eventually into a better world in which there will be no need any more for individual, national armies and navies. But military strength is vital now, and will be for some indefinite and unforeseeable time to come.

The military strength of the United States will be built around atomic weapons. These will be not the only but the most important items of national defense. Since it is well known to all nations that the United States possesses atomic bombs, and that there are three large plants now, and possibly others later, that are manufacturing active materials, it is inconceivable to me that any nation would dare to attack the United States or any other nation that may be defended by the United States, unless that aggressor nation has an abundant supply of atomic weapons.

Therefore, I believe that if there will be another world war, it will be an atomic war. This does not mean that only atomic weapons will be used. In this last war, the most modern of all wars, alongside radar-fuzed projectiles the fighting nations used knives and sticks and arrows, and I believe that another war would also utilize these ancient weapons. In fact, a scientist friend of mine risked the facetious theory that in the next war the opposing sides will demolish each other's industries completely with atomic-power-propelled guided missiles containing atomic explosives in the first 5 minutes, and thereafter the war will be fought with knives, axes, scythes, spades, and sticks.

If we accept the proposition that the military strength of the United States is essential for the welfare of the world, then I believe that the following three facts are self-evident:

1. That from now on atomic weapons will constitute the most important items of national defense.

2. That the security of the Nation will be primarily dependent on the effectiveness of its atomic weapons and of its countermeasures against atomic weapons.

3. That it is therefore of paramount importance that research and development of atomic weapons and of countermeasures against atomic weapons be conducted in the most efficient manner.

During the war military research was conducted primarily by three organizations: The Army, the Navy, and the Office of Scientific Research and Development. This system led to such milestones in progress as radar, VT fuzes, and the atomic bomb. Such independent research with close liaison and collaboration, I believe, would be the best system in peacetime, as it was in war, in all fields of military research. This is the system advocated by Dr. Vannevar Bush in his report to the President, entitled "Science, the Endless Frontier."

When I support Senator Ball's proposition that research and development of atomic weapons should be a joint responsibility of the Commission and the services, I do not mean, nor did he mean, I believe, that research should be conducted by Regular Army and Navy officers. What I mean is research done by civilian scientists and technologists working for and within the armed forces, in daily contact, consultation, and collaboration with the officers of the armed forces. Such close contact insures on the one hand that the scientist does not go off on tangents and develop weapons that cannot be used by the military; on the other hand it makes the officer thoroughly familiar with the weapons developed since he himself participated in the development from the ground up. It is a liberal education for both sides; it makes the scientist more practical and the officer keener and better trained. The other extreme is to have the weapon developed by a separate civilian agency, then dropped into the lap of the military in its complete and final form, to be used by them if they can.

The use of atomic weapons will inevitably revolutionize warfare. I should like to point out here only some of its implications relative to naval warfare. It is almost certain that atomic weapons will not be the only ones used by the Navy. For defensive purposes probably ordinary high-explosive weapons will be used for the most part. Thus development of a variety of weapons will continue, but all developments must center around atomic weapons. It is impossible to conduct intelligently the development of either atomic weapons or other kinds of weapons without a unified planning of the entire program. Furthermore, countermeasures against atomic weapons are very intimately tied up with the nature of these weapons, and must be developed simultaneously and in close relationship. During the war, we always developed our countermeasures simultaneously, and often we did not put any munition into use unless we knew how to counteract it. Sometimes completed munitions were kept in reserve until we were able to counteract it, because the enemy can always capture a sample of the munition and can use it against us; if we have no countermeasures, then we are just as much out of luck as the enemy.

Along with the development of weapons, ships and airplanes must be built or modified to be able to carry these weapons and to combat the enemy's weapons by countermeasures. It is likely that certain types of ships must be eliminated; battleships might have to go if the cost of an atomic bomb is much smaller than that of a ship, unless very effective countermeasures are found. The tendency will probably be toward fast, smaller ships. The tactics of naval warfare may be changed. Convoys and any sort of bunching of ships may have to be avoided. Ships may have to be scattered to larger distances to avoid the sinking of several by one bomb; the scattering in turn would lead to greater vulnerability to submarines using ordinary torpedoes. Large harbors must be decentralized to avoid destruction by a small number of atomic bombs. Since ships, weapons, tactics, harbors will all have to change, it seems reasonable that all these developments should take place within the Navy, simultaneously and in complete harmony.

It is a very unsatisfactory procedure to have the center of all these developments outside the Navy in a separate civilian agency. It is not sufficient to have a few liaison officers in this agency, who come back with stories of the atomic research trying to influence other developments; the development of atomic weapons and their countermeasures must be the nucleus, the core within the Navy from which all activities radiate.

I should like to bring up, if I may, a few additional reasons why it would be undesirable to deprive the armed forces of the right to develop their most important weapons. During the war, under the pressure of war, civilian organizations performed wonders in military research, but during peacetime, with this pressure removed, I am afraid the main driving force would be lacking. Civilians working within the armed forces obtain the drive not from the control of the military, but from the daily contact with them; they talk, eat, live their daily lives with the users of their products, they know what is wanted, they know for whom they are working. Liaison is only a partial and very incomplete substitute.

A corollary of the above is that there is some danger that if all military research and development of atomic weapons is entrusted to a completely civilian organization over which the armed forces have no authority, it may happen that this organization will spend most of its time on fundamental research, or on research directed toward peaceful applications of atomic energy, and will neglect the military applications. Since the armed forces have no control over the situation, they can only complain to the Commission, which may or may not have any effect; even if it has, it would result in lost time and effort. Such situation could not arise if the military developments could be made the joint responsibility of the Commission and the services.

Even during the war, when scientists and engineers put everything into their work to help the war effort, the control of the atomic bomb project was handed over by the OSRD to the Manhattan district of the Army engineers. The procurement and engineering functions were taken over in the summer of 1942, the research and development in the spring of 1943. I gather that to this date the top men of OSRD, Drs. Bush, Conant, and Tolman, are convinced that this transfer was wise; at least I have not seen a statement to the contrary from any of them. You have heard here, gentlemen, and I have heard elsewhere, that the security system of the Army retarded the completion of the bomb by a year, or year and a half. Such statements are very hard to reconcile with the fact that the whole course of the project was planned carefully 3 years or longer ahead of time, and that everything came through on schedule or somewhat ahead of schedule. I do not mean to imply that the security system of the Manhattan engineer district was necessarily ideal. But it is unfortunate that certain atomic scientists, instead of suggesting merely improvements in the security system, suggest that the armed forces be thrown out of the development of atomic weapons completely. On the basis of what I said previously, I am convinced that the participation of the military in military research in peacetime is even more essential than in wartime.

It has been often stated that civilian scientists and engineers do not like to work for a military organization; that they would rather work for a civilian agency. This statement is partly true; the fact is that some of them prefer it one way, some the other way. Many scientists who worked with or for the Navy during the war are not only willing but anxious to accept intelligent guidance in their work by the men of the fleet who will use their products. Others think differently, but the Ball bill solves this difficulty; those who do not want to work within the services can find their place in the civilian agency set up by the Commission.

These are the main points I want to put before you, gentlemen. I deeply appreciate the honor of your request to express my views on the subject.

The CHAIRMAN. Thank you very much, Commander.

Senator HICKENLOOPER. May I ask the commander a question?

The CHAIRMAN. Surely.

Senator HICKENLOOPER. Commander Brunauer, I assume that your statement and your conclusions and recommendations are largely predicated upon the practical assumption that reliable assurances of peace among nations may not be reached?

Commander BRUNAUER. That is correct, sir. I hope they will be reached.

Senator HICKENLOOPER. I hope you don't misunderstand my question. I do not say you advocate they will not be reached, but your statement is predicated upon the necessity for this country in the future to defend itself, or be prepared to defend itself.

Commander BRUNAUER. If the United Organization fails and war will still come.

Senator HICKENLOOPER. Is it your thought that until such time as we get reliable assurances of peaceful intentions among nations that we should not discard or throw overboard the military aspects of research in atomic energy?

Commander BRUNAUER. That is completely true, sir.

Senator HICKENLOOPER. Now, let me ask you this further: Assuming that sometime in the future, either the near future or the reasonably near future, the nations of the world are able to get into such reliable guaranties of peace and the maintenance of peace, would you then think we would be justified in the discontinuance of purely military research in the atomic bomb field, providing all other nations agreed to that and we had proper inspection or proper safeguards that were satisfactory to this country?

Commander BRUNAUER. Yes, sir; I do feel that way. If the country feels satisfied that the safeguards are sufficient to prevent wars, then I definitely feel that way.

Senator HICKENLOOPER. But you still don't believe in throwing away your gun so long as you think there may be a prowler in the house?

Commander BRUNAUER. Yes, sir; more than that, I believe that to hold on to the guns at present will contribute to the eventual solution of the problems of the nations in the United Nations Organization.

Senator HICKENLOOPER. You feel that on any control commission or board that is set up, there should be some representation of the military field of atomic energy, temporarily at least?

Commander BRUNAUER. Yes, sir; not necessarily a military man. It would be perfectly satisfactory to me to have the Secretaries of War and the Navy represent the military of the country on such a commission.

Senator HICKENLOOPER. But is this the point I understand you are making, that during this immediate period of time, or while the threat or possibility of military action remains, that the military interests of this country in this bomb should be in some specific capacity represented on any commission that is set up?

Commander BRUNAUER. Yes, sir.

Senator HICKENLOOPER. Thank you very much.

The CHAIRMAN. Thank you, Commander.

The committee will meet in executive session at 10:30 tomorrow morning.

(Whereupon, at 12:15 p. m., the special committee recessed until 10:30 a. m., Wednesday, February 20, 1946, to reconvene in executive session.)

ATOMIC ENERGY ACT OF 1946

WEDNESDAY, FEBRUARY 27, 1946

UNITED STATES SENATE,
SPECIAL COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The special committee met, pursuant to notice, at 10 a. m., in room 104-B, Senate Office Building, Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Johnson, Byrd, Austin, Millikin, Hickenlooper, Hart, and Vandenberg.

Also present: Dr. Edward U. Condon, scientific adviser to the special committee; James R. Newman, special counsel; and Christopher T. Boland, staff director.

The CHAIRMAN. The hearing will come to order.

General Groves, you have been before the committee a couple of times before, the first time, as I recollect it, on the general information proposition, and then we heard you in executive session on some matters pertaining to the security provisions of a proposed bill. The committee, as I understand it, has decided to invite you to come back this morning to give us your personal views on proposed legislation.

Now, you go right ahead, General.

STATEMENT OF MAJ. GEN. L. R. GROVES, UNITED STATES ARMY

General GROVES. I had hoped to receive a letter from the committee or to have one sent to the Secretary of War outlining my position in appearing, because, after all, it is rather unusual for an Army officer to be asked to appear before a Senate committee to give his personal views as divorced from the War Department.

Senator VANDENBERG. No more unusual than atomic energy.

General GROVES. That is correct, but I have talked to the Secretary of War on the telephone and have received instructions from him, and I feel the only limitation which he has placed on me is that if I give any testimony which I feel is at variance with War Department views, I should state that fact, and so, from time to time, I will emphasize that it is a personal viewpoint and I am not speaking for the War Department.

At the outset, I would like to make it perfectly clear that I have never sought nor do I now aspire to any appointment on or under any proposed commission on atomic energy. Therefore, I do not have any more personal interest in the eventual details of any legislation than any other citizen should have. My only desire is to have the very best form of legislation enacted.

I would like to talk about a viewpoint that I regard as most essential to adequate legislation in this field. First is the make-up of a commission and the duties of a commission.

If the Commission is to function—in fact, if the whole control of atomic energy and development is to function, as I feel that it should—anything in the way of security regulations or regulations affecting other citizens outside of the project itself should be made by the Commission and not by an administrator. There is nothing that can hurt good administration more than to have an administrator who gets to making rules and regulations that affect things other than the immediate operations of his own organization.

I think that any form of bill should avoid giving to an administrator or to any one other than the top commission the power to make regulations, and I refer particularly to security but also to any other form of regulation that might be necessary to adopt. I include in such things any support, and I believe that such support will be necessary to colleges and to universities, to scientific research. I think that should be in the hands of a commission so that the administrator is not put in the position of being someone who has too much power.

During the war that was not feasible. I was both the administrator and the commission, but I had very rigid instructions from the President of the United States and the Secretary of War and the Chief of Staff about security. All of the security measures taken by the Manhattan project during the war and to date are in accordance with the written instructions of President Roosevelt to me, emphasized by oral instructions from him, and by the very pointed verbal instructions of General Marshall.

The type of commission, I think, that you get in this legislation will control whether atomic energy is properly handled in this country or not. It is to me an important factor to get commissioners with the high qualifications that are necessary. The May-Johnson bill provided for nine commissioners who were part-time commissioners. There have been objections to part-time commissioners. I would like to review why I personally—and this is a personal opinion—feel that there are advantages to the part-time commissioners.

It is on two bases: First, that a commission which is made up of part-time people who have other interests will be a better commission. I feel that with the regulatory powers—that is, the power to make rules that affect so many people and affect the United States so vitally—it is important to have a number of men on the Commission. I think that nine is a satisfactory number. Seven would be all right, or 11. I think if you get too many, then it becomes a debating society or people who just sit there and vote "aye." That is not a War Department position at this time.

Senator AUSTIN. I do not understand that. You say the War Department does not favor a commission?

General GROVES. I think I explained before you came in that Secretary Patterson had given me verbal instructions to the effect that while I was to discuss this problem thoroughly with the committee and give my personal views, anytime that I felt that I was not representing the War Department's views I was to make a point of it, and I am making the point that this is a personal view and I am not speaking for the War Department as to how many members should be on the Commission, or anything to do with that.

Senator JOHNSON. Do you know what the War Department's position is on that point?

General GROVES. Well, I don't know what it is. I prefer not to state what that is, because I am not certain enough of it.

Senator AUSTIN. They have not told you, have they, that they are opposed to that?

General GROVES. They have sent to the Bureau of the Budget a report, I believe, on the McMahon bill which would indicate that. I have glanced at that report, read it very hurriedly, and I did not prepare it.

Senator AUSTIN. Have you seen Secretary Patterson's testimony before the committee in that respect?

General GROVES. Yes, sir.

Senator HART. Insofar as I understand, that testimony does set forth the War Department's position.

General GROVES. Until it is changed, that would certainly be correct, sir.

Senator MILLIKIN. You did not write that report?

General GROVES. On the McMahon bill; no, sir, I did not.

Senator MILLIKIN. Would you be at liberty to say who did write it?

General GROVES. No; I don't think so, because I do not know exactly who wrote it all. I know it was prepared under the direction of the Secretary and the Under Secretary and that it was personally discussed as to the major factors with the Secretary.

Senator MILLIKIN. Can you say whether it was written by men who have worked with you in these matters, or by anyone who has worked in these matters in a military capacity?

General GROVES. It was not written by any such person. Our office was consulted and our views were given to them.

Senator HART. General, were any of the members of the original interim committee, whose work founded the original message from the President and the original bill, involved or included in that discussion which preceded Secretary Patterson's testimony?

General GROVES. I do not believe so, but I am not certain, sir. I have no knowledge that they were, and it is my belief that they were not. There may have been one or two who were consulted by phone, but I am not aware of it.

The CHAIRMAN. General, are you aware of a directive issued by the President to the various executive departments setting forth the Executive policy on this matter? Have you seen the memorandum?

General GROVES. Yes, sir; I have seen that.

The CHAIRMAN. And the Secretary of War testified after the receipt of that memorandum in conformity with the memorandum, did he not?

General GROVES. Yes, sir.

The CHAIRMAN. And the Executive policy as it was outlined was for a three-man full-time Commission. I believe that was the Presidential recommendation.

General GROVES. Yes, sir.

The CHAIRMAN. So that gives the official War Department position?

General GROVES. I think so.

Senator AUSTIN. There was supplementary to that an additional board, was there not, in the recommendation?

The CHAIRMAN. I think not, Senator.

General GROVES. I think not, sir.

Senator AUSTIN. I had the impression that there was a provision for an advisory board.

The CHAIRMAN. That is called for in the bill. The power is set up for it.

Senator AUSTIN. That is all right. I am not trying to get a wedge in between the bill and the President or the Secretary of War. I would like to find out whether it is the policy of the War Department to establish a permanent board of three men or three members accompanied by an advisory board.

General GROVES. I don't believe the Secretary testified to that, and as far as I know, the statement was made that it would be a three-man full-time board. What was said and what contact was had with the members of the interim committee I am not aware of in their preparation of that final statement. I believe that previously it had been discussed with them and the feeling had been expressed by some that they would not get as high-caliber men for this task by having a full-time Commission as they would by having a part-time Commission.

When the part-time Commission was originally selected, the theory was adopted on the ground of trying to figure out how you could get a board that would be able to handle this matter. It was not felt that you could get men of the caliber that we needed in many fields to accept permanent positions.

It was also felt, and I think that that has been testified to before the committee by Mr. Smith, Director of the Budget, that the objection is to having a three-man Commission exert executive powers such as were exerted in the days of ancient Rome when they tried to have three men run a state administratively. I think that we have examples of that in this country, and when we have a board which has executive powers, we soon have a situation where there is either turmoil or one strong man emerges, and from there on it is his board or his commission.

In this particular problem, the qualities of the men that are required to be on the Commission are unusual. It isn't anything that a man can just walk into and function perfectly, or even well, by being appointed by the President and confirmed by the Senate. I don't think that that is a full qualification. I think it requires men who have background in many fields. That was one reason why the nine-man Commission appealed to me personally and my personal decision to say that that was the best idea was made by taking various sizes of commissions, both part-time and full-time, and trying to list people that I thought would make up a satisfactory Commissior. That is the basis on which the nine-man, part-time Commission appealed to me.

Senator HART. May I pick that up a little, General?

In checking your idea, do I understand that you rather canvassed the field in the United States to see who, in your opinion, after this great wealth of experience, would be able to measure up to the requirements that you conceded would be necessary?

General GROVES. That is correct, and in some instances to make up this Commission, I made no effort where I was getting into a field that I was not certain of. All I did was to specify the qualities of the man, but to make certain that men of that quality could be obtained. For example, such a board or commission should have representation from science, and that means men who really know what it is all about. You cannot find nuclear physicists who are disinterested. They all will be very vitally interested by anything that is done by this Commission, and I feel very strongly that no one belongs on such a commission who is interested in any way in anything which will really cross swords with his duty as a member of the Commission.

If you take a man such as President Conant, of Harvard, or President Compton, of MIT, they are automatically barred in my opinion, although they would personally be ideal members, because their institutions are vitally interested in nuclear physics research.

I felt that to get men of that caliber, we would probably have to go to the smaller liberal arts colleges, not the universities, the ones that did not have a direct interest in nuclear physics and find a man there, presumably the president of a college such as Williams or Amherst or Lafayette, or something of that character, and that that type of representation was essential.

The CHAIRMAN. General, going over these names that occurred to you as properly qualified appointees on the Commission, you have said that you gave consideration to Mr. Conant and Mr. Compton but had to reject them for the reason given. Will you tell us some of the other names you thought about?

General GROVES. Well, I can give you the quality of the people. For example, I felt that Dr. Bush could be a member of such a commission without interference with other interests. I felt that another man who would be barred by reason of his recent appointment as president of Purdue was Compte, a very able man. You run down the line and you find that any scientist who is an academic scientist—and we need academic scientists on such a regulatory body—would fall into the class I spoke about. He would have to be a man who had taught science and then had become the president of a smaller college.

The CHAIRMAN. Have you any list of names prepared?

General GROVES. In that field we felt that we could get men of that caliber from the colleges. We also felt in industry that we could get men who were accustomed to big things in industry, but it would mean barring, for example, anybody who would be affected by this, and that would primarily bar men from companies which are working with us, companies which might have an interest in seeing us succeed or not succeed, or where the people might have some claim for saying, "Well, that company would like to see this delayed." For example, that would bar, in my opinion, any man who was an executive in either General Electric or Westinghouse.

The CHAIRMAN. Have you a list in your files, General, of these men whom you have thought about?

General GROVES. Yes, sir; I have a number of such calculations.

The CHAIRMAN. With specific names?

General GROVES. With specific names or qualities.

The CHAIRMAN. Would you please send those to me?

General GROVES. Yes; I would be delighted to.

Senator VANDENBERG. Does your idea of this nine-man Commission contemplate that it is totally civilian, or are the services represented?

General GROVES. I felt that the services would have to be represented, and I think that primarily for this reason, that at the present time this is the most powerful military weapon in existence. It is a weapon which can control all future warfare and can spell defeat or victory for a nation and I felt that, until a time should be reached when we knew that the thing could be controlled and could be inspected and could be handled so that we knew we would never be subjected to an attack by this weapon, the Army and Navy would have to be represented.

The CHAIRMAN. You mean on the Commission itself.

General GROVES. On the Commission itself, or in some capacity that would insure that the Army and Navy views were not overlooked.

Senator VANDENBERG. You mean men in active service now?

General GROVES. Men in active service or men on the retired list, although I have always felt that with this length of time which was proposed of 9 years—and that was proposed because it was felt it would take at least 2 years before the man really got into the swing of it if he was not in the field to start with—you would have to have a man who was young enough when he went on the Commission so he could serve his full 9 years and be physically and mentally fit at the time he went off.

Senator JOHNSON. Why should not the Air Force be represented also?

General GROVES. I have always considered the Air Forces as part of the Army or Navy at the present time, and when I say "military representatives," I include land, sea, and air.

Senator JOHNSON. Then, you do include the Air Forces?

General GROVES. By all means, sir.

Senator JOHNSON. Senator Austin may know a great deal more about the trend of things in that direction than any of the rest of us since he is working on the new unification bill, but it would seem to me that all three of the armed forces should be represented on this Commission.

General GROVES. That is correct. As soon as they become three instead of two, or as soon as they become one, as far as I am personally concerned, I would like to see from two to four men on that Commission who were either active or retired, and I would like to see at least one of those from the Air Forces, and I am not particular about the others, except that I think there should be one from the Navy and one from the Army Ground Forces. As long as there are from two to four, I think that the Army and Navy interests, which are essentially the defense of the United States, would be properly taken care of.

Senator VANDENBERG. You said that you were interested in the age level so that you wouldn't lose capacity. Your view and Senator Hart's agree on that subject?

General GROVES. I am afraid I might be younger than almost anyone here except the chairman, and maybe I am younger than he is, so maybe it wouldn't be right for me to say as to that.

The CHAIRMAN. General, I take it, when you say service representation you mean service personnel, not the Secretary of War?

General GROVES. I do not mean a civilian head of a department and I do not mean a man who has to go to the Secretary of War or the Chief of Staff to be told how to vote on anything. In other words, what I want, and feel is absolutely essential, is a man who has the background and who is not going to forget for one minute that, as long as this is a prime, or the prime, military weapon of the country, defense must come first and other things will have to come afterward until the international situation is resolved so that we do not have to worry about this as a military weapon.

Senator MILLIKIN. Do you think, General, that the bill that comes out of this committee should conform itself to the fact that the weapon angle of it is the predominant angle at the present time?

General GROVES. I think so, but I do believe that the bill as it comes out should recognize that while it is a predominant angle at this time, we are prepared for the future and the bill should prepare for the future and not intimate to anyone that we are thinking of this only as a weapon.

Senator MILLIKIN. That would be a matter of mechanics?

General GROVES. I think it is a matter of wording the bill so that it is clear that we are not as a Nation embarking on a policy that we are going to have this as a weapon for all time and that is all we are interested in.

My view is that we are interested in it as a weapon as long as we have to be, and on the day when we can say we can forget this as a weapon, that will be fine.

Senator MILLIKIN. You agree that the weapon is the predominant thing at the present time?

General GROVES. At the present time; yes, sir.

Senator MILLIKIN. Do you see anything on the horizon that leads us to believe that within, say, a year or two it will lose its predominancy?

General GROVES. As a weapon?

Senator MILLIKIN. As a weapon.

General GROVES. No, sir; I cannot see anything.

You are thinking, I suppose, primarily of defense against this, and I see nothing, and I have yet to be told by anyone in whom I have any scientific confidence that there is any possible angle which could be attacked that might result in a defense.

Senator MILLIKIN. Aside from the defense angle, that is, a specific defense to this specific weapon, do you see anything in the world situation that leads us to believe that we may get into such a state of stable peace within the next year or two that we could shift the predominancy of the energy from a war weapon to that of peacetime exploitation?

General GROVES. I don't believe that we can ever shift from the predominancy of this as a war weapon so long as we are unable to make certain that there will be no war.

Senator MILLIKIN. Then, until that time the bill, in your judgment, should reflect that fact?

General GROVES. Yes, sir.

The CHAIRMAN. General, I may be in error, but I seem to remember upon a number of occasions—I am not sure whether you did it before the committee when you were here before, but I seem to have read in the paper at least, accounts of some speeches that you made in which you indicated that you believed that the War Department wanted to get out of this just as quickly as possible. Do you regard your recommendation for War Department generals to be members of this Commission to be in harmony with that former statement?

General GROVES. Yes, sir; because at the present time and in the past, the War Department has had sole control, and it is the sole control that I feel it should get out of.

I think also that when I said from two to four men with military experience on a commission of nine, that means the majority will be in the hands of civilians, as I feel it should.

The CHAIRMAN. Now, General, let's see if we can harmonize that viewpoint with your answer to Senator Millikin's question that you regarded this thing primarily now as a weapon. If that is the major emphasis at this time, would it not follow logically if you adopt your theory that there should be a majority of military on the Commission?

General GROVES. No, sir, because I believe that the Commission should be primarily civilian. It is the feeling of the United States and of all the Anglo-Saxons, dating from the time that Cromwell went into Parliament, that you cannot have an organization with the powers that that organization will have that is not definitely subject to a civilian majority. I believe that the Secretary of War should be civilian and should have civilian assistants for the same reason, and yet that does not keep the Chief of Staff, who is the military adviser to the President, from exerting a great deal of influence on military matters. At the same time, it leaves it to the Secretary of War as the head of the War Department.

Likewise, on this Commission I feel that the Commission must have a civilian majority, and I feel that very strongly because of certain things that the Commission must be responsible for, which are primarily security matters, and these regulations which they must frame and adopt. I think it would be most adverse to the future of atomic energy and to the future of the country to have the action of the Commission attacked on the ground that it was a military commission.

The CHAIRMAN. Do you think that you would obviate that crime by having a 5–4 representation?

General GROVES. I think you would, and I would like to recall that I said from two to four.

The CHAIRMAN. Four more desirable than two?

General GROVES. I think the actual number on it, Senator, depends a great deal on what Senator Austin is going to do. In other words, if we have a unified service, if we have two as we have at present, or three, that will determine really what you should have on that Commission.

I would hate to see a commission or anything established in the law that said the President had to appoint a definite number of military men. I would not object personally to having it stated that he can appoint or should appoint not less than two or more than four.

The CHAIRMAN. Now, I seem to have read an interview with General Eisenhower, and I have called the interview to the attention of the Chief of Staff, in which he advocated an all-civilian commission. Have you discussed that with the Chief of Staff?

General GROVES. I don't recall that.

The CHAIRMAN. I read it in the Christian Science Monitor, a story by Mr. Roscoe Drummond.

General GROVES. I don't believe I discussed that particular thing with General Eisenhower, although I do not recall—I may have.

The CHAIRMAN. That is the way he was quoted in this story, as believing there should be an all-civilian commission.

General GROVES. Now, I would like to repeat what I said before, that I felt that none of these active or retired officers who were on this Commission should be serving as representatives of the War and Navy Departments; that they should be serving as individuals, with that background and that ability to see that side of the picture.

The CHAIRMAN. You have always exercised becoming modesty, but it seems to me you have drawn a bill of particulars here which you could fit pretty well.

General GROVES. Well, I do not want to fit it. I think there are others that could fit it. I think that initially—I don't know how long the transition period will last—there are others that can fit that bill today, and I still stand by my statement of neither seeking nor aspiring. As a matter of fact, while formerly it would have been a question of doing what I was asked to do, I think the experiences of the last 4 or 5 months have taught me that it would now take very strong urging. I would have to be told that it was a must and not just "we would like to have you" or "we think you should." Somebody has got to do some arguing now.

Senator JOHNSON. General Groves, would you see any objection to a requirement in the law that the President shall appoint someone from the military branches as recommended by the Chief of Staff of the particular military branch?

General GROVES. No; I would not see any objection to it.

I have always felt, however, that the less strings that were tied to the President in the matter of appointment the easier it was, but I have no real objection to it.

Senator JOHNSON. He would probably do that anyway?

General GROVES. He would do that anyway except for good and sufficient reason, and I do not know just how it could be done if it were done that way. It would be difficult to make it legal and it would be awkward, and I think it would be something that you could depend on the President. After all, if he loses confidence in the Chief of Staff, he has a very easy remedy.

Senator VANDENBERG. In any event, when one of these officers is appointed, he severs himself permanently from the Military Establishment?

General GROVES. As long as he is a member of that Commission.

Senator VANDENBERG. That wouldn't be long enough.

General GROVES. It would be 9 years, and that means that he severs it permanently really from a practical standpoint.

Senator VANDENBERG. "Permanently" is the word.

Senator JOHNSON. Of course, our Army officers have retirement privileges and you might, if you tried to circumvent that too closely, disqualify a great many very able men who would be very desirable on such a commission because their retirement is a matter of great importance to them. If you are going to sever them from such privileges, certainly you are going to have to do a lot of coaxing.

Senator VANDENBERG. I wouldn't sever them from those privileges, Senator, but as generally indicated these men have got to be absolutely free from domination. If they contemplate a return to the service, they are not free from domination. I do not want to interfere with any of their rights; I just do not want them to come back later and capitalize on what they have done.

Senator HART. Senator, after a military man drops out of his own branch for 9 years, he is not likely to be again actively employed in any case, but if he may return to the service pay roll as a pensioner, then his rights are looked after somewhat like one in uniform becoming a Senator and going back.

General GROVES. I think that has given you my views on the proposed nine-man Commission.

Now, there were other types of commissions proposed. I would like to state that my experience has never made me a believer in ex officio members of such commissions who are busy heads of Government departments, because we want men who can spend whatever time is necessary and, particularly, can attend meetings; we want a man who cannot send some assistant over there to sit for him and have the assistant come back and not be able to tell him even what went on at the meeting.

Now, that may be at variance with the idea of a part-time man, but a part-time man to me is not a man who sits 1 day a month and then comes down and sits and forgets it in-between time. He is working in-between time on problems. He is able to take trips of 2 or 3 weeks at a time, at his convenience, of course, and it can be arranged.

As to the permanent type of commission, I think the real objections that I see to it are, first, that I cannot picture that permanent commission as a group of three or five running an executive agency, unless one man becomes dominant. I think also that I would like to see very much the regulatory features of the Commission separated from the executive and the administrative. It will make it much easier for the administrator if all he is doing is executing the rules established by the Commission.

I think one of the other duties of the Commission, besides passing on regulations, and not only passing on them but, as it means to me, really determining what they will be, is to serve as a board of directors on the general administration by the executive, the administrator. I think that is essential. I think there has to be one top administrator, and not, as was proposed in Senator McMahon's bill, four different departments, each of which would report to the group of three men. I don't know just what qualities those three men would have. I have tried to figure out just what they should be.

If you have one man with military experience and you have one with industrial and one with academic science, you have got just about a bare framework. I don't know whether there should be someone with legal ability in there or not, but you would at least have to have those three—the military, industrial, and academic—and that leaves out a number of things. It leaves out more than one military man, for example, who would either have to be air, ground, or sea, and you have problems involved in that.

Senator JOHNSON. You are leaving out an engineer, also.

General GROVES. It would leave out an engineer. You would have to make your choice between an engineer and an operating man, and these big industrial operations are not easy. They involve labor problems that are most complex; they involve management problems, and they involve a tremendous number of problems where you want the advice of those men.

Now, I would like to recall for you for a few moments what the military policy committee did for me during the past. The military policy committee, as I viewed it, had one primary purpose, and that was at any time that they lost confidence in me they were to tell somebody, and that somebody would then say, "You are through."

Senator MILLIKIN. May I interrupt to ask who made up the military policy committee?

General GROVES. It was made of Dr. Bush as the chairman, with Dr. Conant as his alternate, and with General Styer and Rear Admiral Purnell. Now, actually Conant sat with every meeting of that military policy committee. I also sat with it—that was required in the set-up.

In addition to keeping their opinion on me up to date so that they could report to the proper authorities—that is, the Secretary—and say, "You had better get rid of him," they also passed on major decisions in advance. I didn't embark on the construction of Hanford, for example, without the full concurrence of that military policy committee. I presented the facts; I answered all the questions. Styer and Purnell could handle the military part of it. Bush and Conant could handle the scientific part, and we didn't have any industrialists on that, although I often wished that I had a man to go to for advice; but I had plenty of other industrialists. We went to them for advice constantly. Dr. Conant was an adviser to me from the start. As he puts it very modestly, he said that he was a "kibitzer" on this project. He was the type of kibitzer that tells you what you had better discard and how many cards to draw, too. While he didn't interfere in any way, it was always advice, still it was very sound advice, and that was true also of Dr. Bush. If a problem came up that was essentially chemistry, then Dr. Conant's advice was listened to very carefully, and it was, as a matter of fact, always followed. The same thing was true with Dr. Bush's advice.

When you have men of that caliber—and that is the type of man I would like to see on such a commission—when they give advice you had better listen to it or be very certain that you are right, and then you have to convince them, or probably you are wrong anyway.

Senator JOHNSON. Were Drs. Conant and Bush consulted in the drafting of the so-called May-Johnson bill?

General GROVES. They were members of that interim committee, sir.

Senator JOHNSON. Then, they approved the nine-man Commission?

General GROVES. Yes, sir; and particularly the part-time features of it.

The CHAIRMAN. How often, General, did this policy committee meet?

General GROVES. That policy committee met—I don't recall exactly—at irregular intervals whenever I felt there was anything I needed their help on, or they felt they should be brought up to date. That was an official meeting. Actually, when he was in Washington, I should say that I saw Styer at least every week or 10 days; I saw Conant about every week to 2 weeks, depending on how often he came to Washington, and every time he came to Washington I saw him. I saw Bush just a little less frequently, but that was not necessary because I saw him through Conant who took everything that I said back to Bush. I saw Purnell on anything that I felt I needed his particular advice on, or any important matter that came up.

For example, if we got a report that one of these constants was turning the wrong way, and instead of being able to make a bomb with, say, that much material [indicating] we were going to have to use that much [indicating], they were informed immediately, and they were informed just as the board of directors in a company would be informed. When they came to the board of directors meeting, they knew what it was all about. They were not there just to collect a fee, for there were no fees; they were there and knew everything that went on, but didn't know about the details.

The CHAIRMAN. Admiral Purnell, I believe testified before the committee. It is hard to recollect all the testimony that has been before us, but as I recollect his testimony, my general impression at least was that he had not been in too close contact with the project. Have you read his testimony?

General GROVES. Yes, but also it was quite a while ago.

The CHAIRMAN. Do you agree with my impression?

General GROVES. I would like to say in my opinion that dealt with the one phase of it which was the work done at the Naval Research Laboratory.

The CHAIRMAN. That is where he was consulted?

General GROVES. No, sir; that is the part that he did not know as much as you might have expected him to, but that was because there were many complications concerned with that that dated back long before I came into the project. There were a lot of technical and personal problems there that I would rather not go into in open hearing, but it was a touchy thing to handle, and it was nursed and handled just as carefully as it could be done.

The CHAIRMAN. I gather from your description, General, that you really carried the main burden of the policy making of the Manhattan project.

General GROVES. I would not say that is correct.

Now, for example, take the Hanford works. The decision to build the Hanford works was made with the full approval of the policy committee in advance. Every important decision was taken in advance. We built three piles there, and that decision was approved by the policy committee in advance with a description of just what we thought we would get out of each pile.

The fact that we built two chemical separating plants there was approved by the committee in advance. Then, there was a time when one member suggested that we not complete the third pile. We got some erroneous scientific data, and we thought we could do much better than we could do, and because of that erroneous scientific data one member suggested that we not complete the third pile. That was a subject of considerable discussion in that policy committee and the decision that was reached was, you might say, squarely on all of us.

My general feeling always was this, that while I was responsible for the major decisions, no member of the policy committee would ever be in a position where he would say that he did not know that these decisions were being taken and that if he had known he wouldn't have approved them, because they knew of the major decisions and they approved of them and approved of them in advance, and quite a number of them that were quite important were really taken on the initiative of one of the members of that committee.

There was one particular thing that I would prefer not to state where I was overruled by the policy committee on a certain matter with respect to organization, and that was all there was to it.

The CHAIRMAN. Do you have a record of how many times this policy committee met with you?

General GROVES. Formally?

The CHAIRMAN. Yes.

General GROVES. Yes, sir.

The CHAIRMAN. Do you know how many it was?

General GROVES. No; but I should say offhand that the formal meetings would run from about a month apart to about two to two and a half months, and it all depended on the situation. If there was nothing to be discussed, they did not meet.

The CHAIRMAN. Would you mind submitting for me the number of formal meetings of this advisory board?

General GROVES. I would be glad to, and also with the understanding that that did not mean they were not in constant touch with the situation. There were certain meetings that were held at longer periods than we would like to otherwise because of the fact that we could not always get these people together. Some of them left the country, as you know, from time to time.

The CHAIRMAN. That is always the difficulty with part-time people who have other interests. They might find it difficult to consult in matters of policy.

General GROVES. That is correct, but we never had any trouble with them when they were in this country. It was when they went abroad, to the Pacific and to Europe, that we had trouble.

If there is no provision adopted which includes men with military experience—and I mean by that long military experience, not just the experience of serving in either this war or the last—I believe that something should be done to correct anything which excludes the armed forces.

We have talked a lot about unification of the armed forces, and yet if this is done we would take the controlling weapon, you might say, certainly the controlling weapon of a surprise attack, and divorce it from the armed services and say that the Chief of Staff and the Chief of Naval Operations will have nothing whatsoever to do with it excepting insofar as this Commission permits them to. I think that means that if any such bill is adopted which does not include men with military background on the Commission, the Commission should be directed by law to submit to the Joint Chiefs of Staff all matters of policy prior to adoption and before publication.

In the event that the Joint Chiefs do not concur in such policies, I think they should be submitted to the President for decision. I think it should also direct continuous consultation and maintenance of liaison with the War and Navy Departments on all matters of security, military research, and military applications of atomic energy and development, manufacture, storage, and use of atomic bombs.

The CHAIRMAN. Do you mean by what you have just said that all releases of information, including basic scientific information, should be submitted to the Joint Chiefs of Staff?

General GROVES. You mean each piece?

The CHAIRMAN. Yes.

General GROVES. No, sir; the policy.

Now, I would like to state, for example, how the Smyth report was drawn up. The Smyth report was drawn up by putting down on paper in about the equivalent of a sheet and a half of double-spaced typewriting the rules under which the report would be drawn. Those rules were drawn up originally by me, I think in consultation with various people—I am sure in consultation with Drs. Tolman, Conant and Bush. They were approved later formally by people above me in the War Department—that is, the Secretary—and I don't recall whether they were shown to the President or not. I cannot say, but those rules set forth the basis on which the Smyth report would be written.

Essentially they were that it could not contain anything that was not already known beforehand, and they gave certain exceptions to that as to what could be told; that is so that men of the stature of Hahn or Eisenberg of Germany could not get the answer once knowing the bomb had gone off, and it permitted certain things that we knew could not be kept secret over 10 minutes after the bomb was let off.

The CHAIRMAN. Do you advocate the release of any further basic scientific information?

General GROVES. I will comment on that. These were rules that every person in this room could understand. There wasn't anything scientific about them. They were the type of rules, written by people who had intimate knowledge of the project and intimate knowledge of science and engineering, which would guide Smyth in preparing his report. The report was read afterward by a group of several scientists, particularly Dr. Tolman, on whom I placed the greatest confidence, with the rules right in front of him.

Smyth and Tolman both said that these rules were carried out in the preparation of this report. I read the report also. There were some things in there that I couldn't have told whether they met the rules or not. Maybe some of the physicists couldn't tell when you got over in to the chemical field, but in each instance the necessary check was made by the man who did know that particular small phase of the problem who said that it was within the rules.

Now, the chiefs of staff would concur in the rules and then it would be up to the other people to enforce the rules.

Now, to return to your question, Senator.

The CHAIRMAN. I asked you if you advocated the release of basic scientific information.

General GROVES. I advocate personally—I am very much interested in it—the release of all scientific and engineering information which will not be adverse to the national defense of the United States. Now, in putting that on a practical standpoint, I believe that it means almost all of the medical data which we have secured. It means a tremendous amount of what is properly termed "basic scientific information," things that we learn which have no effect on national defense.

The CHAIRMAN. Are you in agreement with the report of your committee, the War Department's committee, who sent us a copy of the letter addressed to you advocating certain declassifications.

General GROVES. That is the Tolman committee. Tolman was the chairman of that.

The CHAIRMAN. I believe it was Oppenheimer, Urey and Compton.

General GROVES. Yes, I know that. That report has been studied by me in detail. It has been discussed with a few of the members, all the members that could be gathered together at the particular time. As a result of that decision, they have given me an additional report explaining a few of the things that were not clear as to just how far they intended to go, and my own reaction to the report is that in general I am very much in favor of adopting every single recommendation that they have made. There are a few exceptions that I am still worrying about, but I would say offhand that 90 percent of their recommendations I am in favor of.

In view of the statements that have been made before this committee, and in the press and in the editorials of the press, repeated time after time, I feel that it is hardly proper for me to release that without authority from above, and I am taking the necessary steps and don't mind saying that I believe that almost everything in that can be released, and it is a question of when. If it were within my hands, I think that I could tell you exactly what I would do, and I think you would know.

Senator JOHNSON. Can it be released soon enough to assist this committee in drafting the legislation that we expect to draft during the next 2 weeks?

General GROVES. I don't believe it would be of any value to you in drafting it, but I would be very happy to give you as a secret document for your use in the committee the report of the Tolman committee with its addendum showing the things that will help you understand it. I would be very glad to have an officer who served as the nonvoting secretary appear with the report and explain to you just what that means, but it would have to be done in executive session.

Senator VANDENBERG. May I ask you a question, General?

In dealing with the United Nations on this subject, we have proceeded on the theory that any arrangement made by the United Nations Atomic Energy Commission will require the approval of Congress. In other words, we are proceeding on the theory that there is not only a general policy factor involved in this matter, but there is also \$3,000,000,000 worth of American property involved, and that in the final analysis the American Congress is the only power that can make a conclusive decision.

Now, you cannot transfer that analogy completely to the domestic situation, but I want to ask you whether you conceive that Congress has any continuing responsibility of any nature in connection with this affair, and, if so, how you would implement that responsibility?

General GROVES. I feel that Congress has a very definite responsibility, and certainly those of us who have appeared before congressional committees are fully aware of that, particularly when we come seeking money.

I feel that the best control the Congress has on any executive activity really is the power of the purse strings.

On this problem I feel that there are many things; for example, take this release of information that I am now faced with. It is a very difficult decision to make, not because I feel personally that it will hurt the national defense, for as I say, 90 to 95 percent of the data I feel could be released. But it is a decision that I don't believe, in view of what has occurred in the past with respect to the Smyth report, I am justified as an executive officer in releasing.

Now, if the President of the United States tells me to release it, then I will assume that he will decide whether it should be referred to Congress or not. Now, I don't believe that it is sound administration to have to refer such a matter to Congress. If this committee should tell me that they were opposed to releasing that information, I certainly wouldn't release it of my own free will.

Senator VANDENBERG. Let me be specific about this thing. Would you object to the inclusion in this legislation of the creation of a standing joint House and Senate committee for purposes of consultation and advice with absolutely no executive authority but as a permanent liaison with a right of constant knowledge and information with respect to what the Atomic Energy Commission is doing?

General GROVES. I don't know what the views of the War Department are, but I can state what I personally feel about it. I would not mind that in the least, and I think if I were connected with this in the future I would be very happy to have it. I would certainly, on a matter of this importance and with so much security bound into it, prefer to have one committee with which to deal rather than two.

Senator VANDENBERG. Thank you.

Senator BYRD. General, could I ask you if you are in agreement with the declaration of policy contained in the McMahon bill, page 2, "A program for the free dissemination of basic scientific information and for maximum liberality in dissemination of related technical information"?

General GROVES. I would say "yes," provided that nothing will be disseminated that in any way will injure the national defense.

Senator BYRD. You think it ought to be restricted to that?

General GROVES. I think there has to be some restriction as to the national defense attitude. Now, I don't know just when you came in, Senator Byrd, but I expressed the view that until various people that are handling international affairs and other nations really put this world on a peaceful basis and we know there isn't going to be any more war, this is a military weapon of prime importance.

If there is anything that can be done so that it can be inspected internationally, so that this particular weapon cannot be used in time of emergency, then of course that, so far as atomic energy goes, puts the world at peace. I don't know of any way.

As you know, we have got a group of men studying that particular question right now, and I would prefer not to discuss the tentative stories that have come to me from that committee. All I can say is that I think they are finding that it is not entirely an easy task. I didn't say it is impossible; I don't know, and I would prefer not to say until I get the views of the whole committee.

I was very particular in appointing that committee to see to it that it had on its roster—I think there are nine men on it, approximately—a minimum of three and I think nearer five who are very much in favor of international control.

Senator JOHNSON. What is the specific task, please?

General GROVES. The task is to study the practicability and actually to come up with a plan that is scientifically and militarily possible, you might say really scientifically possible, of how atomic energy programs can be inspected throughout the world so that we can be sure that no one can make a bomb without our knowing about it in ample time.

Senator AUSTIN. Mr. Chairman, I would like to ask the general if what he has said is not in accord with the declaration by Great Britain, Canada, and the United States, that not until after effective security against the destructive use of atomic energy has been set up in working order shall the information be reciprocally exchanged and acknowledged with respect to the constructive use of it?

General GROVES. I am fully in agreement with that, and I think everything I have said is in agreement with that.

Senator AUSTIN. I so understood it.

General GROVES. As a matter of fact, in that statement there was only one word that I would have liked to have seen changed in the whole statement, which is pretty good for me.

Senator JOHNSON. What was the word?

General GROVES. I don't mind saying that, but I would like to have it off the record. I will tell you afterward.

Senator MILLIKIN. General, in view of the many variables in the picture, such as the fact we do not yet know what the international arrangement will be on this subject, and the general uncertainty of the whole subject, what would be your reaction to approaching this on a temporary basis of conserving our military security and of letting out as much as can be left for peacetime civilian use, but with the prime approach being that we are cognizant of the fact that there are so many uncertainties that therefore this is not the time to lay out a long-range program, but that it is the time to make an interim measure.

General GROVES. I feel that the Commission would approach it from that standpoint; any commission which is appointed and thought they were sitting down to settle this thing for all time to come would be an improper commission, in my opinion; they would have to approach this on the interim basis.

Right today we haven't got international peace guaranteed for all time to come, and until that comes or when that does come the position would shift.

Senator MILLIKIN. So regardless of the form of the bill, that in act is what we have to do?

General GROVES. I think that is essential. Now, there has been a great deal of discussion about security. I spoke about that in the executive session in response to your request.

The CHAIRMAN. General, before you go into that, that nine-man committee that you say is working in the War Department I presume is the same committee that was appointed at the chairman's suggestion to the Secretary of War?

General GROVES. Yes, sir, at your suggestion.

The CHAIRMAN. We have had no report from the workings of that committee. When do you anticipate that we will receive such a report?

General GROVES. I would like to ask General Nichols,[1] who is in the room, if he can give me that.

General NICHOLS. They are supposed to have the report to us by March 8.

The CHAIRMAN. And that will be made available to this committee?

General GROVES. It will be made available as soon as I have read it. I would like to read it first to see if there is anything that requires further study and so that they can go right to work on that.

Now, we have again an officer acting as their nonvoting secretary so as to push this thing along and get it at the earliest possible date.

The CHAIRMAN. Thank you.

General GROVES. With respect to security, no one is more interested in having freedom of research. That is essential to scientific advancement; I believe in it thoroughly. I believed in it before this project started, and I believe in it more thoroughly now.

All of the scientists that I know are in favor of it, and the ones to whom I have talked—and particularly those men in whom the experience of 3½ years has taught me to have confidence that their opinions are absolutely sound, are all also very strongly in favor of it. I think we all are. It is almost an axiom.

But until other nations are willing to join us in reciprocal arrangements which will effectively control this problem, we have got to continue in accordance with the announcement at the White House by the President and Mr. Attlee and Mr. King. I think as a nation we must do that.

In other words, we cannot afford to give all the information we have, or any essential part of it—and I am referring by the word "essential" to that which will really aid another nation in doing this work—until such time as we are assured that it will not be used against us. That, to me, of course, means a like assurance on our part that we are not going to have to use it and won't use it.

Senator VANDENBERG. In a word, General, you agree that security must precede disclosure at every stage?

General GROVES. Yes, sir.

Now, I think also I would like to emphasize again that the security rules must be made by the Commission sitting as a commission, and I would like to see that emphasized in the bill.

I think it was in the May-Johnson bill that that was something the Commission could not delegate to the administrator. If it wasn't in there, it should have been, because that is a sound way to do it. I don't think one man should be deciding that, and I don't think one man should have too great an influence on it. I also feel there is nothing that will do more to break down the morale of the organization and the influence of the administrator on the whole organization, and the effective cooperation of the people with whom he has to work outside, such as university and industrial laboratories, than placing on his shoulders the responsibility for drawing up regulations that can have criminal effects, or if not criminal, at least a smear on the reputation of the man who is guilty.

Senator HICKENLOOPER. General, may I ask a question, please?

General GROVES. Yes, sir.

[1] Brig. Gen. Kenneth D. Nichols, district engineer, Manhattan district, Oak Ridge, Tenn.

Senator HICKENLOOPER. Did you express yourself earlier in the meeting as to whether or not the administrator should be appointed by the President or selected by the Commission?

General GROVES. No, sir, I did not. My own feeling is that I don't care, personally, much. I liked what I saw in the original bill, that he would be appointed by the Commission, because then he looks to the Commission as his master. If he is appointed by the President, from what I have seen in Washington since I have been stationed here, which has been almost continuously with the exception of 3 years since 1931, there is a tendency at times for people who are appointed by the President to fail to recognize the man's authority for whom they are working, and I believe that the administrator must be the creature of the Commission.

I would have no objection that amounts to anything if the bill should say "We want him appointed by the President and confirmed by the Senate," but I think he is a very important man and he must be of the highest quality. Any man that accepts this position must go in there feeling that he has got a position that will last for a number of years, but I hope not too long, because I think it is a position which is too important to have it fall into the hands of one man and let him continue in that position.

Senator AUSTIN. General Groves, I understand you to mean that even though he might be appointed by the President and confirmed by the Senate, still you would want the recommendation of the man to come from the Commission?

General GROVES. I would like him to feel that the Commission employed him and can fire him. I would think it would be terrible to have an administrator there about whom even a minority of the Commission had doubts as to his ability or had quarrels with, or anything else that would cause trouble.

The CHAIRMAN. General, as to these regulations that you would have this Commission empowered to make, is it your opinion that before issuance, inasmuch as they would be in fact the same as criminal acts, that is, the violation of them would constitute criminal acts, that they should have the approval of the President?

General GROVES. I have no real strong views on that. The only reason that I would prefer not to have them approved by the President is that before they are issued I think it would be just a form for him to approve them. Now, if he would really study them, if he could study them himself, that would be a different thing.

The CHAIRMAN. Of course, we hold the President responsible in fixing his approval on bills involving the sum of $156 appropriated by the Congress. Doesn't it impress you that before any commission is empowered to issue what might be loosely called criminal statutes, they would like to have the same kind of approval?

General GROVES. I have no real views on it except that I think the President is already overburdened, and for him to review a highly technical regulation which this would be would just be adding to that burden.

Now, as I say, as far as the operations of the Commission go, I have no views on it. I would just hate to see anything more thrown on the President than he has to have on him.

The CHAIRMAN. I personally would rather try to remove from him some of the administrative acts on purely civilian matters that don't affect the life and liberty of our citizens, and call upon him to fix his approval to something that might send a man to jail.

I am sympathetic with the burden, but I still would like to protect as well as I could the liberty of our people.

General GROVES. As far as I am concerned, I think that is a matter that I really have no views on. It is just a preference, and I wouldn't want you to feel that I really had any feelings one way or the other.

Senator MILLIKIN. General, on what theory do you justify turning over the control of military security, so far as this energy is concerned, to a civilian commission?

General GROVES. I would really like to see—even assuming that the May-Johnson bill were adopted in its entirety now, and even to the point where there is an amendment requiring at least two and not more than four officers to serve as members of that Commission—the Commission directed to submit policy matters to the joint chiefs of staff before action was taken.

I think that is in step with what we in the country all believe in in one form or another, which is unified command. We may not express in just the same way where this command starts to split off, but there must be that unified command. I think at the present time certainly the Joint Chiefs of Staff are the top military command in the sense of being in uniform.

Now, you could say that that should go to the Secretary of War and the Secretary of the Navy, but it wouldn't have any effect. There would be no difference except that the joint chiefs with present membership would give that direct representation, you might say, to the air forces as well as to the ground and sea.

Senator MILLIKIN. At the present time we have a civilian as Commander in Chief, and we have civilians as Secretaries of War and Navy. They are a part of the hierarchy of military control and have definite positions of responsibility in that hierarchy.

The thought keeps nagging at me that we are setting up something entirely new in having an independent outside body entirely controlled by civilians determining the military security and secrecy of this country.

General GROVES. Well, that is why I would like to see this reference to the joint chiefs which, in addition to the chiefs, you might say, of ground, sea, and air, includes the Chief of Staff to the President himself, so that you are getting the representation there of the people who are really unifying the military defense.

Senator MILLIKIN. Isn't that another way of saying that as long as the energy as a military weapon continues to be predominant, regardless of the mechanics we adopt in the bill the military must keep its hands on it?

General GROVES. I think it has got to keep its hands on the part that is necessary for national defense, and that they should be overruled on matters of policy only by the man at the top, the President, who is after all the man who is responsible for the defense of the United States.

Senator AUSTIN. That point is very well taken, I think, and probably should be considered if we consider that unification is to be considered in any such legislation.

General GROVES. There is one bit of testimony that I would like to have you look at in drawing up any legislation, and that is the testimony by Secretary Ickes when he was talking about the difficulties of operating any organization such as this with all of the present restrictive laws.

Senator VANDENBERG. You mean ex-Secretary Ickes?

General GROVES. I stand corrected, Senator.

I would also like to make the point that my study of the four bills indicates to me the great importance, in actually preparing any bill, of checking the provisions of all four of these bills to see that nothing has been overlooked that should be in. There are important factors in each one of these bills that I think should be very carefully considered before that idea passes by the board.

Senator HART. General, if I may pick you up right there, is it your belief that this legislation which we are attempting to draw up should have very much to say about the patent situation, or is that something that is so involved that perhaps it should be contained in other legislation?

General GROVES. I think that the patent situation should be covered rather briefly in the bill. I think that you know from specific testimony that we have pretty good control of the patent situation. In other words, anything that United States money has paid for, in the development in any way, we have a very good control of. There are certain things, of course, that are invented by people who don't work for us that we haven't paid for, and there we have a problem; but I believe that anything that directs the Commission, or whatever body is set up, to insure that the patent position of the United States is protected at all times should be enough. I didn't need any such direction when I took over, because we immediately put into effect the previous policies that came to us from OSRD, that Dr. Bush had drawn up, and I think we probably went just a little further in this case because it was so essential that no one be able to interfere in any way with our use of any process that we needed to make this thing work.

Senator HART. You mean by that, General, that the Manhattan district found that the patent laws as they were, were entirely workable and suitable for its purposes?

General GROVES. I think they were. There are some problems that we are faced with in the handling of secret patents, and I am not as familiar with patent law as I am with some other things, but in general it revolves around the secret patents. Secret patents were asked for primarily to prevent the possibility of someone later filing a patent on something that we had discovered, and then we would be in the position of having to upset his patent rather than having a definite bar against it.

The possible financial losses to the United States were so great that we felt it was very desirable to protect ourselves patent-wise, and just what the law is on secret patents, how long these patents can be held secret, I am sorry I cannot answer. I think you can get that testimony; certainly Captain Lavender could give it to you.

The CHAIRMAN. We have had him before the committee.

General GROVES. I mean on that particular point. As far as I know, the law is adequate as long as hostilities do not cease. Now, what happens when they cease I cannot tell you.

Senator MILLIKIN. General, do you believe that a civilian commission or a predominantly civilian commission should have the power to tell our military forces how many bombs to make, how many bombs to keep, how to make them, where to keep them, or what to do with them?

General GROVES. No, sir; I think that that would fall into the classification of policy, and would have to receive the approval of the joint chiefs of staff, and certainly if a commission attempted to dictate as to where these would be kept, or anything of that kind, and overrule the wishes of the joint chiefs, I think there would have to be a decision by the President and one that would upset some of the decisions of the Commission.

Senator MILLIKIN. So that legislation on the subject eventually would have to have a view to the military problem of the nature that I have described?

General GROVES. Yes, sir; and I think I read earlier in the hearing my views on how the Joint Chiefs of Staff would come in and would solve that problem satisfactorily. In other words, the joint chiefs would have to have presented to them the policies that affected such matters; in other words, anything affecting the military would have to be approved by the Joint Chiefs of Staff.

It certainly would be something that they would be very vitally interested in if a decision were made to stop producing all active material, for example, because that of itself would definitely limit the number of bombs that might be available.

The CHAIRMAN. General, assuming we had a nine-man commission made up of five civilians and four military men, a part-time commission, would you have the military men vote on questions of peacetime uses and applications of atomic energy?

General GROVES. Oh, by all means. They would be full members of the Commission.

The CHAIRMAN. What special qualifications would you think the military might have to run the civilian end of the matter?

General GROVES. Well, I think I will put it this way: If you try to take the Commission and say an individual member will not vote unless he is a specialist on that problem, you would never be able to get a full vote of the Commission. For example, if a legal matter came up and there happened to be one lawyer on the Commission, he would decide that; and in the same way you might say, "Why should an academic scientist vote when it came to industrial operations?"

It is getting out of his field, but by service on this Commission I feel that all of these men would be broadened tremendously as the years went on, and each year they would have a better viewpoint on the rest of it.

Certainly in the military policy committee, as I said before, when it came to a matter of chemistry, everybody deferred to Conant. If it was a matter of electrical energy, we all deferred to Bush. When it came to something to do with the Navy, we might ask Admiral Purnell some questions as to why that was necessary, but I personally would not dream of telling him how fast a ship could go or how it should go or anything about it. I think that is the general effect of any commission.

Senator JOHNSON. Mr. Chairman, I should like to ask General Groves this question:

I discover an inconsistency in your testimony with respect to the Commission. In the first place, you advocate a part-time Commission; in the second place, you advocate certain members with military experience serving on that Commission; in the third place, you advocate that these military representatives sever all connections with the military.

Now, just how can that be done? If they are part time, they sever all connections with their careers, and then have a part-time occupation; is that consistent?

General GROVES. No; it is not; and I think that the problem is just how that particular thing can be handled if those officers are on the active list. It is very doubtful. I cannot understand quite how an officer who is on the active list, who was made a member, would be able to do the two jobs unless the Secretary of War just said, "Well, when you represent me on this you are not representing me; you are representing the people."

I think the real answer to it is that there will be a tendency to use retired officers on such duty, and officers who have been retired rather earlier than the usual age.

Senator JOHNSON. In that case, of course, they would lose some of their privileges of retirement.

General GROVES. No, sir; not if the bill provided that they could serve in a part-time capacity and still retain their retirement privileges. That was provided for in the May-Johnson bill.

Senator JOHNSON. Yes, but you do not advocate that. You want them to sever all military connections.

General GROVES. If they are retired, of course, they are severed from military connections.

Senator JOHNSON. Obviously, but that wasn't your testimony. You didn't want to restrict it to retired officers. You didn't want to restrict service on this board to retired officers.

What I am trying to get at is that if we are going to use active officers, must we not have a permanent service? You cannot have part-time service and use active military officers and require them to sever their military connections.

General GROVES. I think the primary place where active officers would be more apt to be used would be in the administrative staff and as the administrator or deputy administrator.

When it comes to the Commission, it is very difficult for me to imagine anyone serving as a member of that Commission as an active officer, although I think provision should be there. He might serve for a certain period as an active officer, but I feel personally that the term of office should be long enough so that that officer knows what it is about, for a long enough period so that he will be really useful.

I cannot picture an active officer getting into that position. But I can see certain active officers who could serve on such a commission and represent their owns views without any difficulty whatsoever.

I can imagine, for example, if the Surgeon General of the Army should be particularly fitted for such duty, I can imagine his serving a part-time membership on such a commission and not representing the War Department. I think there may be other special cases of that kind.

Senator JOHNSON. What about such a man as Admiral Blandy?

General GROVES. I think that as long as the Navy retains its sea-duty requirements, that would automatically bar a man of that type.

Senator JOHNSON. Would that be advantageous?

General GROVES. Well, I don't know. I think it is advantageous to require them to serve a considerable length of time on such a commission. You could say, of course, "You are only on it 3½ years"; but we grew up with it, and that is entirely different from somebody who comes in now. They won't grow up with it, and they have to start way behind, so that your problem there is whether you can take an officer like Admiral Blandy and say, "You are going to this Commission for 9 years, and that means you cannot have any more sea duty, or you can only have sea duty when you are not serving on this Commission." I don't think the admiral can have a position where he has to leave his command every month or possibly every 2 months, or more, which is not controlled by the best interests of his command.

Senator JOHNSON. Will this Commission have a tremendous amount of work?

General GROVES. I don't know how much they will have. I think they will have a considerable amount initially, because after all they have got to study it. I think any new member will have a considerable amount of work, but I cannot picture their spending full time on it.

Senator JOHNSON. It wouldn't be like the Interstate Commerce Commission, where applications pour in every day in such volume?

General GROVES. No, sir; because I think those applications would be decided on a policy basis. In other words, they would adopt a policy, and then when the application came in on anything that had to be passed on by them it would be a simple matter to say it either falls within our rules, or doesn't. There is nothing such as the Interstate Commerce Commission has, for example.

Senator JOHNSON. Nor the Federal Power Commission?

General GROVES. Nor the Power Commission, with its multitudinous number of applications.

Senator JOHNSON. Or the Federal Trade?

General GROVES. No, sir.

Senator JOHNSON. The decisions would be few and at greater intervals after the initial work?

General GROVES. After the initial work. I think that if any one moved into this who had not already been in it, I would advise him to spend at least 3 months just finding out what he could; that would mean three solid months of very strenuous effort. Then I think, depending on his background, he would move in and then spend much less time.

I think if you should have somebody on it like Dr. Bush, for example, he would not have to do anything of that kind. He could start right in on a part-time basis except for the drafting of the initial regulations on security, which I picture would take quite a time.

Senator HICKENLOOPER. I assume that what you mean by the fact that it would not take too much time for the Commission, or that it would take full time, means that the Commission would write policies and the administrator and his staff would then carry out the details of the administrative activities and the issuance of licenses, the checking, and all that?

General GROVES. As I see it, the administrator would take care of the administrative details. Now, we contemplate that his administrative duties will divide really into two classes: those of operating the existing organization as it may be reduced, and those of handling the outside contacts. For example if a university wishes to go into research work and wants to get a certain amount of enriched material, which of course has a high value, he would in that department of his activities make the necessary investigation to get all the papers together, and then he would present to the Commission the story of that university: "They can meet our policy requirements on security; they meet our policy requirements on really putting some effort into this thing; they are not just getting it so they can stay in the swim and say, 'Oh, yes; we have a department in nuclear physics.' "

In other words, he would present to them the story either with the statement that it meets all of their policy requirements or meets all the policy requirements with a few exceptions, and these exceptions are such and such, and I think they can be handled in such a way.

Then the Commission would have to decide it. They would also, perhaps, have to actually have appear before them the representatives of any such institution if they were going to decline.

Senator HICKENLOOPER. Would that view be compatible with freedom of scientific research? In other words, is it your view that the Commission should screen applicants, let us say, colleges or universities rather carefully, and have some rather rigid standards before they would be permitted to go into this field by the Commission?

General GROVES. Before the Commission gives them Government material, I think they should meet requirements that will insure the best interests of the United States.

Senator HICKENLOOPER. In your view, should those requirements go beyond just a rough outline of a reliable institution, that is, from the standpoint of reputation and history, a reasonable showing that they seriously want to investigate this field, and a reasonable assurance or reliance that they would maintain adequate security and not use it for subversive or destructive purposes?

General GROVES. That would be my idea.

Senator HICKENLOOPER. And then give them more or less free leeway where if they want to go into the field of atomic research as an original study, or if they want to enlarge or want to experiment in that field, they may do so.

General GROVES. You see, the only problem that comes up that is going to be very difficult—and I am sorry for the administrator if he has to decide it—is what to do with the enriched material that the Commission may decide—as a certain percentage—may be loaned to educational institutions for research work. There won't be enough to go around, and somebody has got to decide which institution gets how much. It isn't enough to say, "We will divide it," because they have to have a certain amount.

Senator HICKENLOOPER. Well, to illustrate a little bit more clearly, perhaps, my thought in this matter, I have in mind a very small college that has not been very well financed. It has been struggling for a number of years, and yet in that situation one man in that college some years ago went into a highly specialized field and today this little poverty-stricken college probably has the most extensive department of that particular kind, small as it may be, in the United

States. It is an extremely valuable department—and of course this department does not compare with nuclear energy, or anything of that sort, but it is an outstanding department.

If regulations were somewhat restrictive, it would be very easy for me to envision some commission saying to this college, "Oh, you are a little one-horse college; you have no finances; your equipment isn't very good; we will deny you the right to go into this field."

Now, it is entirely possible that many small institutions perfectly reliable in their history and their intentions might under too restrictive a policy be barred from investigating this field and thereby impinge upon the freedom of academic research.

General GROVES. I don't think there should be any restriction on any academic research unless such restriction is essential to the national defense or unless such research demands or requires Government support.

If it requires Government support, I think it is the duty of the Commission to decide that the Government is getting the best return on its money. If it is a case of something impinging on national defense, I think that would come about by a sudden discovery and nobody can tell what that might be; for example, what we all feared in the early days, that Germany might have a "bathtub" method of separating U-235. The more we studied it, the more we learned about it, the more we felt that the bathtub would get pretty complicated; and we now believe, I think most people, since we have investigated a great many of those "bathtub" methods and they are always disappointing, they are fine in theory but when you start to work them you do all the separation and when you get through you cannot tell that you have separated anything. We haven't been able to find a method yet, but that is a thing that might happen.

For example, if someone should achieve the thing that people have dreamed of since this started, of getting atomic energy out of a common element, I think if that came up and it was discovered in a small college or in any college, the Commission should immediately be able to control that situation until somebody else moved in and could control it.

In other words, I don't believe that if we make some startling discovery in a college laboratory that that should necessarily be published if it is going to upset our national defense as completely as any such discovery as I have described will do. I don't think they will discover that in my lifetime, and I am not worried about it; but at the same time, it is perfectly possible. After all, lots of things have been discovered in our lifetime that we did not know about when we first started to walk on the ground.

Senator HICKENLOOPER. I think it is perfectly logical to say that the Commission should keep very close supervisory knowledge and control over the results of research to see that those results of research are not used to the point of endangering our national safety.

I think that could be done without destroying the freedom of basic research.

General GROVES. I think it can be done that way.

Now, for example, you are familiar with our laboratory at the Argonne. You have been told about it, and there we are now trying, and have actually drawn up, proposed regulations and a system of establishment which will put that laboratory on a basis where it will practically have free and open research. The only requirement that we hope to have in there is that if at any time we decide that certain work going on there should be secret, we have the right then to ask the man to continue on a secret basis or to abandon the work and turn it over to us. That probably will be the only limitation on the use of that Argonne laboratory by the colleges and universities not only of the Middle West, but for the time being of the entire United States.

Senator HICKENLOOPER. In other words, the restrictions would apply to the application of the results of research rather than restrictions on basic research itself?

General GROVES. Yes; and that is not hard to do if you have cooperation and general good feeling among all concerned, and we have had that with the laboratories, despite what you read in the papers, right straight through this project.

We don't know all of the people that work for us. After all, our direct pay roll ran to a total of 539,000 people, and obviously I didn't know them all. But the leaders were known, and the relationships, at least as far as I was concerned, were entirely satisfactory and quite happy.

The CHAIRMAN. Wasn't that your indirect pay roll, General? Wasn't your direct pay roll around 200,000?

General GROVES. That was the pay roll of people who worked directly for us, either on our own pay roll or on fixed-fee contracts. It did not include such things as manufacturers who made parts for us on a unit-price basis.

Senator MILLIKIN. General, if this were an energy that were a purely military energy we would have no problem here at all, would we?

General GROVES. No, sir.

Senator MILLIKIN. So we have two things that we have to watch in this bill: One is to encourage science as far as consistent with military security—abstract science and applied science; and the other is to encourage so far as we can, consistent with military security, the commercial and peacetime uses of this energy. Both of those things are subordinated at this present state of affairs to our military security. Is that not correct?

General GROVES. That is correct.

Senator MILLIKIN. And any bill which correctly protects and properly proportions its emphasis according to those things would, generally speaking, be a satisfactory bill, would it not?

General GROVES. Entirely. I would like to add there that I personally believe that we are going to get some peacetime benefits from atomic energy. How much, I don't know, and no one else knows. We are certain that there are going to be many benefits in the medical field, particularly in diagnosis; and as to the benefits from a power standpoint, we really don't know, and no one else knows. We can draw up theories; we can prove it on paper, and you can get any answer you want to. But the problems involved are tremendous and it is going to be, unless a tremendous amount of money is poured into it, a long time before that development reaches anything that becomes commercial.

Senator MILLIKIN. But we should put out as much scientific information as is possible, consistent with military security. We should do everything that we can to encourage these peacetime uses of the energy, consistent with military security. The overriding predominant thing at the present stage of the business is our military security.

General GROVES. Yes, sir.

Now, another point is: Why has the Manhattan project done certain work on what you might say are peacetime applications? We have done that for two reasons: First, because in doing it we felt that we would be increasing our knowledge which would enable us to do a better job on the military end of it. That was the real justification. We have also had the secondary consideration that we felt that we were carrying on what would eventually have to be done, and it might turn into something of value for peacetime uses; but certainly with the appropriations as they were made for military purposes, the only justification we would have in the past in our appropriations was to carry it on for the military advantages.

The work that has been done in peacetime applications has all been done with the idea that that increase in knowledge would enable us to do the military job better.

Senator HICKENLOOPER. On that point, as I see it now, General, is there any possible reason why basic research in the atomic energy field should demand that it be given strictly military secrets of the making of the bomb in order to aid that research?

General GROVES. No; and I think that except in one way the more that a scientist knows in his own field and related fields, the better job he can do. But I think in this case the military security overrides that, so that we are in effect decreasing, perhaps, in some instances, his ability to do his best work in his scientific research, because there are certain things he doesn't know that if he did know he would be able to do better. It is just as if suddenly the things that we did might be of value—I am not saying they are—for example to the steel manufacturers; but if they are vital to our military security, the manufacturers have to get along without them or have to find it some other way.

The CHAIRMAN. General, one of the greatest achievements for military security would be the devising of an invention of defense for the atomic bomb.

Now, you have just stated in effect that the compartmentalization of it, due to the necessity for military security, would decrease scientific achievement and advancement. I rather take it that any such proposal would commensurately and proportionately decrease the chances of devising a defense to the atomic bomb.

General GROVES. I don't think so, except very indirectly. It is hard to speak of how to devise something that nobody has yet figured out even the slightest indication of how to do, but the only thing that appeals to anyone is to shoot this thing down in the air, and that means stopping anything that comes through the air. That really does not depend on what is in it or anything about it.

The CHAIRMAN. Yes; but logically, General, it strikes me that you cannot escape the conclusion that since unfortunate restrictions that might have to be placed on this thing for military security might obviate any chance of getting the greatest security of all, which would be a defense for it. You say to me that none has been thought of and none has been suggested. I grant you that is true, and up until 1939 nobody thought this thing could be done.

I cannot see how you can escape the conclusion that the restrictiveness applied under what you term the necessities of military security would very much prejudice our chances, small though they might be, for getting a defense.

General GROVES. I couldn't agree to very much prejudice. I would say they might possibly prejudice, but not very much.

The CHAIRMAN. It is a very important consideration.

General GROVES. Now, I think that really when it comes to military security and the relative advantages of giving out information and not giving it out, what we are interested in from the military standpoint is the relative movement, you might say, of ourselves and other nations. It isn't so much how fast we progress; it is the relative motion of the two.

The CHAIRMAN. General, I have just two questions more, if there are no further questions. I don't want to interrupt.

The first question is this, General: Would you tell us what year you graduated from West Point?

General GROVES. 1918, November.

The CHAIRMAN. And you were commissioned a second lieutenant.

General GROVES. That is correct.

The CHAIRMAN. When were you commissioned a first lieutenant?

General GROVES. May 1, I think, 1919.

The CHAIRMAN. And then a captain?

General GROVES. October 1, 1934.

The CHAIRMAN. And then a major?

General GROVES. I think in July of 1940.

The CHAIRMAN. And then a lieutenant colonel?

General GROVES. I was commissioned a temporary colonel on November 12, I think, of 1940.

The CHAIRMAN. And then your next promotion?

General GROVES. Then I was made a brigadier in September of 1942, and sometime after that I was made a permanent lieutenant colonel.

The CHAIRMAN. And that is your rank now?

General GROVES. Permanent rank. Then I was made a temporary major general in 1944, I think.

The CHAIRMAN. Now, General, between 1919 and 1934, just selecting at random when you were a first lieutenant, what was your principal work?

General GROVES. My principal work from then, besides going to school—I have been going to school since I entered college for 10 years. I have one degree. I don't have any of these doctor's degrees, but I have had 10 years of collegiate and above. During that time I was either a student or a company commander, with the exception of 2 years when I was assistant to the district engineer at Galveston primarily on construction work and general management, and 2 years in Nicaragua.

The CHAIRMAN. Your first experience translating engineering into science has been in connection with this project, has it not?

General GROVES. No; I had 4 years in the Office of Chief of Enneers, a little less than 4 years, from 1931 to 1935.

The CHAIRMAN. What was your rank then?

General GROVES. I was a first lieutenant and a captain. Of course, you know the reasons for rank.

The CHAIRMAN. I don't quarrel with it, General.

General GROVES. I did, a great deal.

The CHAIRMAN. I think it is important that it be in the record.

Now, just one final question.

Senator MILLIKIN. The chairman has demonstrated how fast you learn, General.

General GROVES. I didn't answer your question completely. From 1931 to 1935 I was in the Chief of Engineers Office in charge first of procurement and development of new equipment, and in the last year in charge of the supply division, which included this subbranch of development of equipment.

Senator JOHNSON. I think it should be said, Mr. Chairman, in connection with the promotions that in the first years of the general's service we did not have the automatic-promotion formula that we now have, and that officers had to wait for a vacancy in the next grade, and that there were bottlenecks. They had what the Army calls a "hump," and so the promotions were very far and few between in those earlier years.

The CHAIRMAN. General, you are familiar with the letter addressed to me by the President of the United States on February 1, 1946, in relation to the atomic energy legislation?

General GROVES. I have read it. I don't recall the exact details of it.

The CHAIRMAN. The President stated:

> The Commission established by the Congress for the control of atomic energy should be composed exclusively of civilians.

You find yourself in disagreement with that.

> It is essential that the members of the Commission be full-time Government employees.

You find yourself in disagreement with that.

In the President's message of October 3, which he quotes, he said:

> Our science and industry owe their extent to the spirit of free inquiry and the spirit of free enterprise that characterizes our country. This is our best guaranty of maintaining preeminence in science and industry upon which our national well-being depends.
>
> Legislation in this field must assure genuine freedom to conduct independent research and must guarantee that controls over the dissemination of information will not stifle scientific progress.

I take it you are in agreement with that statement?

General GROVES. Yes, sir.

The CHAIRMAN. Thank you very much.

Senator HICKENLOOPER. General, I just want to make clear my understanding that you did not volunteer or urge this appearance on your part today, did you?

General GROVES. No, sir.

Senator HICKENLOOPER. You came at the specific invitation of the committee to express your personal views and at the urging of the committee, did you not?

General GROVES. Not only at the invitation of the committee, but at the order of the committee.

The CHAIRMAN. I think that should be in the record, Senator Hickenlooper, for the General's protection.

Senator HICKENLOOPER. I thought it was going to be in the other day, but it apparently isn't.

The CHAIRMAN. Thank you.

(Thereupon, at 12:10 p. m. the committee recessed.)

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