CIVIL DEFENSE AGAINST ATOMIC ATTACK

HEARING

BEFORE THE

JOINT COMMITTEE ON ATOMIC ENERGY
CONGRESS OF THE UNITED STATES

IN EXECUTIVE SESSION

EIGHTY-FIRST CONGRESS

SECOND SESSION

ON

CIVIL DEFENSE AGAINST ATOMIC ATTACK

PART 1

MARCH 23, 1950

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CIVIL DEFENSE AGAINST ATOMIC ATTACK

THURSDAY, MARCH 23, 1950

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The joint committee met in executive session, pursuant to notice, at 10:30 a. m., in room G-48, Capitol Building, Washington, D. C., Senator Brien McMahon (chairman) presiding.

(The following statements were presented to the Joint Committee on Atomic Energy. They have been edited so as to exclude all classified information.)

STATEMENT OF PAUL J. LARSEN, DIRECTOR, OFFICE OF CIVILIAN MOBILIZATION, NATIONAL SECURITY RESOURCES BOARD

Mr. LARSEN. With your permission, I should like to open this testimony with a discussion of the broad aspects of civil defense before having members of our staff describe the civil defense planning activities of the Federal Government and, in particular, of the National Security Resources Board.

WHAT IS CIVIL DEFENSE?

Civil defense may be defined briefly as the defense of the home front by civilians and civil authority in time of war. It is largely, but not wholly, passive defense. It consists of measures (1) for assisting the military forces in averting an enemy attack, (2) for minimizing the effects of such enemy attacks as may be successful, and (3) for alleviating, controlling, and repairing the damages created by enemy attack. Thus, it seeks to preserve maximum civilian support of the war effort.

Brief definitions such as the foregoing are, however, subject to misinterpretation. For better understanding of the term "civil defense," it is essential to examine in more detail the measures to be employed by civilians and civil authority in their defense of the home front. By so doing, a better appreciation can be had of the importance of civil defense in the total mobilization picture.

For planning purposes, we have divided the necessary civil defense measures into four groups:

(1) Measures to avert an enemy attack such as camouflage, black-outs, aircraft observer systems, and similar quasi-military activities in which civilians may be called upon to assist.

(2) Advance measures for minimizing the effects of an enemy attack, including such measures as civil air raid warning, the dispersion or relocation of facilities, and the prior evacuation of children and personnel not essential to the war effort.

(3) Measures to alleviate, control, and repair the damages resulting from enemy attack, ranging from medical and health services, decontamination, and fire fighting to the removal of debris and salvage.

(4) And, in connection with the foregoing measures, a group of over-all measures which we term "general considerations," such research and development, legislation, organization, training, policy guidance, military support, and civil defense requirements.

Members of our staff will describe in greater detail the many aspects of civil defense planning.

THE RELATIONSHIP OF CIVIL DEFENSE TO MOBILIZATION PLANNING

As you know, under the National Security Act of 1947, the National Security Resources Board is responsible for advising the President on the coordination of military, industrial, and civilian mobilization. Civil defense planning was expressly made a responsibility of the Board by Presidential directive on March 3, 1949.

There is a close relationship between planning for civil defense and planning for other forms of mobilization. The protection of our citizens, our homes, and our cities against enemy attack and against the effects of enemy attack is the very essence of national defense and, therefore, plans for the mobilization of our resources must include planning for civil defense as well as for more traditional military needs.

Let me give you one example of how civil defense fits into our other mobilization planning work. Before realistic mobilization planning can be accomplished it is necessary to make at least a rough inventory of the Nation's resources available in wartime and to compare this inventory against the anticipated needs. The responsibility for this type of operation is placed on the NSRB by section 103 (c) (4) of the National Security Act. The needs of any civil defense programs must, of course, be determined in any such balance-sheet operation. Members of my staff will describe in more detail how civil defense planning is geared to the Board's other mobilization planning work.

WHAT SHOULD BE THE MAGNITUDE OF OUR CIVIL DEFENSE EFFORT?

One hundred percent security obviously is not possible. Nor is an attempt to achieve absolute security desirable under present conditions, unless we are willing to become a garrison state. If too much of our national effort is expended for military and civil defense purposes, the very liberties we are trying to make secure will themselves be endangered. Take, for example, the question of the security of urban populations from the atomic bomb: From the security point of view alone, the solution would appear to be compulsory dispersion. But what would this mean to our economy and to our democracy?

The dollars and cents cost of decentralizing the some 200 cities in the United States having populations of more than 50,000 would probably be in the neighborhood of $300,000,000,000. The social and political costs of such decentralization might put an end to democracy as we know it. To accomplish such a program of compulsory dispersion we would have to be willing to become a garrison state.

The determination of the civil defense measures which can and should be taken now necessarily involves reconciling the needs of civil defense with other national objectives and programs which are also fundamental to our national security. It would be imprudent if the Federal Government were to fail to take those steps necessary to a sound civil defense program; but it would be just as imprudent if we were to allot too great a part of our security budget to civil defense measures at the expense of our first line of defense, the armed forces.

At the present time, the need is for intelligent basic planning upon which operating civil defense programs at the Federal, State, and local levels can be built. Premature action, based on ill-considered plans, could prejudice the effectiveness of our civil defense in time of enemy attack.

There is one question which I am sure must be in your minds: What would we do if bombs should fall tomorrow? Would we be ready?

To be frank, the answer is that we would not be ready tomorrow—not as ready as we will be a year from now, but more nearly ready than a year ago. Should one of our cities be attacked, it would have to rely primarily on existing services: in the first instance, on its own fire-fighting and police forces and on its own medical resources, then on available military forces. Existing Federal agencies would offer technical assistance: the Public Health Service, which has played an important part in developing plans for the health and medical aspects of civil defense, could assist local authorities in such matters as organizing first-aid stations and emergency hospitals, treating radiation burns and sickness, and administering blood collection and transfusion programs; the Bureau of Animal Industry could inspect the available meat supply and take action against animal disease; and the Children's Bureau could assist in handling the problems of homeless children. The American Red Cross would, of course, play an important role in emergency mass care.

Being ready is necessarily a relative matter. Frankly, I wonder whether we would want to be in a state of absolute readiness. Do we want our women and children evacuated from our cities. Can our cities stand the cost of moving their hospitals and fire stations to outlying areas? We believe that at the present time the soundest approach is to stimulate State and community planning of how they would handle such problems as evacuation and of how one community could call on another for aid. Resource studies should be made so that the needs for fire-fighting equipment, hospitals, and reserve supplies of water can be determined. These are among the steps we have already recommended to the States to increase their preparedness.

Wartime civil disasters would differ from peacetime disasters more in magnitude than in kind. Accordingly, we feel that the development of effective programs for Federal, State, and local cooperation in dealing with peacetime disasters is an important step toward achieving adequate civil defense. As you know—in fact I believe that Senator Johnson of this committee is one of its sponsors—a disaster relief bill, S. 2415, has been introduced in the Senate and is now pending in the Committee on Public Works. A similar bill, S. 2831, passed the Senate in 1948. This bill would encourage Federal, State, and local cooperation by authorizing the use of Federal services and supplies, as well as funds, in alleviating disasters. The passage of this administration measure would be of considerable assistance to the civil defense program.

RESPONSIBILITY FOR CIVIL DEFENSE PLANNING

Civil defense is a national task which must be shared by all levels of government—Federal, State, and local. The Federal Government has the important obligation of developing and furnishing to the States and local governments the information, advice, and guidance which they need to develop sound plans for their own communities.

The detailed planning for specific communities must be done by local governments. Civil defense must be based on self-help. Effective community action in time of dissater requires the development, in peacetime, of a sense of community responsibility for self-preservation. When a disaster strikes, immediate action may prevent complete calamity.

The main effort, therefore, must come from the individul citizen and the community group, with needed help coming from county, State, and Federal agencies as time allows. For this reason, among others, the preparation of detailed disaster plans, geared to the State's plan, should be the primary responsibility of the community. The Federal Government, of course, has the important responsibility, not only for furnishing guidance to States and communitites for the development of their plans but also for being ready to render aid to States and communities in time of actual or impending enemy attack.

Prior to the President's letter of March 3, 1949, the responsibility for civil defense planning had been lodged in the Department of Defense. The Secretary of Defense had established an Office of Civil Defense Planning which issued the Hopley report. The development, operation, and subsequent dissolution of that office in August 1949 will, it is assumed, be covered in the presentation of the Department of Defense.

On the question of civilian versus military control, let me say that civil defense is a responsibility which must be assumed by civilian government, not by the armed forces. In time of war the armed forces must concentrate on their primary mission of repelling attack and carrying war to the enemy. Certain quasi-military measures included in our broad definition of civilian defense are properly the responsibility of the military, even though they may involve civilian participation—measures such as black-outs, radio-beam controls, and aircraft-observer systems. But fire fighting, evacuation, care of casualties, and the like are essentially civilian in nature. They will require a great amount of local manpower. Since civilians must perform such functions, they should be responsible, at all levels of government, for planning them.

Leadership of civil defense planning has been assigned, as you know, to the National Security Resources Board. The fields of civilian participation in active defense and of passive defense measures required by military necessity have been assigned to the Department of Defense. Primary responsibility for planning the protective measures required before attack and measures to alleviate and control damage after attack, has been assigned to the General Services Administration. I believe the committee is familiar with the valuable and important work which the Atomic Energy Commission is doing in the fields of information and training as well as in developing instruments for radiation detection.

I am going to ask Mr. Gill, who has been serving temporarily as Coordinator of Civil Defense for the NSRB staff, to describe to you in more detail the vast scope of civil defense planning, its relation to other mobilization planning, and what progress we have made in our planning.

STATEMENT OF WILLIAM A. GILL, COORDINATOR OF CIVIL DEFENSE PLANNING, NATIONAL SECURITY RESOURCES BOARD

Mr. Gill. By March 1949 the National Security Resources Board had undertaken numerous mobilization planning projects which were basic to civil defense planning. Pertinent examples were: (*a*) Manpower studies, including rosters of physicians, nurses, sanitary engineers, dentists, et cetera; (*b*) studies of strategic relocation, including industrial dispersion; (*c*) resource studies on water, power, housing, transportation, and communication facilities; (*d*) inventories of health and medical supplies, facilities, and equipment—all important and basic to realistic planning for a civil defense program adequate for the Nation's needs.

In its broad mobilization planning activities, the National Security Resources Board was using the facilities and resources of virtually all agencies of government. When, at the request of the President, the National Security Resources Board assumed leadership of civil defense planning in March of 1949, it was recognized that this responsibility could be carried out more effectively by utilizing the information, technical competence, and channels of communication then existing in other agencies.

A number of these agencies—notably the Public Health Service, the Children's Bureau, the Bureau of Animal Industry, the Food and Drug Administration, the Atomic Energy Commission, and the Department of Defense—had been, and are by nature of their normal functions, engaged in planning, training, and in day-by-day operations which are related to civil defense. However, relationships with State and local governments, with respect to over-all civil-defense planning, were conducted, as of March 1949, almost exclusively by the Department of Defense, although certain of the agencies mentioned above, such as the Public Health Service, had extensive contacts with the States on subjects of importance to civil defense.

The first step taken by the NSRB on assuming responsibility for civil defense planning was to make a study of current civil defense activities and to propose a planning program for the future. In early May, the NSRB staff prepared a Report on Civil Defense Planning, NSRB Document 112. After conferring with the President, the Chairman of the NSRB (*a*) approved the report in principle, (*b*) requested several agencies of government to undertake planning responsibilities as recommended in the report, (*c*) invited all agencies with a major interest in civil defense planning to comment on the report, and (*d*) initiated interagency staff discussions on further program development and clarification.

The realinement of civil defense planning responsibilities, in conformance with the President's directive and NSRB policies, brought to the forefront the need for a great deal of clarification and crystallization of thinking on (*a*) the scope and substance of a civil defense program, (*b*) logical responsibilities for planning the various aspects of a program so broad and so complex, (*c*) relationships between civil defense and other closely allied programs such as internal security, (*d*) basic Federal objectives, and (*e*) policy decisions on relationships with State and local governments.

Staff discussions between interested agencies were begun in June, are still being held, and will continue. In spite of the magnitude of the problem, it has been possible to determine basic objectives, to clarify and agree on program scope and responsibilities to an extent permitting agency planning work to proceed at a rapid pace, and to reach necessary policy decisions on Federal-State-local relationships.

In the Department of Defense, the General Services Administration, the Public Health Service, and the NSRB, launching the program required the establishment of small civil defense staffs. Elsewhere in those agencies and in the many other agencies of Government which are participating in civil defense planning, current activities have been or will be extended or expanded to accommodate the additional responsibilities.

Launching the program meant the development of work projects of manageable proportions. A considerable number of such projects has been assigned by the participating agencies to their own staffs or to interagency working groups or committees. Civil defense activities of the Atomic Energy Commission, the Department of Defense, and the General Services Administration have been described by representatives of those agencies. I should like to tell you briefly of our relationships with State and local government, the status of their civil defense planning, our relations with nongovernmental groups and with Canada, and our accomplishments in the field of security location.

RELATIONSHIPS WITH STATE AND LOCAL GOVERNMENTS

On October 5, 1949, the Acting Chairman of the NSRB sent to the Governors of the States and Territories a statement, NSRB Document 121, setting forth policies for relationships with State and local governments. The States were encouraged to establish civil defense planning organizations and were requested to initiate plans for transmission of appropriate information to political subdivisions. I should like to offer this document as an exhibit. (See NSRB Doc. 121 in appendix.)

Civil defense information and recommendations are being sent to the States, and to local governments, through a series of civil defense advisory bulletins. The first of these bulletins, NSRB Document 121/1 (see appendix) which you may wish to include as an exhibit, outlined Federal Government objectives in civil defense planning, contained information on Federal agency planning activities, and advised State and local civil defense planning groups as to specific tudies which they should undertake now. Information was requested on specific questions relating to State civil defense planning organization or activity.

Succeeding bulletins—NSRB Documents 121/2 and 121/3 (see appendix)—contained information prepared by the Atomic Energy Commission on the medical aspects of atomic explosion and on damage from atomic explosion and the design of protective structures. In one of these bulletins, the States were invited to designate participants in teacher-training courses in radiological monitoring and in the medical aspects of atomic warfare.

Attention has been directed to civil defense planning in 40 States and Territories. The considerable volume of correspondence with State civil defense agencies, local government officials, associations in the field of government, and interested individuals is increasing. Direct contacts with State and local officials responsible for the direction and conduct of their civil defense planning are being emphasized.

Of the Federal agencies to which planning responsibilities have been delegated, some have established in their normal current operating procedures certain direct relationships with the States. Examples include the Department of Defense and the General Services Administration, the Public Health Service in the Federal Security Agency, and the Bureau of Public Roads in the Department of Commerce. These agencies, with the cooperation of the State civil defense planning agencies, can employ existing relationships in carrying out defense planning activities.

CURRENT CIVIL DEFENSE PLANNING ACTIVITY IN STATES

Civil defense or disaster preparedness laws are in effect in 17 states and the territories of Hawaii and the Virgin Islands. States include California, Indiana, Maine, Maryland, Montana, Nebraska, New Hampshire, New Jersey, Ohio, Oregon, South Dakota, Vermont, Florida, Idaho, Michigan, Nevada, and Rhode Island. World War II legislation continues in effect in 5 States: Florida, Idaho, Michigan, Nevada, and Rhode Island.

Disaster preparedness plans prepared by executive direction exist in a few other States: for example, Illinois. Civilian civil defense directors have been appointed in 16 States: Alabama, California, Connecticut, Delaware, Indiana, Maine, Maryland, Michigan, Mississippi, Nevada, New Jersey, Texas, Vermont, Virginia, Washington, and Oregon.

The State adjutant general is charged with the responsibility for direction of civil defense in 25 States: Arizona, Arkansas, Colorado, Georgia, Illinois, Iowa, Kentucky, Louisiana, Massachusetts, Minnesota, Montana, Nebraska, New Hampshire, New Mexico, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, West Virginia, Wisconsin, and Wyoming.

RELATIONSHIPS WITH NONGOVERNMENTAL GROUPS

Firm contacts in the field of State and local government have been made with many nongovernmental groups and associations having Nation-wide membership of individual officials or employees, and comprised either of policy-determining officials or of persons representing functional activities of government, for the purpose of securing from them current statistical data and other information and keeping them informed on the defense planning of the Federal Government. NSRB staff representation has been provided at some of the annual conferences of such groups as the International Association of Police Chiefs and the International Association of Fire Chiefs.

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I should also like to mention our cooperation with Canada in civil defense planning. In the belief that this continent might be attacked in the event of a future war, and recognizing the importance of coordinating our civil defense plans with those of our continental neighbors, a meeting has been held here between the Coordinators of Civil Defense of Canada and the United States. That meeting resulted in complete agreement on the necessity for coordination of civil defense planning of the two countries, particularly with respect to air raid warning systems, equipment standards, and similar matters. Meetings between United States and Canadian civil defense authorities will be held frequently in the future.

The experience of Great Britain in civil defense planning and operations has been of great value to us. Civil defense planning was started in England in the middle 1920's, and the program developed there was proved under war conditions. We have sent a representative of the Board, Mr. Eric Biddle, to England to study its present civil defense activities. He returned recently and will be glad to answer any questions that you may have on the present British program and on their World War II civil defense experience. Arrangements are being made to send several of our civil defense planning personnel to the civil defense staff schools which have been recently inaugurated in England.

SECURITY LOCATION

One of the specific statutory responsibilities of NSRB is that of advising the President regarding "the strategic relocation of industries, services, government, and economic activities, the continuous operation of which is essential to the Nation's security."

Basic to all security location planning is the premise that any relocation of facilities must be economically feasible and consistent with our over-all policy of promoting a vigorous and expanding national economy. Planning in this area is necessarily of a long-range nature and we have felt that our best first step was to influence the location of new construction.

Accordingly, in September 1948 a study was published outlining the major security factors involved in industrial location. This study was given wide distribution with a view to encouraging managements to locate their new plants in accordance with sound security principles. A second and more comprehensive study is in process of preparation.

APPENDIX

NSRB Doc. 121
October 5, 1949

EXECUTIVE OFFICE OF THE PRESIDENT

NATIONAL SECURITY RESOURCES BOARD

BOARD SECRETARIAT

Subject.—Civil defense planning: Policies for relationships with State and local governments.

Contents.—Letter dated October 5, 1949, from the Acting Chairman, NSRB, to the Governors of the States and Territories.

A ten-point statement of policies for relationships with State and local governments in civil defense planning.

Comments.—The attached material was mailed to the Governors on October 5, following preliminary discussion with representatives of national associations representing State and local government interests.

This material was submitted to the members of the Board September 15, 1949, by the Acting Chairman, NSRB, and memoranda of approval are on file in the Board Secretariat, received from the members of the Board as follows:

Agriculture: September 19, 1949.
State: September 22, 1949.
Defense: September 22, 1949.
Interior: September 22, 1949.
Treasury: September 26, 1949.
Commerce: September 27, 1949.
Labor: September 30, 1949.

EXECUTIVE OFFICE OF THE PRESIDENT,
NATIONAL SECURITY RESOURCES BOARD,
OFFICE OF THE CHAIRMAN,
Washington, D. C.

MY DEAR GOVERNOR: A number of agencies of the Federal Government are engaged in the various aspects of planning for civil defense in the event of a national emergency. Many of the States are likewise engaged and some have passed, or are considering, legislation which establishes a State civil defense organization and directs local governments to do likewise.

As you may know, the President has directed the National Security Resources Board to serve as the coordinating body in the Federal Government for civil defense planning. In this connection, a primary objective of the Board is to establish basic policies for relationships between agencies of the Federal Government and the States and their political subdivisions. As an initial step in achieving that objective, NSRB Document 121 has been developed, copy attached, which sets forth the views of the Board as to the manner in which the Federal Government will deal with State and local governments in civil defense matters. In addition, the document reflects the Board's thinking with respect to certain criteria which States may wish to consider while engaged in civil defense planning activities.

To be timely, realistic and useful, plans for minimizing the effects of wartime enemy attack, and for repairing the damages from attack must call for joint participation of local, State, and Federal Governments in their implementation. It follows, therefore, that the development of civil defense plans requires the cooperative efforts of Federal, State, and local governments on a continuing basis.

The goal of the National Security Resources Board is the development of genuine and effective Federal-State-local cooperation to avoid unnecessary waste of manpower, time, and money and at the same time to achieve that degree of preparedness which may be required from time to time for our national security.

Sincerely yours,

JOHN R. STEELMAN.

NSRB Doc. 121

Policies for Relationships With State and Local Governments in Civil Defense Planning

1. The Chairman and staff of the National Security Resources Board will deal directly with State governments, or through State governments with political subdivisions within States.

2. Information or advice released by NSRB will be channeled to States; it is assumed that States will relay the same to their political subdivisions when appropriate.

3. Requests for information or advice received from political subdivisions may be answered directly with copies of the correspondence going to the appropriate State government; however, requests of this nature will be referred to State governments for direct reply as State facilities for processing them are developed.

4. NSRB will look to various agencies of the Federal Government for the development of civil defense plans and preparedness measures. When understandings are reached regarding assignments of this nature, State governments will be notified. Where other Federal agencies are involved in civil defense planning assignments which require the maintenance of channels of communication with States and local governments, they will be guided by the policies outlined in paragraphs 1, 2 and 3 above.

5. NSRB will maintain contact with national organizations in the field of State and local government on civil defense planning matters for the purpose of—

(*a*) Securing from them current statistical data and other types of general information; and

(*b*) Keeping them informed of civil defense activities of the Federal Government.

6. The NSRB will encourage States to adopt civil defense legislation which—

(*a*) Creates a State civil defense planning body;

(*b*) Provides for civil defense planning bodies in its political subdivisions;

(*c*) Charges the State officials and subordinate planning bodies with responsibility for both peacetime and wartime disaster relief planning and preparedness measures.

7. Although the report of the Office of Civil Defense Planning entitled "Civil Defense for National Security," known as the "Hopley Report," has not been officially adopted, and although the NSRB does not agree with all the recommendations made in this report, the NSRB does believe the report to be a useful guide to the substantive areas in which planning must be done for Federal, State, and local civil defense.

8. The Federal Government is not prepared at this time to furnish to State and local governments all of the information and guidance needed by them from Federal sources to prepare well-integrated and timely civil defense plans for State and local use in emergency. While the agencies of the Federal Government are working toward the fulfilment of these needs, the NSRB will encourage State and local governments to proceed as far as practicable with their civil defense planning. In the process of this planning, it would appear advantageous in the immediate future for the State and local governments to place major emphasis on plans for relief from the effects of peacetime disasters. The experience gained in dealing with peacetime disaster, if carefully evaluated, can constitute a realistic frame of reference against which wartime civil disaster planning can be appraised.

9. The NSRB, directly or through other Federal agency channels, will transmit to States—

(*a*) Information on activities in other States.

(*b*) Information on activities of Federal agencies.

(*c*) Policy guidance and planning criteria.

10. The NSRB and other Federal agencies will solicit from States current information as to progress in State and local civil defense planning.

NSRB Doc. 121/1

EXECUTIVE OFFICE OF THE PRESIDENT

NATIONAL SECURITY RESOURCES BOARD

December 1, 1949

CIVIL DEFENSE PLANNING ADVISORY BULLETIN

INTRODUCTION

Through this and succeeding bulletins of this character, the National Security Resources Board plans to carry out the provisions of NSRB Document 121 for transmitting frequently to State governments information and guidance for use in civil defense planning. The bulletins will also be used occasionally for the purpose of soliciting information from States. Reproduction of this and subsequent bulletins by the States is authorized.

Bulletins in this series will not be the sole medium for the transmission of information and advice to State and local civil defense planners. These bulletins will, however, be used to call attention to other useful sources of information.

PART I. FEDERAL OBJECTIVES IN CIVIL DEFENSE PLANNING

Various agencies of the Federal Government, under the leadership of the National Security Resources Board, have been discharging their responsibilities for civil defense planning with certain common objectives in view. It is desirable to restate those objectives for the information of State and local governments. They are as follows:

1. Determining the eventual needs for readiness of communities, States, and the Nation to assist in averting enemy attack, or, if attack should come, to minimize its effects and to repair the damage it creates.
2. To advise with respect to the degree or level of civil defense readiness consistent with a balanced civil defense program.
3. Development of plans for an operating civil defense organization in the Federal Government, these plans to be for use only when such an organization is determined to be needed.
4. Securing the assistance of States and communities in reaching the determinations made under 1, 2, and 3 above.
5. Keeping States and communities informed of the determinations made under 1, 2, and 3 above and of any subsequent revisions therein.
6. Developing guides or standards for use of States and communities in making their own determinations of civil defense objectives and the means for achieving them.
7. Giving constant emphasis to the inherent responsibility of States and communities to develop and later to implement their civil defense plans, with recognition of the Federal Government's obligation to furnish information, guidance, and suggestions to States and communities for the development of civil defense plans and its obligation to be ready to render aid to States and communities in time of actual or impending wartime enemy attack.

Implicit in the foregoing objectives is the principle that civil defense planning, and likewise the operation of a civil defense program in time of need, is a responsibility which must be shared by Federal, State, and local governments. For civil defense plans to be timely, realistic, and useful, they must be developed with this principle continuously in view.

In civil defense planning it seems appropriate to determine first, what must be done to accomplish the objectives; second, what resources of manpower, materials, and equipment are needed and what resources are available; and then, finally, what organization is best suited to place the plans in operation. For the present, as the President has stated, the essential need is peacetime planning in preparation for civil defense in the event of war, rather than the operation of a full-scale civil defense program.

We should like to call your attention to the tendency to conceive of civil defense primarily in terms of atomic disaster. True readiness involves the development of measures to cope with all types of potential enemy attack, including conventional bombing and bacteriological or chemical warfare. This all-inclusive planning is being considered by all the agencies of the Federal Government which have responsibilities in the civil defense planning program.

PART II. INFORMATION ON FEDERAL ACTIVITIES IN CIVIL DEFENSE PLANNING

Among the activities which the Federal Government has undertaken are the following:

1. The Atomic Energy Commission is continuing to collect all available data on the effects of atomic explosions on men, animals, plants, and structures. Through its national laboratories and contracts with universities, research institutions and hospitals, the Commission has been sponsoring studies of the effects of radiation and the care of casualties. Information thus developed is published in technical reports of which more than 400, half of them unclassified, have been issued to date. A selected bibliography of unclassified reports and publications of the Atomic Energy Commission and the Manhattan Engineer District (enclosure No. 1), and a selected bibliography of periodical and book material (enclosure No. 2), both pertaining to civil defense against atom bombing, and both compiled by the Atomic Energy Commission, are attached.

2. For the past 10 months a board of scientists and military officers organized by the Department of Defense and the Atomic Energy Commission has been compiling an authoritative summary of the effects of atomic weapons. In addition, the Atomic Energy Commission is currently preparing unclassified papers of importance to civil defense which will be made available to States as soon as they are published. These papers will include information on the treatment of persons exposed to radiation; on the character of atomic damage to structures and means of minimizing such damage; on the operation and maintenance of monitoring instruments, with standards of tolerance; and on decontamination.

3. The Department of Defense, responsible under the civil defense planning program for those aspects which involve civilian participation in active military defense, recently concluded an exercise known as Operation lookout in 10 northeastern States. This exercise was for the purpose of testing the aircraft-observer organization and facilities designed to supplement the radar-detection system, and for planning, instituting, and testing an air-raid-warning system. Volunteer civilian spotters served in the capacity of observers and assisted in operating filter centers and control centers necessary to the system. The Department of Defense is now contemplating additional exercises in other areas of the country and has solicited the cooperation of State and local governments in conducting these exercises. Under the terms of NSRB Document 121, item 4, you are informed that the expansion of "operation look-out" under this or other designation is a recognized activity under the civil defense planning program and States which have been contacted are urged to cooperate to the fullest extent.

4. The educational aspects of the civil defense planning program are being expanded. This activity embraces training work already under way, expansion, creation of new training programs, and the development or revision of training materials. Information on radiation problems and effects has been given to hundreds of physicians, biologists, and public-health officers in a continuing series of training courses in the medical aspects of atomic energy. These courses are operated by the Atomic Energy Commission in cooperation with universities and the armed forces. Information on training developments will be made available to the States through succeeding bulletins in this series.

5. The National Security Resources Board, the General Services Administration, the Federal Security Agency, the Departments of Agriculture and Defense, and other organizations, working together, are developing criteria as guidance for States and communities in the health and medical aspects of disaster relief. The Health Resources Division of the National Security Resources Board has well under way studies on health manpower (doctors, dentists, nurses, etc.), and on health supplies of all types, which will be extremely useful in considering the requirements for health manpower as well as for health supplies and equipment for the implementation of civil defense plans. These studies are basic to more detailed civil disaster plans and are being developed in cooperation with various governmental health agencies.

6. Specific studies have been undertaken by the National Security Resources Board, the General Services Administration, the Department of Defense, and numerous other Federal agencies covering various aspects of other important civil defense problems. These include studies of problems incident to (*a*) rescue of persons under conditions of wartime disaster, (*b*) evacuation of urban areas both prior to and in situations resulting from enemy attack, (*c*) demolition of

damaged structures which are a hazard to public safety, and (*d*) the use, protection, and restoration of housing and community facilities.

7. The Public Health Service, the Children's Bureau, the Bureau of Animal Industry, and the Food and Drug Administration are by nature of their normal functions continuously engaged in planning and training and in day-by-day operations which contribute to our readiness for civil defense. The Public Health Service not only directly participates in disaster relief, but is in constant contact with the State health departments for the purpose of increasing the health of our civilian population and for improving sanitary conditions throughout the Nation. It also advises and assists in dealing with the effects of disaster. One of the functions of the Food and Drug Administration is to inspect and, if necessary, condemn food in disaster areas. The Bureau of Animal Industry's functions with respect to the prevention and control of animal diseases, including the exclusion from the United States of dangerous infections, and with respect to the inspection of animals and meat, are closely related to civil defense.

Additional activities will be reported as they are undertaken and, as studies are concluded, their results will be made available for use in State and local civil defense planning.

PART III. RECOMMENDATIONS FOR STATE AND LOCAL CIVIL DEFENSE PLANNING GROUPS

Some of the civil defense planning done by State and local planners must await information or guidance on technical matters from the Federal Government. As stated in NSRB Document 121, the agencies of the Federal Government are working constantly toward the fulfillment of those needs. There are, however, various types of planning activities in which State and local planners can engage without the need for information, guidance, or assistance from the Federal Government. Examples of planning activities of this type are listed below in the form of recommendations for State and local civil defense planning groups:

1. At this time only tentative estimates can be made of the materials, manpower, equipment, and supplies needed to operate a civil defense program in States and cities in time of war. Studies of existing and potential resources, however, need not be delayed. It is therefore recommended that State and local governments arrange for studies to be made of existing resources of major importance to civil defense plans, if they have not already done so. Among these are (*a*) water-supply systems, including the consideration of potential reserve supplies; (*b*) means of communication when normal means have been disrupted; (*c*) street and highway systems, including means of alternative routes and their adaptability to evacuation; (*d*) means of transportation, such as bus, truck, automobile, water, trolley cars, and subway; (*e*) means for emergency shelter of evacuated persons; (*f*) hospital and first-aid facilities; (*g*) fire-fighting equipment; and (*h*) manpower resources available in connection with the foregoing.

Resource studies of the type recommended above could include, but not necessarily be limited to, the following considerations:

(*a*) Inventory of existing resources now in use;

(*b*) Inventory of reserve or stand-by resources;

(*c*) Capability of existing and reserve resources to satisfy current and anticipated needs;

(*d*) Availability in emergency of substitute resources;

(*e*) Conservation of existing resources;

(*f*) Stock piling of additional reserves;

(*g*) Availability of plans and blueprints of existing water, gas, and communications systems for use in repairing or restoring facilities disrupted or damaged during enemy attack.

Such resource studies should be utilized to incorporate civil defense considerations into current municipal planning and the planning of civic improvements.

2. Effective planning for civil defense must embrace consideration of the question of mutual aid between communities within a State and between States. Legislation may be required to make mutual aid agreements practicable. It is, therefore, recommended that State and local civil defense planning groups examine the conditions existing and consider the removal of such barriers to intrastate mutual aid agreements and interstate pacts as are found to exist. It would be helpful if State governments would give consideration

to the need for and the provision of interstate mutual aid pacts and convey to the National Security Resources Board their respective views and the results of such interstate conferences as may be held to discuss the subject.

3. The Atomic Energy Commission has prepared a report entitled "The City of Washington and an Atomic Bomb Attack." We attach herewith a copy of the complete report (enclosure No. 3) and suggest that it be brought to the attention of those in State and local governments who are concerned with civil defense planning. Although the report points to the potential effects of an atomic attack on the city of Washington, D. C., certain of its principles apply to any other large city. It is recommended that State and local civil defense planning groups also examine the publication, National Security Factors in Industrial Location, which was published in September 1948 by the National Security Resources Board. A copy of this booklet is attached as enclosure No. 4. Additional copies may be secured from the Superintendent of Documents, United States Government Printing Office, Washington, D. C., at 15 cents each. A second and more comprehensive booklet on the same general subject is now in process of development and should be published and placed in your hands within the next 3 months.

4. Civil defense planning groups at all levels should acquaint themselves with the history of civil defense activities in this and other countries and should study selected writings on potential civil defense problems. To aid civil defense planning groups, there has been prepared a preliminary bibliography of civil defense publications, copy of which is herewith attached as enclosure No. 5. This bibliography will be expanded and revised and through the medium of these bulletins you will be kept advised of changes and additions thereto.

PART IV. INFORMATION SOUGHT FROM THE STATES

It is requested that information on the items listed below be made available to the National Security Resources Board at the early convenience of the States. In the event that some of the questions have been anticipated and answered in your previous correspondence with NSRB, please disregard such questions.

1. What State legislative provisions are now effective relative to civil defense planning, both for State and local governments? Please provide copies of acts.

2. Have civil defense planning responsibilities been assigned under the terms of legislation or by executive action to (*a*) a State council, (*b*) a State department, (*c*) a civilian defense director, or (*d*) to the Adjutant General?

3. Please name the department or individual responsible for civil defense planning, and indicate whether correspondence on civil defense matters between the Federal Government and your State should be directed to the office of the Governor, to the planning agency head, or both.

(Enclosures (5).)

List of enclosures

The following enclosures should be considered as supplements to the information contained in NSRB Document No. 121/1:

1. A Selected Bibliography of Unclassified Reports and Publications of the Atomic Energy Commission and the Manhattan Engineer District.
2. A Selected Bibliography of Periodical and Book Material.
3. The City of Washington and an Atomic Bomb Attack.
4. National Security Factors in Industrial Location.
5. A Preliminary Bibliography of Civil Defense Publications.

NSRB Doc. 121/2

EXECUTIVE OFFICE OF THE PRESIDENT

NATIONAL SECURITY RESOURCES BOARD

January 13, 1950

CIVIL DEFENSE PLANNING ADVISORY BULLETIN

1. Attached herewith is a report entitled "Medical Aspects of Atomic Weapons," which has been prepared for the National Security Resources Board by the Department of Defense and the United States Atomic Energy Commission.

2. As indicated in the report itself, additional reports will soon be made available, dealing with (1) damage caused by the air blast created by an atomic explosion and construction designed to resist these effects, and (2) how contamination can be detected and measured.

3. This and subsequent reports of the same nature are essential to the development of realistic and useful plans and readiness measures for civil defense. Therefore, all State and local agencies or individuals concerned with civil defense planning should have access to them.

4. Reproduction of Medical Aspects of Atomic Weapons by States and communities is authorized. Printed copies can now be ordered, at a nominal price, from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C.

(Enclosure: Medical Aspects of Atomic Weapons.)

NSRB Doc. 121/3

EXECUTIVE OFFICE OF THE PRESIDENT

NATIONAL SECURITY RESOURCES BOARD

February 3, 1950

CIVIL DEFENSE PLANNING ADVISORY BULLETIN

INTRODUCTION

This Civil Defense Planning Advisory Bulletin is the third in a series initiated by the National Security Resources Board for transmitting information and guidance to the States for use in civil-defense planning.

PART I. TRAINING COURSES IN ATOMIC SUBJECTS

In keeping with its policies for furnishing information, advice, and assistance to States and communities in civil-defense planning, and with full recognition of the principle that planning and the development of preparedness measures for civil defense are responsibilities shared by local, State, and Federal Governments, the NSRB has completed arrangements to launch the first two of a group of training courses in civil-defense subjects. Those two courses, mentioned separately in the succeeding paragraphs, are concerned with the techniques for dealing with the effects of atomic attack. They have been developed with the cooperative efforts of the Atomic Energy Commission, Department of Defense, and General Services Administration and are designed for laying the ground work for the development and operation of training programs by States for personnel within States.

Participation by the States in these courses is at the discretion of each State. The Federal Government will bear the expense of conducting the courses described below; however, the travel and subsistence expenses of the State participants in the courses will be borne by the States. It is contemplated that States will bear the expenses involved in their subsequent development and operation of State training programs in civil-defense subjects.

A description of the courses which have been developed for inauguration in the early future, including the criteria for selection of State participants, follows:

1. Radiological monitoring

One important phase of civil defense in the event of atomic attack upon the United States is the subject of radiological defense The crux of such defense is the ability to detect, measure, and interpret the significance of any harmful radiations present in an area after exposure to attack by atomic weapons. Therefore, the need of training personnel to perform the function is an important consideration in any realistic civil-defense planning.

The Atomic Energy Commission, as a participant with the National Security Resources Board and General Services Administration in the Federal Government civil-defense planning, is completing arrangements for training courses in radiological monitoring to be given at Atomic Energy Commission facilities. The purpose of this training is to prepare, through the instruction of a limited number of qualified individuals in the subject of instrumentation and radiological aspects of atomic warfare, a corps of teachers who will return to their institutions and train others who, in courses given locally, will subsequently disseminate this information to local civil defense personnel.

The Atomic Energy Commission courses thus will be essentially teacher training in nature and at a comparatively high academic level. Individuals chosen to represent their respective States in this course should possess a background of experience in modern or nuclear physics or electrical or chemical engineering and have considerable teaching ability.

State governors are invited to nominate at least one person from their respective States for this training. In making nominations, it is suggested that the State university system be utilized to the fullest extent for both advice and selection of individuals for training and for the establishment of the subsequent training courses.

Names of candidates for this training should be submitted to the National Security Resources Board by each State governor not later than March 1, 1950, together with the statement of the education, experience, and present position of each individual. Because of the technical nature of the training to be given, it is believed advisable that the Federal agencies review the individual qualifications.

These monitoring courses will be given at five locations: Brookahaven National Laboratory, Upton, Long Island; Oak Ridge National Laboratory and Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn.; the Illinois Institute of Technology, Chicago, Ill.; Reed College, Portland, Oreg.;, and the University of California, Los Angeles. These courses will start in mid-March or soon thereafter, and will be approximately 5 weeks in duration. Government dormitory housing accommodations will be available at Brookhaven and Oak Ridge at a nominal cost.

Upon receipt of nominations from governors and acceptance of candidates, the NSRB will immediately issue invitations to all individuals selected for the radiological monitoring courses and will advise them of definite starting dates and centers to be attended. Because of the time factor involved, telegraphic invitations will be issued directly to the selected candidates.

2. Medical aspects of atomic warfare

Another important phase of the program for wartime disaster relief planning is the establishment of training courses in the treatment of radiological injuries among civilians. To meet this need the Atomic Energy Commission has planned and is now prepared to offer courses in this subject to a limited number of physicians from each State.

The purpose of these training courses is to provide at the State level a nucleus of trained physician teachers in the medical aspects of atomic warfare. It is assumed that physician teachers will return to their States and train others who will subsequently provide training for doctors, nurses, and dentists and allied professions at the local level.

To assist in selection of candidates and to keep registration within limits of available facilities, a committee composed of representatives of the AEC Division of Biology and Medicine, the NSRB, and the interested universities and laboratories have specified the following sources from which selections should be made, and, criteria for individual qualifications:

A. Source criteria

1. A qualified teacher from each class A, 4-year medical school within the State;
2. A qualified teacher from each osteopathic college within the State approved by the American Osteopathic Association;
3. A qualified physician from the State health department;
4. A qualified physician from the largest professional association of physicians in the State.
5. A qualified physician from each city within the State having a population of 100,000 or more, and which is too far removed (at least 75 miles) from a medical school to be convenient in training the secondary group of teachers.

B. Criteria for individual qualifications

Those nominated for the teacher training courses should meet the following qualifications:

1. Should be a competent, experienced teacher or educator;
2. Should have some background of special knowledge related to atomic energy in order that he can absorb a large amount of material on the medical aspects within the short training period of 1 week;

3. Should be interested in the field of atomic medicine to the extent that he would keep abreast of the advances in this field.
4. Should be willing to assume responsibility for teaching this subject to medical students, physicians, and other health personnel; and to cooperate with the State and community civil defense organizations.

It is suggested that the governors of each State or Territory may wish to appoint a committee to assist in nomination of candidates for these courses. Such a committee might be composed of the deans of class A 4-year medical schools within the State; the president of the State medical society or his designated representative, and the State health commissioner or his designated representative.

The location of the medical training centers and the States from which the candidates for each course will be drawn are indicated below. It is possible that, in some instances, not all candidates can be accommodated at the nearest AEC facility and that some of them may have to obtain training at one of the AEC facilities other than as indicated.

AEC Laboratory, University of Rochester, N. Y.: Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont.

Johns Hopkins University School of Medicine, Baltimore, Md.: Delaware, District of Columbia, Maryland, New Jersey, North Carolina, Pennsylvania, South Carolina, Virginia, Puerto Rico.

Western Reserve University School of Medicine, Cleveland, Ohio: Indiana, Kentucky, Michigan, Ohio, West Virginia.

University of Alabama School of Medicine, Birmingham Ala.: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Tennessee.

Argonne National Laboratory, Chicago, Ill.: Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Wisconsin.

University of Utah School of Medicine, Salt Lake City: Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming.

AEC project, University of California (Los Angeles): Arizona, California, New Mexico, Oklahoma, Texas, Hawaii, Alaska.

The training courses at all centers will last one week. Those at the University of Rochester and Johns Hopkins Medical School will begin on March 27, 1950, and those at Western Reserve University Medical School on April 3, 1950. Definite starting dates for the other four centers will be determined and communicated to State governors within the next 10 days. Candidates for this training should be submitted to NSRB by each governor not later than March 6, 1950, together with the statement of the education, experience, and present position of each individual. As in the case of the monitoring courses, it is believed advisable that the Federal agencies review the individual qualifications, because of the technical nature of the training to be given. Upon receipt of nominations from governors and acceptance of candidates, the NSRB will immediately issue invitations to individuals selected from the medical training courses and furnish them any additional necessary information. Because of the time factors involved, telegraphic invitations will be issued directly to the selected candidates.

PART II. ATOMIC WARFARE DEFENSE REPORTS

The second report in a series prepared for the National Security Resources Board by the Department of Defense and the United States Atomic Energy Commission, dealing with the effects of atomic explosion, is titled "Damage from Atomic Explosion and Design of Protective Structures." A mimeographed copy is enclosed.

Printed copies of this report will be sent soon to State civil defense agencies in numbers sufficient to meet their immediate needs for distribution to key State and local civil defense planning personnel. Additional printed copies may be secured from the Superintendent of Documents, United States Government Printing Office, Washington, D. C., at 10 cents each, with a discount of 25 percent on quantities of 100 or more.

The first report in this series, entitled "Medical Aspects of Atomic Weapons," which was forwarded to States on December 2, 1949, as an enclosure with NSRB Document 121/2, is now available at 10 cents per copy and may be secured from the Superintendent of Documents, Washington 25, D. C. A discount of 25 percent is given on quantities of 100 or more.

(Enclosure: Damage from Atomic Explosion and Design of Protective structures.)

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CIVIL DEFENSE AGAINST ATOMIC ATTACK

HEARING

BEFORE THE

JOINT COMMITTEE ON ATOMIC ENERGY
CONGRESS OF THE UNITED STATES

IN EXECUTIVE SESSION

EIGHTY-FIRST CONGRESS

SECOND SESSION

ON

CIVIL DEFENSE AGAINST ATOMIC ATTACK

PART 2

MARCH 30, 1950

Printed for the use of the Joint Committee on Atomic Energy

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(Created pursuant to Public Law 585, 79th Cong.)

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CIVIL DEFENSE AGAINST ATOMIC ATTACK

THURSDAY, MARCH 30, 1950

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The joint committee met in executive session, pursuant to notice, at 10:30 a. m., in room G-48, Capitol Building, Washington, D. C., Senator Brien McMahon (chairman) presiding.

(The following statements were presented to the Joint Committee on Atomic Energy. They have been edited so as to exclude all classified information.)

STATEMENT OF DR. NORVIN C. KIEFER, DIRECTOR, HEALTH RESOURCES DIVISION, OFFICE OF CIVILIAN MOBILIZATION NATIONAL SECURITY RESOURCES BOARD

Dr. KIEFER. The necessity for coordination of civil defense plans with total wartime mobilization plans already has been discussed with you. The plans for health (and medical) services in civil defense, which I would like to describe to you, represent a specific illustration of this general principle.

The NSRB is concerned with three types of health resources—health manpower, supplies, and facilities—and about 20 professions of which the chief representatives are physicians, nurses, dentists, veterinarians, sanitary engineers, and pharmacists. Our general health resources mobilization plans are based on consideration of both civilian and military wartime needs.

Civilian needs are of two chief types: First, to maintain adequate civilian health services throughout the duration of war, and second, to provide emergency health services following civilian wartime disasters. The latter type must include care and treatment of civilian casualties, maintenance of public health protection, and restoration of environmental sanitation measures.

Civil defense needs are an integral part of the general needs for mobilization of health resources; to consider them as an independent entity would be illogical and, in fact, dangerous. For example, use of health manpower for civil defense purposes cannot be planned without thorough consideration of the effect on health manpower needs of the armed forces or the remainder of the civilian population. So far as possible, the huge quantities of health supplies needed for civilian wartime disasters must be provided—but not by drawing off supplies that the military forces need just as badly.

With your permission, I should like to describe in general some of the conditions that might follow a successful enemy attack on our civilian population, some of the consequent problems that the health services would have to solve, and, finally, some of the specific plans that are being devised to meet these problems. I an going to present an unpleasant but specific example of the magnitude of our problems before telling you what the Federal Government is doing to meet them.

Estimates of the potential number of civilian casualties are of somewhat limited usefulness because unpredictable factors, such as the degree of success of penetration of our defenses by enemy planes, or the accuracy of enemy bombing, may make the most careful estimate of casualties grossly inaccurate; it is even possible that in another war there would be no effective attacks on our cities. Nevertheless, in our civil defense planning work it is only prudent to assume that there will be a large number of casualties among our civilians. My statement to you is based on this assumption.

Because I am trying to make an entirely realistic presentation, I must state that the adequacy of health services following disasters causing these assumed casualties can be viewed only in relative terms. Completely adequate health services would become impossible after any disasters of substantial size because NSRB studies of American health resources have shown that the following shortages would occur under our assumed conditions:

1. There would be inadequate numbers of all types of health personnel.

2. There would be severe shortages of health supplies.

3. There would be serious shortages of hospital facilities.

4. Even if we could assume—and we certainly cannot—that we would have adequate numbers of personnel and adequate supplies, immediate mobilization and transportation of large numbers of professional persons and huge quantities of bulky supplies to reinforce local services and commodities would be severely limited by availability of interurban transportation (which might be crippled by enemy attack) and of intracity travel (which would be impeded by fires, debris, and similar obstacles).

Consider, for instance, a civilian disaster such as the one at Hiroshima which resulted in about 80,000 casualties. It is estimated that just to furnish the initial first-aid and treatment for this number of casualties would require, in the first week, supplies that would demand nearly 200 railroad boxcars for transportation.

Let me continue to use Hiroshima as an example. In some American cities, just as Hiroshima, 50 to 90 percent of the hospitals would be unusable because of total destruction, severe damage or inaccessibility owing to surrounding fire and rubble. Approximately the same percentage of the physicians and nurses would themselves be casualties. Even if they were not, thousands of physicians, nurses, and other health personnel would have to be mobilized in nearby and distant cities and quickly transported, with equipment, to the stricken city. Within the first week, at least a quarter of a million pints of whole blood or blood derivatives—with an equal number of bottles, tubes, and needles—might be needed.

About 40,000 of these injured persons might not be able to reach even a first-aid station by themselves but would have to be transported by litter and later by vehicles to emergency hospital facilities. These emergency hospitals might have no light because of damage to electric power; they might be without safely treated water—in fact, they might be without any water other than that which could be delivered by tank trucks; and they might be deprived of heat because of fire hazards.

We have been aware of all of these staggering difficulties for well over a year and during that time have been working—with other government health agencies—on the most effective means of solving them. It is a slow, deliberate process, not because of lack of appreciation of wartime dangers, not because of lack of cooperation from other agencies, not because of unavailability of professional competence, but because the problem is too huge and the decisions to be made are too important to allow for hasty or haphazard planning.

To strike a more encouraging note, let me state that there is little about the effects of either old or new weapons which is new to the health professions. The atomic bomb produces burns, lacerations, amputations, crushing injuries, and blast injuries which all surgeons are accustomed to treating. Radiation sickness is a new type of wartime injury, but it is not a new disease and its symptoms are recognized by physicians, particularly radiologists. Biological warfare is only an extension—with some new means of introduction and dissemination—of a form of warfare that nature has waged against man for centuries and for which our health departments have, over decades, built effective defenses. Chemical warfare introduces new agents but does not materially change principles of treatment now used by internists and surgeons.

In the last several years, unprecedented advances have been made in the treatment of injuries and diseases, including many of those which might be encountered frequently in future warfare. There are, however, some "new wrinkles" in warfare for which short periods of specialized training for all physicians will be necessary.

The fundamental problem therefore remains a quantitative one: to mobilize and transport professional health personnel and health supplies in enormous numbers; to transport, hospitalize, and furnish prompt treatment to unprecedented numbers of casualties; to maintain or restore environmental sanitation, and to preserve the safety of food, milk, and water following unparalleled damage to normal protective facilities, equipment, and services. These are the problems which we must solve.

We are fortunate in having existing governmental health agencies with competence related to practically every health aspect of civil defense. The Health Resources Division of NSRB therefore requested these agencies to present detailed recommendations concerning 69 assigned subjects which comprised all or certainly most of the important fields for which national planning is necessary to provide health services in the event of civilian wartime disasters. The Public Health Service worked on 43 of these subjects. The Health Resources Division itself did all of the work on some of those which were closely related to total mobilization planning.

In addition to the official agencies, national professional organizations have been consulted and their advice will be utilized freely now that basic recommendations are ready for further consideration. Incidentally, our problems and tentative recommendations were presented, in January of this year, to a standing panel of consultants, consisting of five prominent nongovernmental physicians and dentists. They contributed valuable suggestions and expressed their enthusiasm for the nature and progress of our civil defense health plans.

About 1,500 typed pages of tentative proposals and recommendations were submitted to us. These have been revised or supplemented by discussions in numerous meetings and conferences. Individual projects are now being integrated according to major functional areas and will form the basis of recommendatons to the President. The plans, however, will never be final; they will have to be revised periodically. We are attempting to establish patterns which are elastic and readily adaptable to alterations necessitated by changing methods of warfare or concepts of defense.

A difficult preliminary step is to grade proposed activities according to relative essentiality and urgency. This is necessary because, although implementation of practically all of the recommendations would be desirable for an adequate national civil defense program, the cost might be prohibitive. Priorities therefore are being devised on the basis of calculated risks and with consideration of existing services which could, without expansion, provide definite, even though incomplete assistance.

I would now like to describe the major areas in which we are planning in order to meet the challenge of war on civilians in the atomic age:

I. SPECIAL TRAINING

A. For atomic warfare defense

Courses for teachers to train all physicians, nurses, and dentists in the treatment of radiological casualties have been announced and are being started by the Atomic Energy Commission in cooperation with the National Security Resources Board and General Services Administration.

Courses for public health physicians and nurses, sanitary engineers, and veterinarians have been planned and will be started by the Public Health Service in April. These are designed for instruction in problems of radiological contamination of food, water, and environment in both peacetime and wartime.

B. For biological warfare defense

After several conferences between representatives of NSRB, the Department of Defense, the Public Health Service, and the Bureau of Animal Industry, a unanimous agreement was reached to down grade the security classification of certain aspects of biological warfare defense in order to release needed information to appropriate State and municipal public health officials. The Public Health Service and the Bureau of Animal Industry were designated as the appropriate agencies to conduct courses of instruction for such persons. These agencies are now devising the contents of such courses and will present their proposals to NSRB.

C. For chemical warfare defense

Brief instruction in this field is needed by physicians, nurses, sanitary engineers, veterinarians, and other professional personnel. Such courses will be ready for inclusion with the others.

D. First-aid courses for the general public

It is anticipated that about 20,000,000 persons can be interested in taking civil defense first-aid courses. The Red Cross could devise a new manual and organize and initiate such courses within 3 or 4 months. Advice on the content of the course would be obtained from the National Research Council and other professional groups.

II. HEALTH PERSONNEL FOR CIVIL DEFENSE

Federal health personnel for civil defense would be needed for two purposes:

(*a*) Wartime Federal office of civil defense. Most of the health personnel could be assigned from the regular officers and recruited Reserve officers of the Public Health Service just as they were for the World War II Office of Civilian Defense.

(*b*) Mobile reserve units which could be transported any distance to reinforce local health personnel at the site of a disaster: Affiliated hospital units of inactive Public Health Service Reserve officers similar to those which were organized in World War II, as well as mobile public health units, could again be recruited and organized—on a larger scale than in World War II—and brief specialized training could be given to members.

The Public Health Service has submitted tentative recommendations; detailed proposals will soon be available.

Organization of State and local health personnel should be affected by State and local civil defense organizations with advice from the Federal Government. In most instances the official State or local health departments probably should be charged with responsibility for civil defense health services in their respective areas. Complete cooperation from the various professional organizations is indispensable.

It is extremely difficult to estimate the number of professional personnnel which would be required to care for civilian casualties of warfare in the atomic age because no useful precedent is available. The only previous relevant incidents are those at Hiroshima and Nagasaki. In both cases, Japanese first-aid, medical, and other health services broke down so badly that review of their experiences is of little value to a determination of the numbers of health personnel which would be necessary for adequate services. Military tables of organization are not applicable to civilian situations; furthermore, no army ever has suffered a sudden, localized disaster of comparable magnitude.

Estimates of the number and types of professional personnel required would be valuable to plans for organization, mobilization, and transportation of such persons for immediate assistance to a stricken community. We therefore are utilizing the advice of both military and civilian experts in making these estimates. In addition, estimates of the types of casualties, by percentage of the total numbers, have been prepared.

During wartime, today's shortages of professional health personnel would be greatly exaggerated by military needs. Our peacetime economy could not support sufficient numbers of such manpower to meet every wartime need; nor could facilities to train additional personnel be rapidly expanded during wartime. These Nation-wide wartime shortages would constitute one obstacle to immediate provision of the thousands of professional persons needed in a wartime disaster area. Furthermore, high casualty rates might be expected among professional personnel in the attacked city and there would be serious transportation problems implicit to furnishing of mutual assistance. A great deal of attention therefore must be—and is being—concentrated on methods, mobilization, and transportation for health personnel.

III. HEALTH SUPPLIES NEEDED FOR CIVIL DEFENSE

Estimates of civil defense needs for health supplies are being made with consideration of current surveys of Nation-wide health supply inventories, maximum manufacturing potentials, available materials and vulnerability of the health supply industry to enemy attack. Such supplies include instruments, drugs, chemicals, biologicals, antibiotics, glassware, textiles, and other consumable items needed for protection of both human and animal lives. Blood will be discussed separately. Studies of both resources and requirements in these health supplies constitute one of the major planning fields of the Health Resources Division. They have been in progress for some time. Preliminary results are now available; more will be within the next 2 months.

Our studies indicate that although, with proper planning, wartime health supplies could be furnished in quantities adequate to meet both essential civilian needs and the additional demands imposed by military operations, the amounts of surgical supplies and equipment would be grossly inadequate for major wartime civilian disasters. The chief reason for the latter difficulty lies in the fact that no substantial reserves of these supplies are held in civilian warehouses, which are practically nonexistent, on retail dealers' shelves or in hospitals. We are, therefore, giving serious consideration to methods of building necessary security reserves of health supplies. The possible methods include Federal purchase, and storage on a regional basis. In the meantime, States and municipalities can determine the location and nature of all health supplies within each State and within or nearby each large city.

IV. HOSPITAL SERVICES FOR CIVIL DEFENSE

Nine assignments in this planning area were made, chiefly to the Public Health Service, with the Atomic Energy Commission, Department of Defense, and the American National Red Cross making major contributions. Their recommendations, revised by the Health Resources Division, are now ready for discussions with nongovernmental hospital and related organizations, and include those for—

(*a*) Interchange of hospital accommodations between military, governmental, and nongovernmental hospitals.

(*b*) Relationship of civil defense and other wartime needs to future hospital building programs. Fortunately, the emphasis of the Hospital Construction Act on suburban and small community hospital needs is automatically resulting in a considerable amount of dispersion of new hospitals from the industrial—and therefore strategic—hearts of metropolitan areas.

(*c*) Evacuation of patients from hospitals.

(*d*) Organization of first-aid stations, emergency hospitals and related facilities. Specific recommendations for organization of these services have been devised.

(*e*) Selection of buildings for use as emergency hospitals. Detailed general suggestions have been submitted. Further study of individual local problems is needed.

(*f*) Medical and nonmedical equipment for emergency hospitals. Itemized lists of the needs have been submitted and are being critically examined.

(*g*) Recommendations for methods of conservation of hospital water supplies during a water shortage in a wartime disaster. The recommendations which have been submitted are sufficiently complete to permit publication and wide distribution, after discussion with nongovernmental hospital organizations.

V. CIVIL DEFENSE FOOD SUPPLY PROBLEMS

Recommendations for nutritional standards relating to emergency rations for the infant, child, and adult populations, the injured and ill, and persons requiring special diets, in areas of civilian wartime disaster, have been submitted by the Public Health Service and the Children's Bureau. These include detailed recommendations for a priority rating of needs for emergency milk rations in order to prevent deaths or damage to health among certain groups to whom an uninterrupted supply of milk is essential.

VI. FOOD AND MILK SANITATION

These are normal responsibilities of the Public Health Service, the Bureau of Animal Industry, the Bureau of Dairy Industry and the Food and Drug Administration, and their State and local counterparts. Extensive recommendations for specific adaptations of existing practices, and standards to fit wartime disaster situations, have been submitted by Federal agencies.

VII. PROTECTION AND MAINTENANCE OF WATER SUPPLIES AND EMERGENCY SEWERAGE AND WASTE SANITATION

From these planning fields arise some of the biggest civil defense health problems. Water supplies are essential to life; unsafe water supplies can be just as deadly as loss of water supply or as bombs. That the purity of these supplies is customarily assured in American cities probably makes us more helpless and in greater danger when we are deprived of normal safety measures. Emergency treatment of water, emergency methods of disposal of excreta and other sewage and solid wastes must be provided immediately in civilian wartime disasters. The sanitation aspects of these services are normal responsibilities of Federal, State, and local health departments. Detailed recommendations for emergency practices and standards have been submitted to us by the Public Health Service.

VIII. MISCELLANEOUS ENVIROMENTAL SANITATION MEASURES

These include:

(*a*) Sanitation in emergency eating places to prevent wide-scale food poisonings and other gastro-intestinal diseases.

(*b*) Special sanitation problems incident to evacuation of large numbers of people from a wartime disaster area. The Public Health Service has submitted detailed recommendations for measures required in these two areas.

(*c*) Control of rats and other rodents, and flies and other disease-carrying insects, after wartime disasters. It is rare that large-scale destruction does not have as one aftermath extensive problems of control of rats and insects which transmit serious diseases to man. Control of this problem is necessary in order to preserve the lives of those who escape the direct blow of the enemy attack. These measures are normal activities of government agencies, particularly the Public Health Service. Detailed recommendations for extension of these activities to meet wartime disaster conditions have been submitted to us.

IX. SPECIAL PROBLEMS

A. Blood and blood derivatives

It has been estimated that several million pints (or units) of blood might be needed within the first few weeks of an attack on our civilian population. Provision of large quantities of this indispensable lifesaving item presents some unique problems which arise from the fact that under proper refrigeration, whole blood can be preserved for only 3 or 4 weeks.

Intensive research on methods to extend this period is being conducted but until it is successful we must base our plans on present limitations. It would be extremely wasteful and probably impossible to maintain a 3-week stock pile of such proportions. Plasma can be kept for several years but, although it is useful in the treatment of shock, it is by no means a complete substitute for whole blood.

Therefore, the only recourse is a highly efficient organization—including a huge reserve of standard bottles and other supplies—ready to stage a mass blood procurement from persons outside the attacked area.

It is entirely possible to devise, on paper, an organization which could recruit millions of blood donors within a period of one to several days. But this is a highly technical operation which produces a commodity that can be lethal unless it is collected and transfused with strict conformity to complex safety standards.

To activate an adequate and safe wartime blood program without previous, extensive, actual experience in peacetime would be virtually impossible. If an efficient integrated, Nation-wide peacetime blood program could be organized it would answer an immense and vital peacetime need and also would offer a strong foundation on which an expanded wartime program could be built with relative ease, safety, and speed. Standardization of equipment is imperative and, in addition, great efforts must be made to extend the period in which whole blood can be preserved and to develop more effective blood substitutes.

The NSRB therefore is initiating a series of conferences between the various interested agencies in order to solve these problems and to plan a blood program which will be adequate for wartime civilian and military needs. The Public Health Service has already submitted detailed recommendations, including those for emergency blood-matching laboratory services and for a number of other emergency laboratory services which would be essential to the management of civilian wartime disaster casualties. Extensive suggestions for mobile laboratories, laboratory personnel organization and use of auxiliary laboratory workers are included.

B. Standardization of supplies for treatment of burns

One of the most common types of casualties in civilian wartime disasters is burns. Even before the advent of the atomic bomb, fire raids such as those on Hamburg and Tokyo resulted in enormous numbers of burn casualties. Based on Hiroshima experiences, about 60 percent of atomic bomb casualties would be burn cases, with or without other accompanying injuries or radiation sickness. It is well known that burns require an extraordinarily large amount of nursing care and of supplies. The multiplicity of methods of treatment for burns makes it essential that if reserves of health supplies are developed they must conform to the needs of one uniform system of treatment. We therefore are concentrating a great deal of attention on the development of a method of treatment which would be medically sound and effective and, at the same time, practical for use in large disasters.

X. TRANSPORTATION PROBLEMS

Recommendations relating to litter services, emergency ambulances, and evacuation of civilian casualties are being developed by the Public Health Service, American Red Cross, and Department of Defense. Needs for transportation services for professional health workers in disaster areas also are being considered.

XI. SPECIAL VETERINARY MEDICAL SERVICES

Specific training programs have already been described. Recommendations for emergency measures to prevent spread of disease from animals to man and for emergency standards of meat inspection have been prepared and submitted by the Bureau of Animal Industry.

XII. INDUSTRIAL HYGIENE AND MEDICINE

Detailed proposals for special disaster programs within industry, as well as suggestions for methods to minimize industrial hazards to neighboring areas have been prepared by the Public Health Service. All ultimate services in this area must be integrated with the general community organization.

XIII. MENTAL-HYGIENE PROGRAM

Peacetime planning for measures to study the psychological impact of war on civilian populations is a part of general mobilization plans. Special comprehensive methods limited to civil defense uses have been described, and suggestions for the management of psychiatric patients confined to institutions in disaster areas have been submitted, by the Public Health Service.

XIV. MORGUE AND BURIAL SERVICES

These services are indispensible to provide identification of bodies and to avoid the health hazards arising from inadequate burial facilities. The Public Health Service has submitted recommendations with the help of the Department of Defense. Some of these are sufficiently complete to permit publication as manuals within a short time.

XV. MAINTENANCE OF VITAL STATISTICS

Detailed recommendations for wartime extension or adaptation of peacetime vital statistics, reporting and identification procedures have been submitted by the Public Health Service. Without extensive peacetime planning—and, in some cases, implementation—many of these extended and extremely important services could not be provided in wartime.

This completes my summary of the NSRB planning activities for health services needed in civilian wartime disasters. In each of these 15 areas, comprehensive proposals are now being prepared by the Health Resources Division in consultation with other governmental and nongovernmental agencies and professional organizations and individuals. All material is being developed for the purpose of aiding States and communities in their civil defense planning activities. In some areas further study and research is required. Some of the plans—such as those for training courses—will be ready for implementation during this fiscal year. Some of the recommendations could be published in the form of reports or manuals within a short time. In every case, periodic review must be made to determine whether revision is indicated by shifting international relations and changes in potential methods of warfare.

STATEMENT OF RALPH R. KAUL, ACTING DIRECTOR, HOUSING AND COMMUNITY FACILITIES DIVISION, OFFICE OF CIVILIAN MOBILIZATION, NATIONAL SECURITY RESOURCES BOARD

Mr. KAUL. In any future war we can expect urgent housing needs to arise almost immediately in all industrial communities and military centers, whether or not these communities are subject to enemy attack. These needs would arise when essential war plants are expanded and put on a two- or three-shift operation, or when essential plants have to be relocated into undeveloped areas for strategic reasons, or when military installations, located near outlying and dormant communities are suddenly put into full operation.

Civil defense will add to these needs to the extent that housing and community facilities are destroyed and shelter must be provided for the evacuees of disaster areas. During the past year the National Security Resources Board has been developing a comprehensive planning program for the mobilization of housing and community facilities to meet wartime needs.

PROGRAM

The allotted time will not permit a detailed description of the entire war housing and community planning program. But before I get into the direct civil defense planning of the Housing Division, I would like to simply enumerate the seven major problem areas in which we are working. These areas are—

First, utilization of existing housing;

Second, the regulation of private construction, maintenance, and repair;

Third, the provision of emergency and mobile housing and community facilities;

Fourth, the management and operation of war rental housing;

Fifth, the provision of adequate facilities and services for community mobilization;

Sixth, the encouragement of research and development in this field; and

Seventh, planning for the organization and administration of a wartime-housing program.

All of the housing mobilization plans have a bearing on civil defense preparedness but there are two programs which are particularly important to civil defense. These are housing utilization and emergency and mobile housing. I would like to discuss these programs briefly as examples of what is being done and how we in the National Security Resources Board staff have gone about doing it.

EXAMPLES OF MOBILIZATION PLANNING—PRELIMINARY INVESTIGATION

Since the cities of this country had never been subjected to enemy attack, one of our first jobs was to look into the World War II experience of other countries. Early last year, in April to be exact, the National Security Resources Board arranged with the Housing and Home Finance Agency, Department of State, and the Civil Affairs Division of the Army to investigate the housing and care of civilian population in the bombed cities of England, Germany, and Japan. Several significant facts emerged from this preliminary investigation:

First, the magnitude of damage to housing and community facilities was vastly greater than our estimates. In England, for example, the German bombings seriously damaged or destroyed 4½ million out of 13 million dwellings. Similar damage occurred in German cities where Allied air attacks resulted in the damage or loss of 6,000,000 out of 18,000,000 dwelling units. These were the results of conventional warfare over a period of months. In Hiroshima, on the other hand, one atomic blast totally destroyed or severely damaged 59,000 out of 90,000 buildings in an area of less than 10 square miles. None of these countries were prepared for the large number of their people left homeless and destitute and the corresponding loss of strength in their industrial and civilian economies.

Second, no type of housing or construction system was found which could replace housing losses of such magnitude in a war economy. England, Germany, and Japan had to cut out practically all new housing construction and meet the problem with emergency structures and with greater use of existing facilities.

Third, under the pressure of enemy attack the civilian populations accepted very substandard living conditions providing families were housed together and given privacy. For example, the separation of parents from children or the lack of a private bathroom or kitchen, with no foreseeable prospect of getting them, proved to demoralize families and war workers even more than bombings.

Lastly, it was revealed that community facilities, such as restaurants, theaters, nurseries, laundries, beer parlors, and the like, had a tremendous influence on morale and efficiency. It was found that workers would put up with very inadequate housing provided there was a retreat to adequate community facilities. This condition was confirmed in the experience of our own occupation forces in Japan and Germany.

UTILIZATION MEASURES

In the light of this preliminary investigation, the planning of utilization measures in wartime was given a high priority in the program of the Housing and Community Facilities Division. Detailed research projects on housing utilization policies and methods in England, Germany, and Japan were initiated. The first of these to be completed is a study on Emergency Measures for Housing and Community Services in Germany during World War II, prepared for the National Security Resources Board by the United States High Commissioner for Germany. This study brings out several noteworthy factors in civil defense planning:

First, housing utilization measures were cut to fit the requirements and resources in each community. Even under the extreme regimentation of a totalitarian system, the German Government had to depend on the initiative and discretion of local authorities for adequate housing measures. This is indicated by one of the conclusions in the German report, which I quote as follows:

> Particular emphasis was given to the flexibility of the general orders. The Nazi authorities * * * understood that in this particular instance the initiative of the local authorities must not be limited except for the framework of over-all planning and direction.

Second, in some German cities where civil defense measures were well organized, bombings did not result in complete community disorganization as was the case in cities where civil defense was not well planned. This was brought out clearly in the comparison of the cities of Duisburg and Hanau in the report. The city of Duisburg was exposed to air raids early in 1941, and a competent and well-organized civil defense system gradually grew up in that community. As a result, the casualties were small and essential work was effectively maintained during the period of intensive bombings in 1943 and 1944. The city of Hanau, on the other hand, felt that it was too small and unimportant industrially to be a target for heavy air raids. Civil defense plans were not taken very seriously. When a large air raid did occur in December 1944, the Hanau population was panic-stricken and fled the city without organization or plan. Within one night, this community of 43,000 people became a mass of ruins with only five or six thousand people left of its original population of 43,000 and it has never recovered from this disaster.

Third, sustained air raids caused a migration of the civilian population from the large vulnerable cities into the smaller outlying towns.

For example, the population of Cologne dropped from 763,000 people in 1943 to 40,000 when the armistice was concluded, whereas the university town of Heidelberg increased from 86,000 to 120,000. The air raids thus created congestion and housing shortage in these smaller towns as critical as that in the bombed cities.

The surveys on England and Japan are bringing out similar results and conclusions. On the basis of these investigations, and taking into account the homes use program in the United States during the war, the NSRB is developing a housing utilization plan for wartime. This plan includes registration methods by which available housing resources can be quickly appraised in any community. It would provide a range of inducements and regulations which could be employed, depending upon the local circumstances, to assure the maximum use of available accommodations. Finally, it takes into account possible methods for the requisition and assignment of housing to meet critical needs in disaster areas. It is too early to have any final conclusions but as the housing utilization plans are perfected and amplified, they will provide for community mobilization and civil defense needs in any future emergency.

EMERGENCY AND MOBILE HOUSING

The second planning area of the Housing Division which is directly related to civil defense requirements is the provision of emergency and mobile housing and community facilities. Although we have some 43 million dwellings in this country, less than three-tenths of 1 percent of these resources are mobile or capable of being moved from areas of housing surplus to the critical war areas. We must be prepared to provide housing and community facilities of many types which can be shipped into disaster or shortage areas ready for immediate use, or those which can be built quickly with a minimum of local labor and materials. This is how the Federal Government has tackled this problem and the progress that is being made in the field:

Emergency and mobile housing was given a top priority among the other programs.

Our second step was to work out specific projects and assignments for the participating Federal agencies.

For example, through the combined efforts of the State Department, the United States High Commissioner for Germany, and the Department of Defense, studies have been undertaken of emergency and protective structures in England, Germany, and Japan.

The first of these studies, the one of the German experience, was completed and submitted to the National Security Resources Board only last week. There has not been sufficient time to appraise this study fully, but it does bring out the importance of various types of emergency and protective shelters, as well as the planning of communities to minimize the effects of bomb damage. The report is now being distributed for review by the General Services Administration, the Housing and Home Finance Agency, the Department of Defense, and the Federal Security Agency, and will be used in the development of mobilization plans in this field.

The Department of Defense, through the Munitions Board, has been working on a number of types of shelters and emergency facilities which can be used for civil defense purposes. These include tent and panel structures of the Army Quartermaster, mobile water and power units of the Army engineers, and mobile and demountable community buildings of the Army engineers and the Navy Bureau of Yards and Docks.

Other agencies, such as the Housing and Home Finance Agency, the Public Health Service, and General Services Administration, are working on trailers, sectional houses, mobile medical units and other types of shelters and facilities in which they have special competence. Also, case studies have been started which show the housing and community needs in war towns and disaster areas and how those requirements were met in actual experience.

The third step is the evaluation of these projects and assignments as they are completed. For this purpose an Interagency Working Group on Emergency Housing and Community Facilities was created last fall by the Chairman of the National Security Resources Board. It consists of the Housing and Community Facilities Division, Housing and Home Finance Agency, Department of Defense, General Services Administration, and Federal Security Agency. The Group has met intermittently since it was created and has considered the task in terms of four major questions:

1. What are the kinds of housing and community facilities that will be needed?
2. What types of emergency facilities could be provided under wartime shortages of materials, labor, equipment, and so forth?
3. How can up-to-date plans on emergency housing and community facilities be kept in constant readiness for use by Federal, State, and local governments in any sudden emergency?
4. What steps can be taken to encourage research and development and the strengthening of housing resources that would be needed in wartime?

Within a few days the Interagency Working Group will complete its first and preliminary report. As soon as this report is completed and reviewed by Mr. Paul Larsen and Dr. Steelman, a copy will be furnished for the information of the committee. If time permits, I can briefly summarize for you the results, thus far, of this interagency project:

Case studies are being reviewed on the housing and community services in eight war communities and disaster areas as follows: Oak Ridge, Tenn.; Seneca, Ill.; Orange, Tex.; Provo, S. Dak.; Richmond, Calif.; the Texas City disaster; the Vanport flood, and the Maine fires.

These studies are bringing out the types of requirements in wartime. The Oak Ridge story, for example, shows the vital need for prefabricated mobile housing. Texas City brings out the urgent need for emergency feeding, sheltering, and medical facilities. Vanport shows the job that trailers could do as a stopgap housing resource.

REPORTS ON AVAILABLE FACILITIES

Also, the Working Group has reviewed, or is reviewing, some 16 special types of emergency housing and community facilities, which already have been developed and would be available for use if an emergency came tomorrow. These reports include such systems as:

Portable tent-type shelter, Army Quartermaster
PHA house trailer
Ibec concrete house
Mobile medical units
Sectional mobile house, TVA system

and a number of others which are listed here for the record:

Steel arch rib hut (Quonset), United States Navy
PHA portable house
PHA dormitories
PHA demountable house
PHA temporary dwelling units
Precast concrete units
Water pumping, purifying units, Army engineers
Portable electric unit, Army
Mobile sanitary facilities
Mobile commercial facilities.

I have here the preliminary report on the portable tent-type shelter, recently developed by the Army Quartermaster, as an example of this work. The shelters are briefly and pictorially described in this report, which includes a summary of their potential civil defense uses. The reports will be used by Federal, State, and local civil defense authorities to let them know what is available and to give them the widest possible choice of solutions for their emergency needs.

The Interagency Working Group proposes to continue its survey of emergency and mobile housing until all important systems and methods have been reviewed, and to keep the reports up to date with technological developments and significant changes in requirements in this field.

CONCLUSION

The final step in this process of mobilization planning is an end product of readiness measures and future plans. In closing, I would like to sum up briefly the preliminary findings thus far, and our plans for continued emphasis and work in the coming months:

First, civil defense authorities will need a wide choice of mobile and emergency housing and community facilities when mobilization starts. A number of reports are now in shape for reproduction and distribution. Eventually all types of emergency facilities will be evaluated and cataloged for mobilization purposes.

Second, there is need for continuing research and development of emergency and mobile facilities. The systematic appraisal of our emergency housing requirements and resources will serve as a stimulus and guide to the work of Government agencies, as well as private industry and research organizations. As our work progresses, the research activities of the Federal Government will be drawn more and more into the solution of civil defense requirements.

Third, with all our large housing resources and construction capacity, the amount of mobile or portable housing in this country is negligible. There is a need for increasing the resources of housing and facilities which can be shifted in wartime to critical areas. Much can be accomplished in building up this resource if we give greater consideration to mobility, speed of construction, conservation of labor and materials, and economies of mass production in our peacetime housing and construction programs.

Fourth, we cannot safely count on having the time or resources for a vast construction program after the emergency starts. Our communities must be prepared to use their existing housing and community facilities wisely and fully to meet emergency needs. We have made a good start in assembling and reviewing the wartime experience in the United States and in those foreign countries that have suffered serious damage to their cities. This mobilization planning will culminate in recommendations for community mobilization measures which provide the greatest personal safeguards and at the same time achieve the degree of utilization necessary to meet disaster needs.

Finally, we are giving consideration to protective construction and community plans which will minimize the effects of attacks on our cities. A good start has been made in the analysis of the foreign experience. As our work goes forward on vulnerability analysis, which Mr. Paul Larsen has already described, the Federal Government will be in a position to provide increasingly effective leadership and guidance in this area.

In closing, I would like to mention that we have had the cooperation of numerous individuals and organizations in the housing and community planning field, and the unstinted assistance of the other Federal agencies participating in this work. Our future progress in this field depends on the continued cooperation and hard work of these agencies.

I thank you for permitting me to discuss this work with you and will attempt to answer any questions the committee may have in this mobilization planning field.

SUMMATION STATEMENT ON CURRENT CIVIL DEFENSE PLANNING, BY PAUL J. LARSEN, DIRECTOR, OFFICE OF CIVILIAN MOBILIZATION, NATIONAL SECURITY RESOURCES BOARD

Mr. Larsen. The planning program which the National Security Resources Board has undertaken on civil defense aspects has been outlined in general to your committee.

In summation, it can be said that the over-all planning has been basic in order to round out a complete civil defense plan from the Federal Government standpoint, the implementation of which will be the responsibility of the States and local community organizations. Our planning in respect to this Federal plan has differed from other nations' planning, basically because of our governmental structure and the belief that civil defense operations must be maintained on the basis of our democratic system of Government.

It is our belief that the responsibility of the Federal Government in civil defense activities even after implementation will not require the establishment of a large Federal organization in order to insure adequate civil defense to overcome disaster which may occur by enemy action. The Federal agency for civil defense will be basically responsible prior to mobilization for (1) formalizing a Federal plan which will be accepted by States and local communities, (2) assisting States and local communities in training of volunteer workers, (3) establishing national schools for training of key State and community civil defense personnel, (4) evaluating requirements of equipment and resources for civil defense and determining which of these should be obligations of the Federal Government and/or State and local communities, (5) evaluating weapons effects in order to determine sound dispersion and evacuation policies of Government activities and/or other vital installations, (6) maintaining such reserve stores or critical materials as will be required in event of disaster plus control and distribution of these to communities requiring them in the event of disaster, and (7) maintaining close liaison with the public and public groups through the medium of information, public relations and education on civil defense planning and the dangers which the public should prepare for without introducing hysteria or fear which would affect morale and effective civilian participation in the civil defense program and the public's main functions of maintaining activity at top level for the war effort.

The National plan can in our estimation be implemented by the States and local communities for the present without necessity for Federal civil defense legislation beyond that now existing in the National Security Act of 1947. Additional legislation will be requested when appropriate in order that the Federal Government can implement its planning, training, and operation program in order to establish supplies for emergency uses and to establish an operating Federal organization.

We will, in the future, submit to your committee, if you so request, our firm plans when these are ready so that your committee may have full knowledge of the progress of Federal planning on civil defense.

APPENDIX

The following was among the material distributed to the States in connection with the National Securities Resources Board Civil Defense Planning Advisory Bulletin of January 13, 1950, designated "NSRB Document 121/2."

MEDICAL ASPECTS OF ATOMIC WEAPONS

Prepared for the National Security Resources Board by the Department of Defense and the United States Atomic Energy Commission

This document is issued by the National Security Resources Board as one of a series designed to meet the current informational needs of Civil Defense Planning Agency representatives of State and local governments, and other citizens interested in the discussion and planning of civil defense.

JOHN R. STEELMAN,
Acting Chairman.

FOREWORD

This is one of a series of reports which assess in general terms what is known about the results of an atomic explosion, what damage and injuries a bomb can cause, and what can feasibly be done to protect people and structures. This first report deals particularly with the effects of an atomic bomb explosion upon people within its range, the medical and biological aspects of injuries and their treatment. This and the other related reports are being prepared at the request of the National Security Resources Board, which has been charged by the President with responsibility for coordinating plans concerned with civilian defense in event of war.

The material is based on a wide variety of investigations, discussions, and documents brought together by experts in the various fields. Later reports will deal with (*a*) the damage caused by the air-blast created by an atomic explosion, and how buildings can be constructed to resist these effects, and (*b*) how contamination can be detected and measured.

A complete book on the effects of atomic weapons is under preparation by a board of editors organized by the Atomic Energy Commission's Los Alamos Scientific Laboratory for the Department of Defense and the Atomic Energy Commission. Some of these reports to NSRB will be based upon material gathered for the comprehensive book.

INTRODUCTION

A single atomic bomb of the type dropped on Nagasaki and Hiroshima during the war can lay waste the heart of a large city and injure and kill great numbers of people. In the two Japanese cities, over 100,000 were killed, and nearly as many were injured. If a bomb were dropped in such a way as to leave the area contaminated with radioactive materials, other casualties might result and rescue and repair work would be hampered. The area of damage, the number and kind of casulties and the extent of contamination would depend on how powerful the bomb was, and on how it was used—whether at high or low altitude on a clear or stormy day, or exploded in a river or harbor.

Each way in which a bomb was used would have its own particular type of Hazard. In some cases, the area of damage would be at a maximum; in others the area of damage might be reduced but radioactive contemination would be more severe. In these discussions, we are primarily interpreting data derived from the Japanese bombings in which an atomic bomb, considered as roughly equivalent to setting off 20,000 tons of TNT, was exploded at a height of about 2,000 feet above the earth on a clear day. This was about the altitude at which a bomb of this power is estimated to have the greatest effect. Higher than this, its blast effects would be weakened, lower than this, the circle of damage would be reduced.

The power of the bomb

The Hiroshima and Nagasaki bombs caused total destruction and serious damage to buildings—death and injury to people—for 2 miles from the point at which the bomb was set off, the extreme limit of damage was about 4 miles. More powerful bombs could cause a wider area of damage, but very great increases in explosive force are necessary in order to accomplish relatively small increases in the area of damage. For example, it would be necessary to double the power of a bomb in order to increase the radius of severe damage and injury by one-fourth from 2 to 2½ miles. Estimates based on the type of bomb dropped over Japan can be used as a rough basis for discussion and planning.

The way bomb is used

A high air burst, such as that in Japan, leaves no dangerous amounts or radioactivity on the ground. A bomb exploded in the air at low altitude—as in the Alamogordo test—will pulverize and vaporize materials in its immediate vicinity. It will not affect as wide an area, and the screening effect of hills will be increased since the explosion takes place closer to the earth. Radioactive contamination will, however, be severe within a limited area.

An underwater explosion of an atomic bomb also might cause serious contamination. The area affected would depend on where the bomb exploded, on the combined depth of the water, and the soft bottom such as mud, and upon the direction and force of the wind. At Bikini, the underwater (Baker) test caused what is known as a *base surge*—a 200- to 300-foot "wave" of heavy radioactive mist which spread outward from the base of the mushroom tower of water, turned into a low-lying rain cloud and precipitated radioactive materials over the surrounding area. If the explosion of a bomb caused such a base surge, contamination of any adjacent land areas would result. Other types of injuries from the explosion itself, however, would be reduced.

Effects upon people

The effects of the burst of an atomic bomb upon people are essentially the same as those caused by an amount of TNT that releases an equivalent total of energy, but with certain added factors. Mechanical injuries suffered in the collapse of buildings will predominate in both cases. The main differences are, first, the greater amount of radiant heat released by an atomic explosion; second, the large amounts of light, including ultra-violet; and, third, the large amounts of nuclear radiation.

Injuries to people from an atomic bomb can be divided into four general categories—those caused by the blast pressure wave directly; those caused when buildings are wrecked; those caused by burns either in the wreckage or from radiant heat; those caused by nuclear radiation, either directly or through residual contamination.

In the case of an underwater blast, the water absorbs the radiant heat, light, and nuclear radiation, hence direct injuries from these sources do not occur. The contamination absorbed by the water is, however, spread whenever a base surge is formed.

In the case of such a high air blast as in Japan, some 15 to 20 percent of the deaths probably will be caused solely by nuclear radiation. The remaining 80 to 85 percent will be caused primarily by injuries suffered in the collapse of buildings and by burns, although many of these also suffered severe radiation exposure.

Direct injury from radiant heat occurs at the explosion of the bomb; Japanese people in the open suffered third-degree burns up to 1,500 yards and second-degree burns up to 2,500 yards. The effect was instantaneous. Nuclear radiation continues in dangerous quantities for 60 seconds but most of it is concentrated in the first few seconds, 50 percent occurring in the first second. People suffered injuries from nuclear radiation, but beyond a mile and a quarter injuries fell off sharply. The shock wave from the blast sweeps outward rapidly from ground zero and, in the case of Japan, took up to 10 seconds to travel 2 miles to the perimeter of greatest damage. Injuries from its effects occurred throughout this region.

In the following sections, we will discuss (*a*) the type of injuries caused by an atomic explosion, and the extent to which they occurred in Japan at various distances from ground zero, (*b*) the nature of the radiation hazard, the effects of exposure, and some of the treatments for acute radiation sickness, (c) the nature of the hazard from radiological contamination—not encountered in Japan—and some of the precautions that can be taken against it.

Injuries From Atomic Bombs

Air blast effects

Air blast effects on people fall into two categories: (a) Those caused directly by the pressure wave of the blast, and (b) those caused indirectly by collapse of buildings, flying wreckage, and by people being thrown against solid objects.

Direct injury

Direct blast injury may occur wherever the air comes into contact with body surfaces—particularly the intestinal tract, the stomach, the lungs, the ears, and the sinuses about the nose. Greatly increased pressure, especially if the increase is sudden, can tear these tissues. Few injuries of this sort were reported in Japan among survivors.

In the water, the dangerous level for pressure is about 500 pounds per square inch. In an underwater atomic explosion, any person immersed in the water probably would be killed or seriously injured up to 2,000 yards from the zero point.

Indirect injury

Secondary blast injuries are an important cause of death in an atomic bomb explosion. Since practically all brick and light masonry buildings with weight-bearing walls in the blast area will be wrecked, wooden buildings flattened, and the doors and other partitions of blast-resistant steel-reinforced concrete buildings blown out, people in or near these buildings will be killed or injured by collapse of structures, and by missile effects of debris. Among such injuries will be crushing, fracturing of bones, and lacerations and bruises of various types. Mechanical injuries resulting from atomic bomb damage vary in no way from those that would be produced by other explosives or missiles.

Flying glass contributes a large share of superficial injuries to be expected in any powerful explosion. In Japan, glass fragments penetrated over an inch beneath the skin. The clinical course of Japanese patients with mechanical injury showed that there was no damage attributable specifically to the nature of an atomic blast which impaired either rate or type of healing. Such impairment as occurred was clearly attributable to infection, loss of blood, starvation, loss of body fluids, or a combination of these factors.

Injuries due to heat and light

Severe burns were caused both by the radiant heat from the explosion of the atomic bomb (flash burns) and from the fires that broke out in the wreckage (flame burns). The effects of visible light probably are not significant. Even those who looked directly at the burst apparently suffered only temporary dazzling and loss of vision, but no clear-cut evidence of harm was reported. Temporary blindness resulted when the intense light bleached out the substance within the eyeball called "visual purple," and persisted for several hours until the body could manufacture a new supply.

Where hemorrhages of the eye occurred, it was from the general systemic effects of nuclear radiation. Conjunctivitis was common, but this infection of the outer eye was caused by smoke and dust.

Flash burns

The flash burns caused by an atomic explosion may be first degree, merely reddening the skin; second degree, causing blisters; or third degree, damaging all layers of the skin. The severity of an individual's injury, as with other types of burns, depends not only upon the degree of the burns, but even more upon the proportion of the body's total skin area that is affected.

Atomic bomb flash burns are distinctly different from those caused by other types of explosion, since they are due to radiant heat rather than to hot gasses, as in the case of shell bursts or gasoline explosions. They are readily distinguished because atomic flash burns are sharp in outline and are oriented to the point of the explosion. Shadow effects are prominent. An ear, for example, might be badly burned yet the skin behind the ear be unharmed.

Even loose clothing afforded some protection against atomic flash burns, and color also had a protective effect. White clothing tended to reflect the radiant heat, darker clothing to absorb heat. Burns sometimes were cross-hatched where light clothing was marked with dark lines. Tight clothing was less protection, and burns were inflicted at elbows and where straps crossed the shoulders, for example, while other places where clothing was loose were protected, or less severely burned.

The effects of ultraviolet light produced by the bomb are uncertain. Ozone generated from the air by the explosion would absorb a great deal of the ultraviolet spectrum. The flash-burned Japanese did show darker pigmentation about their scars, and this is still apparent, but no clear evidence has been found that ultraviolet radiation caused this or that such radiation played a prominent part in causing burns.

Flame burns

The flame burns in Japan mostly occurred when people were trapped in the wreckage of buildings which afterward caught fire. A conflagration may be expected to follow any atomic bomb blast. Not only is the radiant heat sufficient to ignite wood and lighter materials, but the collapse of structures overturns stoves and furnaces, breaks electric wires and ruptures gas lines. About 70 percent of Hiroshima's fire-fighting equipment was destroyed, firemen were killed, the water supply was disrupted, and streets were clogged with debris.

The uprush of the atomic cloud after the explosion causes an inrush of wind, and heat from fires augments this effect. At Hiroshima a "fire storm" resulted, with gale-winds sucked inward toward the center by the continued uprush of hot air. This did not occur at Nagasaki, but must be assumed as a danger in an atomic blast. At the very least, fires about the perimeter will tend to consolidate and cut off help from people trapped within the blast area.

Burns suffered from flames, in such cases, differ in no way from those encountered in any ordinary intense fires. If the case is not complicated by injury from nuclear radiation, the determining factors in survival and rate of recovery will not vary from those of a comparable ordinary burn. Where radiation injury has been suffered, infection will be a grave danger as explained in the following section.

Among the injured in Japan, there were many cases where excessive scar tissue (keloids) formed, and many of the survivors have contraction deformities resulting from improper care of burns and other injuries during the healing process. The deformities and the keloids are not specifically related to exposure to the atomic bomb, but rather to slow healing and to infection. The keloids also apparently stem from a tendency in the Japanese as a race; and burns suffered in nonatomic bomb raids resulted in comparable amounts of scar tissue. Adequate medical care would reduce the amount of keloids and prevent much of the crippling.

Had proper medical care been available, it is also probable that many of the Japanese who died from burns, as from other causes, might have been saved. The death totals must be weighed in relation to the fact that all medical care for days after the atomic blast was totally disorganized.

Adequate care to injuries and burns suffered in an atomic explosion present a problem of great magnitude. While the types of injuries, aside from the radiation hazard, are similar to those encountered in ordinary bombing or other catastrophe, the large numbers of individuals involved in an atomic blast, and the general chaos that results, present a problem whose solution requires a great deal of careful planning and preparation.

It would be unrealistic to prepare for fewer than 40,000 to 50,000 severely burned persons from a single atomic explosion. Ideal care of a severely burned patient, according to one such case, would include provision for 42 tanks of oxygen, 3 nurses, 2.7 miles of gauze, 36 pints of plasma, 40 pints of whole blood, and 100 pints of other fluids plus drugs such as morphine and the antibiotics. Obviously such ideal treatment would be impossible under catastrophe conditions. Although not all the burn cases would require as much support as the case cited above, this example, nevertheless, makes apparent the magnitude of the burn problem alone. Fortunately severe symptoms from radiation in those not killed outright do not ordinarily come on until several days after the acute exposure, so that those suffering from burns and mechanical injuries will actually constitute the chief immediate medical problem and make their heaviest demands on emergency facilities at a time when those suffering solely from acute radiation will require very little attention.

The Radiation Hazard

The nuclear radiation that causes direct injury in an atomic explosion includes *neutrons* and *gamma-rays*. The former are tiny invisible particles driven out of fissioning atoms; the latter are invisible electro-magnetic waves very similar to powerful X-rays and constitute the greatest radiological danger in an atomic blast. Both forms of radiation cause the same type of injury. They penetrate deeply into the body and *ionize* the atoms that make up the various elements—carbon, nitrogen, hydrogen, oxygen among others—so that the atoms are no longer neutral electrically, but carry a positive or negative electrical charge which makes them violently reactive chemically. Nuclear radiation, or *ionizing radiation*, disrupts the complex combinations of these elements and thus changes the proteins, enzymes and other substances that make up our cells and bodies. As a result, the cells are injured or killed, and bodily functions can be affected; if enough cells are damaged or killed, the person becomes seriously ill or dies.

This ionizing radiation cannot ordinarily be detected by the senses. If one touches a hot stove, the sensation of heat and resulting tissue damage is immediate. But one may receive an amount of ionizing radiation that will produce far more serious tissue damage than a burn without any sensation. Although chemical and physiological changes are produced almost instantly, no damage will be apparent for several days.

Beyond these general facts cited, we know very little about the exact mechanism by which radiation harms living molecules, cells and tissue. The clinical effects have, however, been extensively studied in Japan. And in the United States a Nation-wide research effort to investigate these effects has been under way since the early days of wartime development. (See Sixth Semiannual Report of the Atomic Energy Commission, July 1949.)

Acute radiation illness

These clinical findings in Japan show that people exposed to heavy radiation suffer various injuries, sicknesses, and malfunctions which together are called the *acute radiation syndrome.* Physicians find that the severity of the symptoms is related importantly to two factors: the amount of radiation absorbed in a single dose, and the proportion of the body exposed.

It is possible to expose a skin cancer an inch in diameter to 5,000 roentgens [1] of radiation (X-ray) without any effect on the patient other than that upon the cancer cells and, some scarring of adjacent normal tissues. But one-tenth this amount of radiation (about 500 roentgens), given over the whole body would probably prove fatal. And 400 roentgens of whole body irradiation is believed to be the dose that will kill about half of all the persons exposed to it (a dose called the human LD–50, or 50 percent lethal dose). Half of that amount of whole body irradiation, 200 roentgens, would cause radiation illness and, in rare cases, might result in death. The degree of acute radiation illness, and the probability of recovery or death, will thus vary sharply with the dosage received. The syndrome also can result from radioactive materials absorbed and lodged widely within the body where they then could emit their destructive radiation at close range. This danger from *internal* radiation is discussed later. Here, we are concerned with the effects of *external* radiation.

Results of exposure

Clinical observations have made it clear that heavy external exposure to penetrating radiation causes a massive break-down of the body's tissues, particularly in certain organs of the body. Since destruction of cells in various tissues reaches its height at different times after exposure, symptoms from these injuries will occur at different times. Two features make this type of body damage unique:

1. No two organs or tissues of the body suffer exactly the same amount of damage. Lymphoid tissue, bone marrow, the sex organs, and the lining of the small intestine suffer heavy damage. Muscles, nerves, and fully grown bone are not so easily injured. Other tissues, such as skin, liver, and lung, lie in between these extremes.

2. Unless the radiation has been extremely heavy, cells may not die for hours or days. For a week after skin is injured, it may show only a surface reddening and swelling of the underlying tissues. Blistering and loss of dead skin may be delayed for 2 weeks.

[1] The roentgen is a measurement of the ionizing effect of radiation. The precise definition of this measurement is less important here than the number of roentgen which will produce a certain effect upon a person exposed to it. A roentgen is defined as the amount of X-rays or gamma-rays required to produce ions equivalent to one electrostatic unit of charge in one cubic centimeter of air under standard conditions.

The course of illness in acute radiation syndrome can be described from the case records of Japanese exposed to atomic bombings, where their injuries were uncomplicated by blast damage or flash burns. Among Japanese who received 600 roentgens or more of radiation, the onset of the syndrome was violent and, in 75 percent of the cases, the first symptoms appeared within a half hour of exposure, great weakness followed and death sometimes occurred within 24 hours. Some patients lived 10 days. Among those receiving around the LD–50 or 400 roentgens, the first symptoms might not appear for several hours and, after the first onset, the patient might be able to carry on normal duties for a week. One Soldier in Japan, exposed in this way, afterward marched 15 miles with a full pack.

The sequence of symptoms among all exposed to heavy radiation was roughly the same, but the time intervals of various phases of the illness varied according to the severity of the exposure. Those who received around 400 roentgens or less developed additional symptoms—loss of hair and severe infections. The illness of a typical patient among the latter group goes through four phases:

Phase I.—Within an hour or so after exposure, the patient becomes nauseated, vomits, and suffers general prostration and weakness. Diarrhea may occur and his blood pressure may fall a little. In general, the heavier the dosage, the more ill the patient will be. This phase is quite similar to the "radiation sickness" suffered by patients treated intensively with X-ray or radium.

Phase II.—After the first onset of the illness, symptoms tend to disappear, and for a period of a few days to several weeks the patient feels less ill. For patients who have suffered the heaviest radiation, this period will be short. Reports have stated that Japanese injured by radiation alone were entirely without symptoms during this time, but the best information is that they were sick people who, because of the emergency, drove themselves to do what had to be done.

Phase III.—The illness reaches its height during this phase. Whether or not the patient survives depends on his ability to endure this acute stage. The patient becomes apathetic and develops a fever and rapid heart action. He becomes increasingly weak and loses weight. He loses his appetite, may become nauseated and suffer severe diarrhea which is sometimes bloody. Small hemorrhages may appear in the skin and the gums bleed. In severe cases, infected ulcers may spread throughout the mouth and alimentary tract. The hair may fall from the head and body about 3 weeks after exposure.

The slightly injured recover quickly, but those who receive a heavier dose of radiation may continue gravely ill for weeks. The most severely injured may grow progressively worse over a period of weeks and finally succumb, or may die within a few days.

Phase IV.—Patients who survive enter a convalescence during which a feeling of weakness and fatigue are the outstanding symptoms. It may be months before the patients recover normal strength and weight. The skin hemorrhages disappear and the hair, if lost, gradually regrows. Usually within 6 months, the patient feels completely well. All usual methods of examination indicate that, by this time, the patient is normal. Nevertheless, it is too soon to say that survivors will not suffer further ill effects.

Other reactions

Besides the symptoms described, the acute radiation illness includes damage that can be detected only by laboratory tests—changes in blood cells, in male sex organs, and in the functioning of other organs.

Several symptoms of the third, or acute, phase of the illness stem directly from injuries to certain elements in the blood. Infections and ulcerations arise because radiation destroys white blood cells that normally aid in combating bacteria. A few days after radiation exposure, the number of white cells declines and, in severe cases, the cells disappear almost entirely. The skin and gum hemorrhages are seemingly connected with a fall in the number of *platelets* in the blood, since these substances play a role in the clotting of the blood. Other causes, such as an increase in anticlotting substance that resembles heparin, a normal blood chemical, also contribute. Platelets begin to decline only after an interval of weeks and, where the patient survives, reappear during convalescence. A third, and very serious, effect upon the blood, the decline in the number of red cells, causes anemia and contributes to the general weakness and debility so marked in acute radiation illness. The decline in the number of red cells starts immediately after exposure and may continue for months.

Microscopic studies of tissue, amplified by more complete research with animals, indicate these blood changes are caused by radiation damage to the bone marrow and to the lumphoid tissue where these various cells are born. And the injury to tissue, as well as the course of illness in the patient, can be traced to damage to the cells. Radiation causes the cells to swell, disorganizes their structure and stops them from reproducing themselves. The stoppage of cell division occurs immediately after irradiation; structural changes appear more gradually. The most spectacular change is the collapse of certain parts of the cell, and the shrinkage of the nucleus followed by death and disintegration. The interruption of cell division is temporary, but when new cells begin again to divide they often show bizarre changes in their inner structure.

Treatment of radiation injuries

Many people believe that very little can be done in treatment of radiation casualties. This is true in case of a lethal dose; but certainly is not true when the exposure is in the median lethal range. Many borderline cases can be saved by:

a. Good medical and nursing care.

b. Whole blood transfusions, given as may be required in the individual case until the bone marrow has had time to regenerate and produce blood.

c. Control of infection by antibiotics such as penicillin.

d. Intravenous feeding to supply necessary sugars, proteins and vitamins.

e. Control of the bleeding tendency by use of drugs.

Whole blood would be required in great quantities, primarily to treat the casualties suffering from mechanical injuries and burns, secondarily to treat victims of ionizing radiation.

It has been estimated that for a catastrophe such as at Hiroshima approximately 250,000 pints of blood would be needed, 80,000 per week for the first 3 weeks. Subsequent to this, there would be only a nominal requirement for whole blood. This time relationship favors the possibility of obtaining blood from donors, processing it, and transporting it to the operations area, as is envisaged in the blood program of the American Red Cross.

Equally, the time factor would permit evacuation of victims to unbombed areas where better nursing care, so essential to recovery, could be better provided.

After effects of radiation exposure

Many people who recovered from radiation sickness itself afterward died from tuberculosis, pneumonia, or some other disease which appeared as a complicating factor during that illness. No unusual ill effects directly attributable to ionizing radiation have occurred among Japanese survivors. Whether or not such after effects will occur among these survivors will have to be answered in the future. There are two possible after effects from radiation exposure that cannot be fully assessed for many years—effects on heredity, and effects on fertility (occurrence of sterility).

Since the demonstration in 1927 that X-rays increased the natural rate of mutations in the fruitfly, there has been much interest in the possibility of similar effects of radiation on man. Mutations have been produced in a variety of plant and animal forms by acute as well as chronic exposure.

Mice bred up to six generations while continuously exposed to 1.1 roentgen daily of gamma radiation from radium gave normal litters and had normal life span. Mice exposed to 8.8 roentgens per day, up to a total dose of 880 roentgens for females and 1,100 roentgens for males, showed no genetic changes in the first generation offspring. Single doses of 1,500 roentgens delivered to the testes of mice have produced gene mutations, both by radiation of the mature sperm present, and by changes in the sperm-forming cells, abnormalities of the feet, retardation of growth, and anemia appeared in the offspring.

From these and other investigations, it is found that the likelihood of parents having deformed children after suffering sublethal amounts of ionizing radiation is very slight.

Genetic effects

A study of the Atomic Bomb Casualty Commission in Japan deals with possible effects of massive radiation doses on human heredity. Any genetic effects among the Japanese at Hiroshima and Nagasaki will show up in the offspring of exposed people though possibly not until the second and subsequent generations. No such effects have been observed up to this time. Perhaps 25 years must elapse before reliable information can be obtained about the effects of radiation exposure upon heredity following atomic bomb explosions.

Sterility

Another Casualty Commission study deals with the fertility of the Japanese affected by atomic bomb radiations blasts. Ionizing radiation can cause permanent sterility, but it appears to require about 400 roentgens—the range of the median lethal dose. Temporary sterility occurred among many Japanese, both male and female, but the vast majority of them have returned to normal. It cannot be stated that all returned to normal because investigators do not know how many of them were sterile from other causes before the bombing. Many have produced normal children since their illness.

Cataracts

No significant development of cataracts—a growth which makes the lens of the eye opaque and causes blindness—has been noted among the Japanese as a result of exposure to radiation although a few have been recently observed. Full evaluation of this hazard must wait on lapse of sufficient time for full development and investigation.

Injury zones in atomic burst

Radiation injury sufficient to cause acute radiation illness will occur frequently for wholly exposed persons even a mile from ground zero. Exposed people 1,400 yards away will receive the LD–50 dose of gamma radiation which will cause the death of about half of them. Under 1,000 yards, exposed people will certainly be killed. Neutron radiation would prove lethal up to 500 yards, but all people so exposed would equally receive a lethal dose of gamma rays.

In the following section, types of injuries to be expected at various distances from ground zero, as judged by effects in Japan, are given in summary. Measurements are of the radius of concentric circles whose center is ground zero—directly below the point of explosion. The effects in these zones will depend somewhat on local factors, especially such topographical features as hills, and the change from one zone to another is gradual rather than abrupt.

Half-mile radius

Within a half-mile of ground zero when the atomic bomb is similar to those used against Japan and detonated about 2,000 feet in the air, the following will occur:

The blast pressure created by the bomb explosion would demolish all structures not of reinforced concrete or steel construction. Even buildings of this type would suffer 70 percent destruction. Persons not sufficiently protected by shelter able to withstand the blast would undoubtedly be killed by falling buildings or flying wreckage.

Intense thermal energy generated by the explosion would cause fatal burns to unprotected persons and would start fires in the wreckage.

Because of the concentration of ionizing radiation nearly everyone not protected by earth, steel, or thick concrete would die. The most serious cases would succumb within a few hours to 4 or 5 days after exposure. A second group would develop susceptibility to infection due to destruction of their white blood cells and would die from 4 days to 6 weeks after exposure. Another group would incur multiple hemorrhages and die within 2 to 3 weeks from this cause.

One-half to one mile

Structural damage due to blast and fire would be general in the area outside the half-mile circle and up to one mile from ground zero. Residential buildings would be almost destroyed. Only fire and shock-resistant buildings would be immune to any appreciable extent. Casualties from flame burns, blast effects, and injuries due to falling debris and flying glass would consequently be prominent.

Second or third degree flash burns would be suffered by people not protected.

Injury from ionizing radiation also would be serious, but as the distance from the explosion point increases, shielding is more effective in lessening of damage from the rays.

One to one-and-a-half miles

Beyond a mile, blast damage would still be extensive to residential structures. Fire damage would be extensive in inflammable areas. Flash burns can be expected at this distance. Secondary injuries remain fairly prominent, in the absence of protection by natural or artificial barriers. At Nagasaki, steep hills sharply limited the effects of blast and fire.

Radiation could be expected to be very prominent among the causes of injury up to approximately one and a quarter miles from ground zero. After that distance, such cases drop off sharply.

One-and-a-half to two miles

At Hiroshima the average limit of heavy structural damage was roughly 2 miles from ground zero. The limits of fire damage would roughly coincide with this boundary, except where wind causes wider effects.

Flash burns will not be so severe in this area.

Although some Japanese at Hiroshima and Nagasaki who were ill of radiation sickness were reported to have been as far away as 1½ to 2 miles, observations at tests held since then indicate this is impossible.

Over 2 miles

Structural damage due to blast and fire is appreciably lessened beyond 2 miles from ground zero and secondary injuries correspondingly decrease. The maximum distance of a recorded structural damage at Hiroshima, however, was 4.1 miles.

Radiation injury and flash burns would be insignificant in this zone.

Radiological Contamination

The radiation dangers discussed so far are those affecting people exposed to immediate injury from the explosion of the bomb. Under certain conditions, radiological contamination could become a dangerous after-effect of the explosion. A high air burst, on a clear day, probably would produce no dangerous contamination at all on the surface of the earth—it did not in Japan—and people could enter the area even directly under the point where the bomb exploded immediately afterward without danger from this source. This is because most of the residual radiation is swept up into the atomic cloud by the in-rush of wind that follows the explosion and is afterward dispersed into the general atmosphere. Most of this radioactive material will eventually fall to the earth but will be so dispersed and diluted that it will rarely, if ever, be hazardous. Heavier particles will fall first, so the greatest outfall will be concentrated immediately downwind from the explosion point. Here, again, no hazard occurred after the Japanese explosions.

A burst close to the surface, or under water, would increase the amount of contaminated material. When a base surge occurred, heavy contamination might be expected. The amount of such residual radioactivity, and how long it would continue to a degree dangerous to people, would depend upon many and variable factors, which are discussed in other reports of this series. Residual radioactivity can be detected and measured by trained teams using Geiger counters and similar devises, and their measurements would determine when and for how long it would be safe to enter a contaminated area.

Residual radiation could come from three different sources: (*a*) *Fission products* produced by the splitting of atoms in the bomb explosion and deposited on the surface; (*b*) *unfissioned uranium or plutonium* so deposited; and (*c*) *Materials made radioactive* by the radiation emitted during the explosion and either already on the surface or afterward deposited there. The radiation danger during the explosion comes from neutrons and gamma-rays. Residual radiation does not include neutrons but comes from gamma-rays and from two other types of nuclear particles—alpha and beta. The latter two are chiefly dangerous when emitted by material lodged inside the body, but they can injure the skin when they strike the outside of the body.

Alpha particles, which are positively charged helium nuclei containing two protons and two neutrons, have tremendous ionizing power—the factor which causes injuries to peoples' bodies—10,000 times that of gamma-rays. But alpha particles will be stopped by an inch or two of air, by a sheet of paper, or by the surface layer of the skin, which they affect very much like a burn. Alpha particles are emitted by unfissioned uranium or plutonium but, of these two, uranium is only moderately radioactive and so is not a serious hazard. Plutonium, however, is several thousand times more radioactive than uranium and would be dangerous in contact with the skin or especially if lodged inside the body.

Beta particles, which are negatively charged electrons, have 100 times the ionizing power of gamma-rays but can travel only a few yards through the air. Ordinarily, they also can be stopped by a sheet of paper or by clothing, and wi penetrate only about a fifth of an inch into the skin, which they affect very much like a burn. Beta particles are emitted, along with gamma-rays, by fission products and other materials made radioactive by the explosion. The gamma-radiation would be the chief external radiation threat, but would be even more dangerous if the substances were taken into the body.

Thus, while the bomb burst is a direct radiological menace exclusively because of external whole body radiation, residual radiation is dangerous not only as a source of external radiation, but also internally, if taken accidentally into the body in any quantity and lodged there. Under such conditions, internal radiation can cause acute radiation illness if widely enough distributed, can destroy or hamper vital functions of the body, or can cause cancer. These two types of residual hazard, external and internal, are discussed separately.

Internal radiation

Radioactive materials can enter the body through the mouth, through breathing, or through a wound. They are particularly destructive when retained in the body for some time. Alpha and beta particles, which can be stopped by the skin, meet no such barrier inside the body. If lodged there, materials that emit these particles can cause serious damage. In evaluating the radiation hazard from these sources, three main factors must be considered:

First.—The chemical characteristics of a radioactive element are important, because they determine in what organ the material is likely to be deposited. Materials that behave chemically like calcium will be deposited in bone. Plutonium and strontium are two such elements.

Second.—If a material is taken in through the mouth, its solubility in body fluids is important. What chemical forms are we dealing with? How much is absorbed from the gastric intestinal tract? Fortunately, most of the fission products are quite insoluble and will not be absorbed in significant amounts. Compounds of strontium, barium, and iodine are the most soluble. Plutonium exists usually in the form of an oxide and only about five-hundredths of 1 percent of the amount ingested is fixed in the body. Swallowed materials must gain access to the circulating blood before they can be deposited in an organ. Thus, even in the stomach and intestines, they are for all practical purposes still outside the body as far as radioactive poisoning is concerned.

Once plutonium enters the blood stream, it may be carried to all parts of the body, and much of it is deposited in the liver, spleen and bone. The most significant points of deposit, as far as serious injury is concerned, are close to the blood-forming tissue in the bone marrow. Here, because of the tremendous ionizing power of its alpha particles it is a constant source of injury to the adjacent tissues. If it remains in the body long enough, the injury will result in the formation of malignant tumors and severe anemia.

Third.—The length of time materials remain in the body depends upon their "biological half-life"—the time required by the body to lose one-half the radioactivity by decay and the body's regular processes of elimination. This varies from hours to years with the different elements. In the case of plutonium, the biological half-life is 50 years. The amount of plutonium deemed safe to have fixed in the body has been considered to be one microgram (a millionth part of one twenty-eighth of an ounce), but further analysis may show that this should be lowered by a factor of 10.

The plutonium hazard

The amount of plutonium scattered after a high burst of an atomic bomb on a clear day may be considered inconsequential. Even after a much lower burst, contamination is negligible: one would have to swallow the surface contamination contained in an area of several square yards to get a dangerous amount. The situation probably is not greatly different when atomic bombs are exploded in other ways.

Drinking water contamination

Much concern has been expressed regarding the contamination of drinking water. In a high air burst on a clear day, the fall out of radioactive materials is so small that dilution by the water probably ensures safety. The efficiency of the filtration plants, and the distance of sources of supply from cities are further safety factors. Fission products and fissionable material have a tendency to adhere to any organic material with which they come in contact. They will cling to the banks and the bottom of lakes, to the pipes, and other material to such a degree that it is probably that very little would ever reach the populace. Water containing one-millionth of a curie of fission products per liter is considered safe for drinking. (This means that about one atom in 250,000 billion billion is disintegrating every second.) Many popular mineral waters contain more than this. Hazards in the case of a storm or base surge remain to be evaluated. Testing for radioactivity is advisable. At Bikini, sea water from a heavily contaminated source was distilled (that is, turned into steam and condensed, not merely boiled) and found safe for drinking purposes.

Inhaling radioactive particles

As to the hazard of inhaling particles of matter, the size of the particle is important. The nose filters out almost all particles larger than 10 microns in size (one inch equals 25,000 microns). It will filter out 95 percent of all particles over 5 microns in size. The size at which particles most readily pass from the small air pockets of the lung into the blood stream is about one-half micron. Particles 1 to 5 microns in size may, however, reach the lymphatic system.

At a bomb burst, contaminated particles of this size—the largest only one five-hundred thousandths of an inch in diameter—ascend rapidly into the atmosphere. If they settle, as on a rainy day, they usually attach themselves immediately to larger particles. The chances of inhaling a dangerous amount of these small particles is small. A combat-type gas mask will filter out 99.999 percent of all such particles.

Contaminated wounds

If someone is wounded while in a contaminated area, the hazards of the situation will depend almost entirely upon the amount and kind of contamination present, and the extent to which the contaminated material is soluble in body fluids. It is difficult to conceive of a situation in which a sufficient amount of contamination would be present to endanger life by this means of exposure, although material introduced into the blood is fixed in the body in a very short time.

Such a wound should be cared for in the same manner as any similar injury in an uncontaminated area. Cleansing with soap and water is particularly important, and cutting out of damaged tissue. The wound should then be closed. Amputation is not indicated.

External radiation

The chief external radiation hazard in a contaminated area will come from gamma-rays thrown off by fission products or by materials made radioactive by neutrons or gamma-rays during the explosion. Alpha and beta radiations will be dangerous chiefly if they come into actual contact with the skin, but it will be necessary to guard against contaminated dust. Filter-masks, clothing tight at the wrists, ankles, and neck, and tight-wristed gloves will afford protection against alpha and beta particle contamination. Material heavily contaminated with beta-emitting material should not, however, be handled even with gloved hands since it can cause severe burns. Tongs or equivalent instruments should be used. Clothing should be discarded at the edge of the contaminated area to avoid spreading radioactive contamination. Thorough soap-and-water bathing would be a valuable precaution.

Bodies that have been exposed to radiation can be safely handled.

Gamma radiation cannot be turned aside by such simple measures as protective clothing, but dense material, such as concrete, can reduce its ionizing effect. Three inches of concrete will cut the amounts of gamma radiation by half, and the customary 9-inch concrete wall used in construction would reduce gamma rays to one-eighth their original potency. However, the gamma radiation from a bomb is measured in thousands of roentgens and, even at distances of 1,000 yards from ground zero, 21 inches of concrete would be necessary to cut down gamma rays enough to prevent serious radiation injury. Gamma radiation from contamination will not approach the power of direct bomb radiation, but it still can be severe. The best protection against contamination that gives off gamma radiation is to use instruments to detect its presence and to avoid any dangerous concentration.

What is a dangerous concentration of ionizing radiation? There is a general agreement that, wherever possible, it is desirable to avoid all exposure to ionizing radiation. This, of course, is impossible. Radiation exists everywhere in the world; it comes from radioactive material distributed throughout the earth's crust but its chief source is the bombardment of the earth by cosmic rays from the sky. Human life has always been exposed to this radiation.

In the atomic-energy program, a standard has been set—called the maximum permissible dose—which stipulates an exposure which experts believe a man could experience every day in his life without danger of injury. This has been fixed at a maximum of one-tenth of a roentgen a day with a weekly maximum of three-tenths of a roentgen. But this standard applies to *daily* exposures—a very different matter from a one-time exposure in emergency. Thus, in the course of a medical study of a disease of the stomach or intestines, a patient may be exposed to some 40 roentgens in undergoing a series of X-ray examinations. X-rays of the teeth may subject the patient to about 2 roentgens. It is clear that a person may be subjected to a one-time exposure of many times the daily "maximum permissible dose" without suffering injury.

In emergency operations, a person could probably be exposed to 50 roentgens of total body radiation without incurring injury and be able to continue at his duties. A person exposed to 100 roentgens might have some nausea and changes in the number of blood cells, but most likely would be able to continue at his normal duties. Those exposed to 200 roentgens probably would become incapacitated after the injuries suffered began to take effect—probably a matter of some hours. In rare cases, as stated earlier, 200 roentgens might ultimately cause death.

While acute exposures of 200 roentgens and more will result from atomic bomb explosions, radiation of this degree will rarely result from residual contamination deposited by a bomb. The rate of exposure is of considerable importance. A person who receives 600 roentgens in a single exposure within a period of a few minutes will have small chance of survival, but if a man received only 30 roentgens a day it probably would take a total of as much as 1,800 roentgens to prove fatal.

* * *

The medical aspects of atomic bomb explosions have been presented here only in summary, but the main factors that must be considered have all been touched upon. In future publications, a more technical and detailed analysis of the problems involved from the medical man's viewpoint will be presented.

The summary indicates clearly that a major task for medical authorities will be the care of blast and burn injuries; that a main problem will be caring for patients in numbers that would swamp the normally available facilities, even in the improbable circumstance that facilities were not appreciably damaged. Dispersion of facilities thus becomes important as does organization of emergency work over wide areas, so that outside help can come to the rescue of bombed areas, and so that patients capable of being moved can be evacuated to places where they can receive better care.

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DAMAGE FROM ATOMIC EXPLOSION AND DESIGN OF PROTECTIVE STRUCTURES

Prepared for the National Security Resources Board by the Department of Defense and the United States Atomic Energy Commission

This document is issued by the National Security Reserves Board as one of a series designed to meet the current informational needs of Civil Defense Planning Agency representatives of State and local governments, and other citizens interested in the discussion and planning of civil defense.

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Acting Chairman.

FOREWORD

This report assesses in general terms certain effects of atomic weapons. It deals particularly with the damage an air blast would cause to various types of structures and buildings, and building construction to resist these effects. A complete handbook on atomic weapon effects is under preparation by a board of editors organized by the Los Alamos Scientific Laboratory for the Department of Defense and the Atomic Energy Commission. The present report is taken from the material gathered for the comprehensive report on the effects of atomic weapons. This material is based primarily upon the material contributed by Sherwood B. Smith, Office of the Chief of Engineers, United States Army, and Curtis W. Lampson of the Ballistics Research Laboratory, Army Ordnance Department, with the invaluable technical assistance of many other specialists who have advised the Los Alamos Scientific Laboratory in evaluating the effects of atomic weapons.

Wind velocity (mph)	Duration (sec)	Overpressure (psi)	Miles	Feet	Damage
					Limit of light damage at 8 miles.
50	1.25	1.5		12,000	Light damage to window frames and doors, moderate plaster damage, complete window damage.
			2.25		
60	1.23	1.7		11,000	Flash charring of telegraph poles. Roof and wall covering on steel frame building damaged.
			2.0		Partial damage to structures in area.
70	1.20	2.0		10,000	Blast damage to majority of homes. Severe fire damage expected. Flash ignition of dry combustible materials.
			1.75		
80	1.15	2.4		9000	Heavy plaster damage.
					Moderate damage to area.
100	1.12	2.9		8000	Severe damage to homes, heavy damage to window frames and doors, foliage scorched by radiant heat.
			1.50		
125	1.06	3.6		7000	
					Structural damage to multistory brick buildings. Roof tiles bubbled (melted by heat).
			1.25		
160	0.98	5.2		6000	Severe damage to entire area. Severe structural damage to steel frame building. 9-inch brick walls moderately cracked.
					Electrical installations and trolley cars destroyed. Multistory brick building completely destroyed.
			1.0		
200	0.90	7.4		5000	12-inch brick walls severely cracked.
					Steel frame building destroyed (mass distortion of frame). Light concrete buildings collapsed.
270	0.77	10	0.75	4000	Reinforced concrete smoke stack with 8-inch walls overturned.
					18-inch brick walls completely destroyed.
380	0.62	16		3000	
			0.50		Virtually complete destruction of all buildings, other than reinforced concrete aseismic design.
550	0.45	24		2000	Limit of severe structural damage to earthquake-resistant reinforced concrete buildings. Reinforced concrete building collapsed, 10-inch walls, 6-inch floor.
					Mass distortion of heavy steel frame buildings. Loss of roofs and panels.
			0.25		
800	0.37	36		1000	Decks of steel plate girder bridge shift laterally.
				0	Air Burst of an Atomic Bomb.

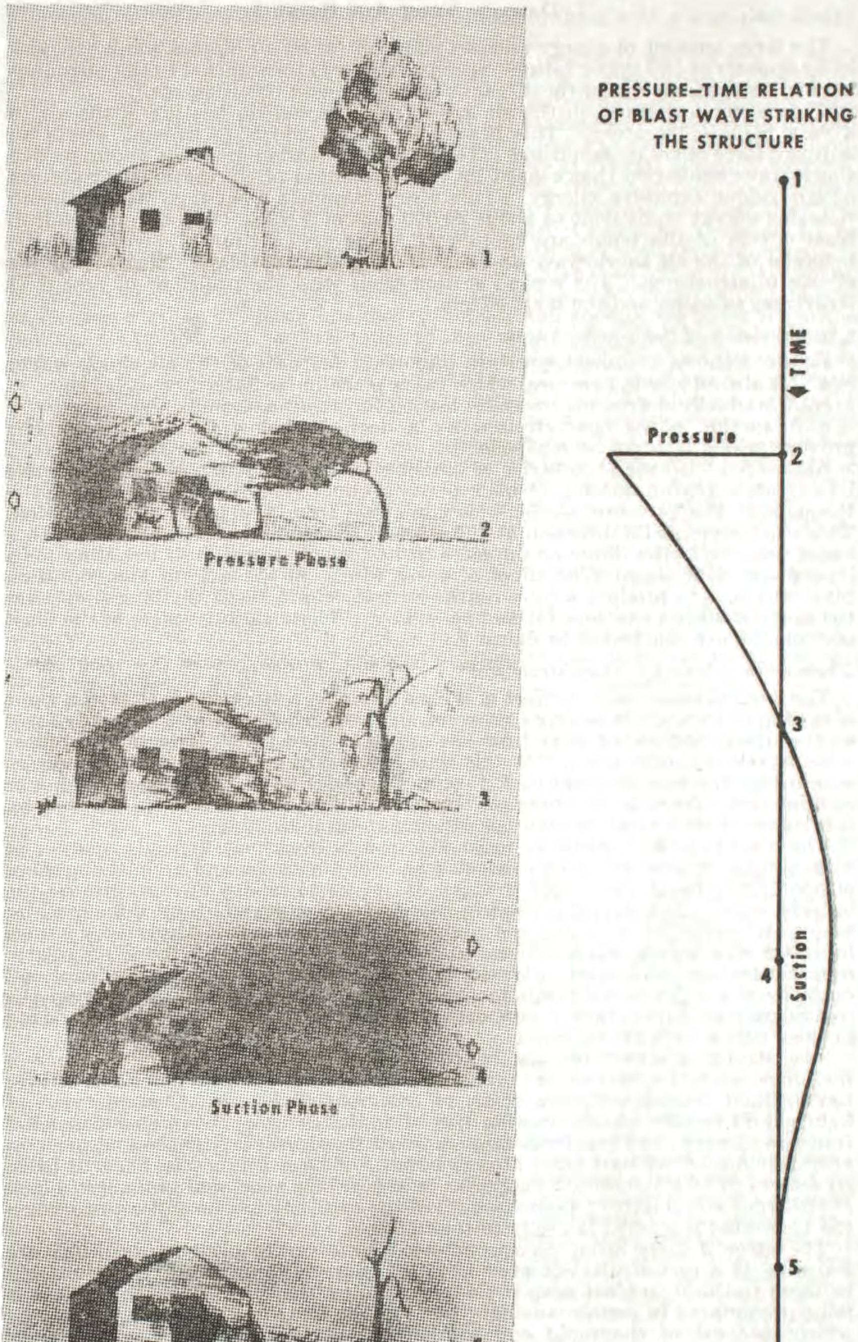

FIGURE 1.—*The effect of a blast wave striking a structure.*

I. Damage From Air Blast

The large amount of energy released suddenly when an atomic bomb explodes in air appears in two major forms—*mechanical energy* transmitted to the surrounding air, and *radiant energy* (heat, gamma rays, nuclear particles, etc.).

The mechanical effect on the air arises from the sudden heating of the air to a very high temperature. This heated air, in its efforts to expand, exerts an outward force of great magnitude. The sudden expansion produces a compressive shock wave similar to that caused by the detonation of conventional explosives of equivalent explosive energy. This report assumes a nominal atomic bomb releasing energy equivalent to about 20,000 tons of TNT. Only the mechanical, blast effects of the bomb are considered. The first section is devoted to the behavior of the air shock wave and the damage it is capable of doing to various classes of structures. The second section deals with the problems of designing structures to withstand the blast effects.

Characteristics of the air shock wave

Figure 1 shows graphically certain important features of the air shock wave:

a. An abrupt rise in pressure, which takes place immediately.

b. A gradually decreasing pressure, lasting for about a second.

c. A suction phase characterized by a decrease below normal atmospheric pressure which lasts for several seconds.

Associated with the abrupt rise of pressure in the first phase of the blast wave is an intense wind velocity which persists—but with diminishing velocity—throughout the pressure phase, blowing away from the point of detonation. This wind reverses its direction at the start of the suction phase, blowing with a lesser velocity in the direction opposite to its former course, but persisting for a longer period of time. The effect of these winds, in the case of long duration blast waves, is to produce a force on the structure for a relatively long time after the shock front has enveloped it and passed by. These various stages of the blast phenomena are illustrated in figure 1.

The nature of blast effects on structures

The general nature of the effect of a blast wave on a structure is that of a giant blow due to the sudden onset of pressure, followed by a more or less steady force on the structure directed away from the source of blast which lasts until the blast wave envelops the building. At this time a pressure builds up on the opposite side of the structure (exerted back toward the blast) and adds a net squeezing or compressional force to the over-all structure unless the pressure is relieved by the failure of doors and windows or other structural members.

The ability of a building to resist this rough treatment depends mainly, of course, upon its strength, to a lesser degree upon its shape, and upon the number of openings through the building which can serve to relieve the pressure on the outside walls. The strength, used in this sense, is a general term influenced by many factors, some of which are obivous and others not. The most obvious indicator of strength is massiveness of construction, but this is modified greatly by other factors not immediately visible to the eye, such as (*a*) the resilience and ductility of the frame, (*b*) the strength of beam and corner connections, (*c*) the redundancy or duplication of supports, and (*d*) the amount of diagonal bracing in the structure.

The strongest structures are heavily framed steel and reinforced concrete buildings, while the weakest are probably certain shed type commercial structures having light frames and long spans of unsupported beams. Certain types of lightly built residential construction also fall in this category, but well-constructed frame residences show good resistance to blast from ordinary bombs and presumably would also to blast from atomic bombs. The resistance to blast of brick structures in which the walls support a load is rather poor, due probably to lack of resilience and relatively poor strength of the connections put under stress when the blast-load is applied laterally to the building.

The effect of shape is not very pronounced in conventional structures which are generally of a rectangular plan form, but of course a long narrow structure will be more resistant to blast against the end than on the side. The shape effect is most pronounced in certain auxiliary parts of the structure such as smoke stacks which, because of the rapid equalization of pressure around them and their relatively low wind drag, are surprisingly resistant to blast; these frequently remain erect when the structures adjacent to them are leveled to the ground. On the other hand, flat surfaces such as windows in an extensive wall surface will have no rapid relief of pressure except by breakage and, having a short period of vibration, will have a maximum of strain induced in them with a high probability of failure even at comparatively low blast pressures.

Recognizing that substantial variations in blast resistance will occur as a result of differences in building design and construction, it is nevertheless possible to draw significant conclusions from a table of expected damage versus distance, assuming that the strength of the structures approaches what may be termed an average value. Damage information given in table I was prepared largely from data acquired by exhaustive surveys of the damage at Nagasaki and Hiroshima. The numerical values are calculated. Differences from our own construction practices may produce some discrepancies, but it is not believed that they will be very significant. Certain of the Japanese structures were designed to be earthquake resistant, which probably made them stronger than their counterparts in this country; other construction was possibly lighter than our own. However, contrary to popular conceptions concerning the flimsy characteristics of Japanese residences, a group of highly qualified architects and engineers who surveyed the damage concluded that the resistance to blast of American residences in general would not be markedly different from that observed in these cities. Examination of table I indicates that for a nominal 20,000-ton TNT equivalent energy atomic bomb, the categories of damage together with their radii and areas will be as follows:

a. Virtually *complete destruction* will occur out to a radius of approximately one-half mile from the ground zero point when the bomb is exploded at about the optimum height (assumed 2,000 feet) to cause the maximum of destruction. This area of destruction will be approximately three-quarters of a square mile.

b. Damage ranging from *severe to destructive* will occur out to a radial distance slightly in excess of a mile from ground zero, which corresponds to an area of 4 square miles. Severe damage is defined as major structural damage resulting in collapse or liability to collapse of the building.

c. Moderate to destructive damage will occur out to a radius of about 1⅝ miles, corresponding to an area of 8 square miles. Moderate damage is defined as damage that is short of major structural damage but sufficient to render the structure unusable until repaired.

d. Partial damage will be inflicted out to a radius of approximately 2 miles. This adds 4 square miles of damage area, making a total of 12 square miles subject to some degree of damage more severe than plaster damage and window destruction.

e. Light damage, which is mostly plaster damage and window breakage, may extend out to a radius of 8 miles or more, encompassing an area of about 200 square miles. Actually these distances at which window and light plaster damage will be inflicted vary markedly with the meteorological conditions at the time of detonation. It is possible to have a "focusing effect" which can produce appreciable damage at quite remote distances. This effect would depend on a set of meteorological conditions which exist occasionally over extensive areas of the United States.

The distances and areas of the various classes of damage cited above are based on the nominal atomic bomb mentioned earlier. Larger bombs would cause greater damage, but a bomb of twice the size—40,000 tons TNT energy equivalence—would not double the area, but would increase it by about 60 percent. The radii of the various zones of damage would be increased by about 25 percent.

Ground shock damage from an air burst

The burst of an atomic bomb in the air at a height that gives maximum air blast damage exerts a fairly large reflected pressure, of the order of 25 to 50 pounds per square inch, on the ground directly underneath the point of burst. This pressure exists for a period of time equal to the duration of the blast wave itself, although the rate of dissipation with time would be more rapid.

Applying such a load suddenly to the ground surface causes it to act somewhat like a bowl of jelly does when a finger is placed rather gently but suddenly in the center. The surface waves radiating out from the center produce what is termed "ground roll," which in the case of an air burst is a rather minor oscillation of the surface sufficient to be felt but insufficient to cause any damage. However, the pressure acting on the earth's surface will be transmitted downward, with some attenuation, to any superficially buried object in the ground. These pressures might damage certain structures having shallow depths of burial, but air-raid shelters could be designed to withstand such pressure.

In general it can be said that the ground shock effects from an air bomb burst will probably be negligible at a distance, and even directly underneath the burst moderately strong underground structures will be undamaged.

Shallow burial may not be enough protection to prevent certain public utilities such as tile sewer pipes and drains from being damaged by earth shock, but metal piping would probably not be harmed except where it was exposed to disruption by damage to surrounding structures resulting from air blast.

Structural factors which influence blast resistance

The general effect of blast on structures varies with a number of factors—the distances from the explosion, the direction and vertical angle from the explosion, the shape and size of the structure, and the equalization of pressure by local failure such as window breakage.

EFFECTS OF BLASTS ON STRUCTURES

The preceding general discussion of blast phenomena will be useful in the more detailed consideration that follows of the effects on buildings, bridges, utilities, and housing. The probable effect of blast resulting from explosion of a nominal atomic bomb on various types of structures and utilities will be taken up in turn. Experience in Japan will be our primary guide but it is also necessary to consider structures of types that were not found in the blasted area and differences in construction practice which would affect comparative results in Japan and this country.

Very careful surveys were made of the areas affected by the atomic bomb in Japan. Small masonry buildings were engulfed by the oncoming pressure wave and collapsed completely. Light buildings and residences were completely demolished by blast and fire. Manufacturing buildings of steel construction were denuded of roofing and siding and only the twisted frames remained. Everything above ground at close range was destroyed, except reinforced concrete buildings and smoke stacks. Some buildings which, at a distance, appeared to be sound were found on closer inspection to be damaged and gutted by fire. Some buildings leaned away from ground zero as though struck by a hurricane of unusual violence.

There were many evidences of the effect of radiant heat in starting fires and in scorching and drying out materials that were not highly combustible. Telephone poles were charred and granite surfaces were etched by heat and by the sand blasting effects of the high winds carrying abrasive material. All vehicles at close range were damaged by blast and were burned out.

Many telephone poles were snapped off at ground level, carrying the wires down with them. Gas tanks were ruptured and collapsed and exposed gas mains across bridges were broken. Most important, water pressure was lost due to the break-up of pipes leading to buildings and houses and of mains across bridges. This breakage increased greatly the additional hazard of fires. The following paragraphs contain discussions of the details of this blast-inflicted damage.

Multistory reinforced concrete frame buildings

There were many building of this type in Hiroshima and a smaller number in Nagasaki. They varied in resistance to blast according to design and construction but generally suffered remarkably little damage, particularly those designed for resistance against earthquakes. After the severe earthquake of 1923 a code was established for all new construction to reduce earthquake damage. The height of buildings was limited to 100 feet and design for a lateral load of one-tenth the gravity load was required. In addition, the recognized principles of stiffening by diagonals and inproved framing to provide continuity were specified. The more important buildings were well designed and constructed according to the code, but some were built without much regard for its requirements.

Close to the explosion, the vertical component of blast was more important than the lateral (sidewise), so that there was heavy damage caused by the downward force exerted on the roof. Depending upon its strength, the roof was pushed down and left sagging or failed completely. The remainder of the structure was less damaged than similar buildings at greater distances because of the lesser horizontal force.

At greater distances the lateral force was proportionately greater and produced these effects:

a. Buckling and failure of the roof slab by lateral compression.—This was apparently caused by the force applied to the side of the building which in turn was transferred to the roof, tending to push it back. Since the roof was restrained by connections to less affected portions of the building, it failed in compression.

b. A similar failure in floor systems.—Failure usually occurred in the bay between the first row of interior columns and the affected wall. Buckling was usually upward.

c. Cracking of concrete and overstressing of concrete and steel at haunches and connections.—This effect was apparent in a large number of buildings and is readily explained by the tremendous lateral force applied.

d. Failure of columns by shearing action.—Columns in the first story were cracked diagonally. This was probably caused by the higher shearing force in the first story resulting from the lateral pressure on the building. Since these columns would receive a heavier lateral force than those above, it is quite natural that they would fail first.

e. Failure of exterior walls.—On the side toward the blast, walls were dished inward. The degree of such action depended upon the distance from ground zero, the strength of the wall, and the number of windows which, by breakage, assisted in equalizing pressure rapidly.

f. Failure of floors.—Floors were most affected by direct blast in those cases where pressure equalization was not possible. For example, the floors over enclosed basements were pushed downward when higher floors were undamaged.

g. Miscellaneous effects.—In addition to the above structural damage, there was heavy damage to false ceilings, plaster, and partitions. Such damage occurred in varying degrees out to a distance of 12,000 feet in Nagasaki. Glass window panes were blown out as far as 12,000 feet from ground zero. This type of damage is extremely important because of the large number of casualties caused by missiles and flying glass.

Multistory steel frame buildings

There was only one building of this type on record. This was in Nagasaki at a distance of 4,750 feet. The roof was dished 3 feet but the remainder of the frame was largely unaffected. The only part of the structure not classified as being of heavy construction was the roof, which was of thin concrete supported by unusually light steel trusses. The downward failure of the roof was the only structural damage in the building. Reinforced concrete buildings at the same distance were undamaged. However, it is difficult to draw any conclusion as to relative resistance of the two types.

Steel industrial buildings

In Nagasaki there were many steel buildings used for manufacturing; these were generally of the shed type, with some of the saw-tooth design. Roofs and siding were of corrugated sheet metal or asbestos cement. In some cases there were rails for heavy gantry cranes, but most cranes were of low capacity. Construction was generally comparable to that in the United States. The first effect of blast was to strip off the siding and roof material. Since this did not occur instantaneously, a large impulsive force was applied to the frame. Severe damage occurred up to a distance of 6,000 feet.

There were several types of failure of such structures. At close range the buildings were pushed over bodily, while at greater distances they were left leaning away from ground zero in many cases. The columns, being long and slender, offered little resistance to the lateral force. Sometimes columns failed by a combination of lateral force that caused flexure and, at the same time, an increased downward load from the vertical component of blast on the roof. This caused buckling and collapse. Roof trusses were buckled by compression resulting from blast on the exposed side of the building.

A difference was noticed in the effect on the frame depending upon whether a brittle material like asbestos-cement or a material of high tensile strength such as corrugated sheet iron was used for roof and siding. Asbestos-cement broke up more readily and transferred less force to the steel frame with less structual damage.

Fire produced heavy damage to unprotected steel members so that it was impossible to tell exactly what the blast effect had been. In general, the steel frames were badly distorted and would have been of little use even though siding and roofing material had been available for repairs.

Other types of industrial structures

Wood trusses were also used to support the roofs. These were more vulnerable to blast because of poor framing and connections and were readily burned out by fire. Concrete columns were used in some cases with steel roof trusses. The concrete columns were more resistant to buckling than the steel.

Machine tools.—Damage to machine tools was caused by debris, particularly in reinforced concrete sheds, by fire in wood frame structures, and in all cases by dislocation and overturning caused by damage to the structure. In many cases the machine tools were belt driven, so that the distortion of the building pulled the machine tool off its base, damaging or overturning it.

Stacks.—Stacks are of special interest. Those of reinforced concrete were particularly resistant to blast. This can be accounted for by the shape and small cross section, which permitted the blast to equalize quickly, by their long periods of vibration, and by their inherent strength. Steel stacks stood up fairly well, but, being lighter in weight and subject to crushing, were not comparable to reinforced concrete. Well-constructed masonry stacks also withstood damage reasonably well.

Building with load-bearing walls

Smaller buildings of this type with light walls collapsed. Large buildings with cross walls and of somewhat heavier construction were more resistant but failed at distances up to 6,200 feet. Even when the building remainded standing, cracks were observed at the junction of cross walls and side walls.

Timber-Framed Buildings and Housing

While the quality of the workmanship in wood buildings was high, little attention was paid to engineering principles. Mortise and tenon joints were weak points and connections in general were poor. Timbers were notched excessively or splices were put in improper locations. In general the construction was not well adapted to resist wracking or twisting action. Housing collapsed at Nagasaki up to a distance of 7,500 feet and there was structural damage up to a distance of 8,600 feet. Roofs, wall panels, and partitions were damaged out to a distance of 9,000 feet.

Bridges

There were a number of kinds of bridges exposed in Hiroshima and Nagasaki. Those of wood were burned in most cases but the steel girder bridges came through remarkably well. One was only 260 feet from ground zero. It was a girder type and had a reinforced concrete deck. There was no sign of any structural damage. The spans had apparently been deflected by the blast and had rebounded, causing a slight movement. Other bridges at greater distance suffered more lateral shifting. A reinforced concrete deck was lifted from the supporting steel girders of one bridge, presumably by force of the blast wave reflected from the water below.

Utilities

In Nagasaki the public utility system was comparable to that in an American city of 30,000 population, except that open sewers were used.

Damage to the water supply essential for firefighting was of the greatest significance. Except for one case, this was caused not by failure of the underground mains but by loss of pressure through breakage of pipes in houses and buildings. In one filled-in area, surface depressions up to 1 foot in depth were observed at scattered points as far as 2,000 feet from ground zero. This caused a series of failures of 12-inch cast iron water pipes 3 feet below ground. This breakage was probably caused by unequal vertical displacement. There was no serious damage to reservoirs and water treatment plants as they were located at too great a distance from ground zero.

Overhead utility poles were broken close to the ground by blast, and overhead utilities were heavily damaged at distances up to 10,000 feet. Underground electrical conduits were little affected. Switch gear and transformers were not damaged directly by blast but by secondary effects such as collapse of the structure in which they were located or by debris. Motors and generators were damaged by fire.

Gas tanks were heavily damaged by blast at 6,600 feet; the escaping gas was ignited but there was no explosion. Gas mains suffered no observable damage except where exposed over bridges. Street railway equipment was heavily damaged by fire and blast. Buses and automobiles in general were damaged by blast, and were burned out at shorter distances. As an example, an American-made car was heavily damaged and burned at 3,000 feet while one at 6,000 suffered only minor damage.

Shelters

Caves were used for shelter to a large extent, but there were many timber, semiburied shelters with earth cover. The semiburied shelters were not particularly well built, but in some cases they withstood the blast at a distance of 900 feet from ground zero and none was damaged beyond one-half mile.

DISCUSSION OF PROBABLE EFFECTS IN THE UNITED STATES

While the structural effects observed in Japan are comparable in general to what would be expected in this country, some differences are worthy of discussion. Studies of the resistance of small bridges in Japan to atomic blast gives no direct guide to the question of the larger bridges in many American cities.

Reinforced concrete frame buildings

In Japan, reinforced concrete buildings of earthquake-resistant design withstood blast quite well. These buildings were designed for a lateral force equal to 10 percent of the vertical load. When lateral pressure tends to displace the top of the building with respect to the foundation the resulting action is roughly the same as if earthquake forces moved the foundation against the inertial resistance of the structure.

Our multistory buildings in this country are generally designed to withstand wind load only. Therefore our reinforced concrete buildings would be generally less resistant to collapse than those designed for earthquake resistance in Japan. In the 11 Western States of this country, the building codes provide for the design of structures to resist horizontal earthquake forces varying from 2 to 16 percent of the vertical load, which is usually taken as dead weight plus half the vertical design live load. Of the earthquake zones the Pacific coast area has the highest requirements. The earthquake design requirements as stipulated in the building codes are similar to those for wind loads, but call for a 33-percent increase in the allowable working stresses. These buildings would be proportionately more resistant as the percentage of horizontal to vertical design load increases.

Steel-frame buildings

The effect on steel-frame buildings, such as multiple storied office and hospital structures, should be approximately the same as that on reinforced-concrete. Tall buildings having heavy steel frames and a long period of vibration should withstand the effect of blast very well.

Industrial type buildings

Our steel industrial buildings would probably fare no better than those in Japan. The saw-tooth roofs designed as rigid frames would be especially vulnerable to blast damage.

Housing

Tests made on typical housing of wood frame construction with conventional bombs up to 500 pounds, and at various distances, indicate a high degree of resistance against blast beyond 30 feet. While no direct interpretation of these results can be made with regard to the blast from a large explosion which would have quite different characteristics, it is believed that the radius of material structural blast damage from a nominal atomic bomb burst would not exceed 7,500 feet. This is slightly less than the extreme radius in Nagasaki, where severe damage to houses extended in some cases to a distance of 8,500 feet.

Bridges

In Japan, bridges withstood vertical blast loads very well, and there is no reason to believe that all bridges would not behave in a similar fashion. Lateral loads, even if excessive, would affect the less important structural members of the bridge. The actual lateral loads are difficult to calculate. We are dealing with blast wind velocities that may approach that of sound. It is clear, however, that in this case only the drag pressure will be of great importance, and there will be relatively small effect from the shock wave blast because of the comparatively small size of the members. Wind tunnel tests would be necessary to provide accurate data on drag coefficients.

II. Protective Construction

In planning protective construction, it is reasonable to assume that any prospective enemy would attempt first to destroy our ability to wage war by attacking selected vital facilities. In such an attack the enemy would attempt to do the greatest possible damage with the bombs available and the force he has to deliver them. Conversely, the primary objective from the standpoint of protective construction is to make it as difficult as possible to reduce our war potential. If we could make the enemy expend more effort to produce the same damage, it should be an important factor in the outcome of any future war. In fact, by making our country less vulnerable, we increase our military strength.

With the above general objective in view, this section indicates measures of protection that can be provided by site planning, design of new structures, and modification of existing structures. The effects of the atomic bomb discussed in section I provide a good basis for indicating protective requirements. Of primary interest to the architect and engineer are air blast, earth shock, prompt ionizing radiation, and radiant heat. There is a great deal that can be done to minimize the damage resulting from these phenomena.

New construction affords the best opportunity for the inclusion of measures of protective construction at minimum cost. Location is probably the primary consideration, involving both the existing target value of the surrounding area and the new plant. If the facilities being planned are important to the war potential, they may be dispersed so as to reduce their attractiveness as targets.

Also, it is possible to make structures more resistant to blast, ground shock, and fire, and thus increase the protection afforded to personnel and equipment. For example, blast effect is reduced by strengthening structures, particularly against lateral and downward blast forces, and avoiding types and materials of construction that would be hazardous to occupants when buildings are subjected to violent forces.

Fire hazard is reduced by site planning for new construction; by use of fire-resistant construction; by avoiding exposed inflammable materials which might be ignited by radiant heat; and by insuring adequate means of fighting fires.

New facilities might be placed underground in an existing mine or a site excavated in rock for the purpose. This provides a high degree of protection and the cost is not unreasonable, particularly when an existing mine is used. Studies of European experience and possibilities in this country indicate that for the most vital industrial facilities underground construction is entirely practical. Also, control facilities for civil defense could be placed underground to good advantage.

The effectiveness of various combinations of the above measures may depend upon the particular situation. Therefore it is necessary to evaluate the hazard, the importance of the facility, and the cost of protective measures to decide on the measures to be used. Furthermore, it is necessary to consider the broad problem including civil defense. An atomic bomb explosion will affect a large portion of a city, so that protection of any facility is inevitably linked with that of the community in which it is located. Disaster control is vital, and protective construction measures must insure that services essential for control, rescue, and limitation of fire damage will remain available.

PROTECTIVE MEASURES

With the above general introduction the separate measures that may be employed will be discussed in greater detail. These relate to the broad field of protective construction as applied to industry, city planning, and civil defense. Specific examples are given to indicate what is possible. In general it is assumed that damage within a radius of one-half mile would be so severe as to make protection of above-ground facilities impractical within that area.

It is important to bear in mind that the statements made here concerning types of protective measures that might be employed are simply statements of physical fact. Applying some of these measures, such as dispersion, means far-reaching decisions of policy that will affect many people and communities. This discussion does not go into the policy questions which are outside the scope of this paper.

Dispersion

Dispersion is of primary importance in planning rescue and damage control services in a city. Constant effective control is vital in carrying out rescue operations and limiting fire damage. It may well be that control centers must be located centrally in which case structural protection of the centers would be desirable. However, it appears entirely feasible to have control centers at two or more locations at least 3 miles from the probable target area and thus obtain reasonable assurance that control can be maintained. Control requires adequate and uninterrupted communication with field units to obtain information on casualties and damage, and to direct relief efforts. Since a major disaster may destroy all normal communications facilities, the control center should be able to broadcast from a self-contained power unit.

Duplication

The provision of duplicate services on a stand-by basis is another principle of protective construction. For example, a separate connection to a second power source might be provided and thus duplicate incoming power lines serving a manufacturing plant. To be effective, the lines should be separated as far as possible. It is rarely practicable, however, to have complete duplication. In many cases, it is possible to provide greater assurance of continued operations by partial duplication. For example, there might be a primary control center, complete with all necessary communications and a secondary control center so equipped that it would serve as a primary center in case of damage to the regular primary center. It is quite possible that the extra space and communications over and above that needed for use as a secondary station could be provided at reasonable expense.

Duplication of water supply to the fringes of various areas in a city, assuming loss of pressure in those areas, will be desirable. Similarly, increasing the fire-fighting force and facilities in suburbs of a large industrial city to assure better protection of the city itself might be considered a form of duplication.

METHODS OF REDUCING BLAST HAZARDS IN BUILDING

The most serious danger to persons and equipment in a building is from total collapse. Design to reduce danger of collapse is discussed in the latter part of this section. From an over-all viewpoint, the more important consideration is to reduce the hazard to persons who are in buildings that are able to resist collapse but would be damaged to some extent. A well-attached, reinforced concrete shell on a frame of either steel or reinforced concrete will provide a high degree of protection to persons both inside and outside the building, whereas a lightly attached wall of concrete blocks or bricks will provide almost no protection inside the building and will provide missiles both inside and out. Avoiding danger of injury from flying glass, displaced equipment, falling fixtures, and false ceilings is particularly important.

Flying glass is a serious hazard that should be considered in design. Measures used in protection against conventional bombs, such as muslin glued or pasted over the surface of the glass and frame, would have little value as the long duration of an atomic blast would cause the glass to be blown out anyway. Tentatively, wire glass plus half-inch-mesh wire screening, securely nailed to the frame, may afford a partial measure of protection. This would not cut off light appreciably and would stop the larger, more dangerous pieces of flying glass. Another possible measure would be the use of plastic substitutes for glass.

Consideration should be given to the possible hazard from fixtures and heavier ornamental plaster or other interior treatment that might be thrown down by the blast or wracking action on the building. The safest procedure would be to remove any hazardous item. If this is not fully practicable, such partial safeguards should be provided as may be feasible.

Blast walls of the type provided to localize damage from ordinary bombs will be helpful in reducing injury from flying missiles and will afford some protection against atomic blast. Similarly, walls around transformers and other equipment will be effective in reducing damage. These walls should be of reinforced concrete 12 inches thick and should be made resistant to overturning. This may be accomplished by use of counterforts, providing a wide base, or by use of steel beams incorporated into the wall and extending into the ground. The last method is preferred.

In an industrial plant, there may be requirements for protected areas—for essential control or first-aid facilities—that will provide reasonable safety against blast and radiation injury at a distance of one-half mile from ground zero. A total thickness of about 21 inches of concrete will be required to protect against serious prompt radiation injury at one-half mile. If a first-aid room is to be provided in a steel mill-type factory building, for example, it should be of reinforced concrete of that thickness. Consideration in design should be given to possible debris load, blast pressure, and wracking action. Locations where heavy debris loads might come on the first-aid room should be avoided. In framed structures the roof of the room should be designed for a static load of 500 pounds per square foot to resist debris loads and blast. Walls of the shelter should be designed for a static load of 500 pounds per square foot to protect against blast. There should be no windows, and doors should be designed for the same pressure as the walls. There should be at least two means of exit. Fillets at the corners with diagonal bars to resist wracking action are recommended. Water storage, emergency rations, and emergency lighting will be desirable.

In a city, a protected area on one of the lower floors of a fireproof, well-constructed, reinforced-concrete or steel-frame building might offer the best possibility for a control or first-aid room. The building should be either in a group of fireproof buildings or isolated from other buildings to avoid hazard of a general conflagration. An effective degree of blast protection within such a building could be provided by enclosing a properly located area with a 12-inch reinforced-concrete wall, anchored to the floor to prevent displacement and braced or secured at the top to prevent overturning. It is believed, in this case, that the blast pressure inside the building would be considerably reduced and that a 12-inch thick wall would be adequate at a distance of one-half mile. It is assumed here that the exterior walls of the building would have a protective value against prompt radiation equivalent to 9 inches of concrete, which together with the special area wall, would provide a total effective thickness of 21 inches.

Underground construction

Vital installations may be put underground in an existing mine or newly excavated site, to obtain a high degree of protection against the atomic bomb. Studies recently completed indicate that there are no serious difficulties in constructing and operating underground manufacturing plants. When noxious fumes or large amounts of heat are produced, the capacity of the air-conditioning equipment must, of course, be adequate, which will add to the cost; but for certain types of manufacturing there is only a small difference in the cost whether the plant is built above ground or below ground in an existing mine. Estimates are that there are approximately 320 million square feet of floor space available in mines of suitable type in the United States. Many of these are within reasonable distance of transportation and labor supply. Construction in a suitable geologic formation would be more costly but by no means prohibitive.

There may be tunnels or caves near cities that can be used for control centers, emergency operating rooms, or for storage of medical supplies. They must be in good condition and in a suitably stable geologic formation. The entrance doors must be protected against blast by barricades (walls in front of doors to reduce blast effect) and should be of heavy steel construction.

Heavy concrete construction

Military requirements exist for heavy concrete structures that will afford protection against direct hits of high-explosive bombs and which will provide protection against the atomic bomb except at extremely close range. Such structures would be of little use in an area where large-scale fires might occur which would render them untenable, or where they might become isolated by damage to communications. There is serious question as to the justification for such construction in a city, that is, heavy enough to withstand a very close atomic-bomb explosion, but it may be required for vital facilities in vulnerable areas where underground construction is not feasible.

Design of buildings to resist blast effects of the atomic bomb

If buildings must be constructed in possible target areas for atomic-bomb attack, prudence dictates that they be designed so as to increase the safety of occupants and offer the greatest practicable resistance to collapse and damage. Target areas are defined generally in the NSRB publication, *National Security Factors in Industrial Location.* A general evaluation of the importance of industry or other activity in war should provide additional guidance as to vital targets. Any building to be constructed within 3 miles of any such vital target should be considered as in the target area. In determining the degree of protection to be provided, the location of the building within this area should be considered.

Considerable study is being given to the problem of blast-resistant design by the Department of Defense and educational institutions. There remains, however, a great deal to be done before satisfactory design procedures can be established. Therefore more detailed discussion would have little value at this time.

RECOMMENDATIONS ON CONSTRUCTION

For the present the following tentative recommendations are made: *Multistory reinforced-concrete or steel-frame building.*—It is suggested that the designer assume a horizontal wind component of 90 pounds per square foot and a vertical component of 70 pounds per square foot for protection against structural collapse from an atomic bomb releasing energy equivalent to 20,000 tons of TNT, exploding at a horizontal distance of one-half mile and a height of approximately 2,000 feet. It is also suggested that buildings and their component parts be designed employing the methods, allowable stresses, and details employed in wind- or earthquake-resistant design. For greater distances, it is recommended that the designer reduce the pressure in proportion to reduction in peak pressure indicated in table I, allowing for the change in vertical angle.

The above recommendations are based on the experience in Japan for this type of building limited to 100 feet in height. Wind load is believed to be the best basis for design to resist blast. Design for a 90-pound horizontal-component wind load compares roughly with an earthquake-resistant design for a lateral force equal to 10 percent of the weight. Since earthquake-resistant buildings suffered no damage to the frame at 2,000 feet and beyond in Nagasaki, this appears to be reasonable.

Smaller reinforced-concrete buildings.—Design for same pressures prescribed for multistory buildings as monolithic structures employing principles of earthquake-resistant design.

Steel mill buildings.—Design for horizontal component of wind pressure of 90 pounds per square foot and vertical component of 70 pounds per square foot for resistance of frame at horizontal distance of one-half mile and height of explosion of 2,000 feet. This assumes that failure of corrugated metal or asbestos-cement siding and roofing will reduce the load on frame, thus compensating for the lighter weight. Use of a material such as asbestos-cement which will break up more readily than corrugated metal will contribute to reduction in load on frames and reduce injuries and damage from pieces of siding or roofing that strike occupants and equipment.

General considerations in structural design of buildings to resist blast

Rigidity, redundancy, and ductility are important factors affecting resistance of buildings to blast. All of these increase resistance but it is now necessary to suggest design methods for improving resistance in these respects. Stability is also a factor, but in the usual case will be less important. The stresses produced by overturning effect should be considered in all cases, however.

Rigidity.—It is believed that the general solution of the problem of designing a building to resist high lateral and downward pressures is to provide additional resisting elements, such as transverse shear walls, lateral beams, and deep lateral trusses, and to design concrete floors and roofs to transmit the lateral forces to shear walls. In bending caused by frame action, the conventional use of the column as the resisting elements is unsatisfactory for high lateral forces. The establishment of design requirements for a static wind load is largely arbitrary and is useful in providing a design criterion. It will be beneficial to include any design feature that will provide greater strength where cost is not materially increased. It will also be found that limiting the height of buildings is desirable in order to avoid high lateral stresses.

Redundancy.—In the sense used here, redundancy is the quality of a structure to resist damage when certain members fail, by bringing into play other structural elements. Suppose, for example, that first-story columns were damaged by shearing action but that there were reinforced-concrete walls that would help support the load from above. The walls may be damaged too, but they may continue to support the second floor of the building. In a Manila public building several columns in a row in the first story were destroyed by artillery fire. The second floor sagged slightly but the damaged portion was bridged by the undamaged structure above. In general, reinforced-concrete structures have this quality. No absolute guide can be laid down for design, but a study of probable points of failure and possible support that might be provided by adjacent portions of the building should indicate to the designer both possible and practical means of adding to the blast-resistant quality of the building.

Ductility.—Ductility in a building material refers to its quality of yielding gradually under stress, or of undergoing deformation before failing. Usually a ductile material would deform to a greater extent within the elastic limit under the same load than one that is less ductile. In that sense a requirement for ductility is not consistent with rigidity. Nevertheless, ductility is an important consideration in resisting collapse. When the elastic limit of a ductile material such as steel is exceeded, considerable yield results before failure occurs. On the other hand a brittle material such as concrete would yield only to a limited extent before failing.

Tests have shown that for blast resistance purposes a structural-grade steel is much better for reinforcement than a hard-grade. When a reinforced-concrete structure is subjected to heavy blast forces and damage occurs, the softer steel may elongate or deform without failure where the hard-grade steel snaps. More energy is absorbed in the plastic range by the structural-grade steel. Accordingly, the use of a structural-grade reinforcing steel is recommended. In the usual case such a selection will have little effect on rigidity.

Bridges

Since most of the bridges exposed in Japan were small in size there is little indication of what would happen to the larger bridges of varying types found in the United States. It is recommended that bridges be analyzed dynamically. For chord members or suspension cables, drag force would receive primary consideration. The vertical component of blast on the deck could be serious, but bridges are designed for vertical load. Stressing of cross-bracing by the lateral component of the blast force would probably not be critical.

Strengthening existing structures and reducing hazards

This is a much more difficult problem than that of incorporating necessary measures in design. It will be necessary to analyze the structure, find weak points and then determine the best method of strengthening. It is believed that adding bracing and shoring of new transverse reinforced concrete walls will, in most buildings, be more feasible than strengthening the frame. Removal of portions of interior construction and fixtures likely to injure personnel or provision of adequate safeguards must be considered. Also overhanging cornices, finials, etc., on the outside, will be a hazard to passers-by, and their removal would be worth while. One very simple requirement is for the provision of materials for replacement of roofing and siding of steel mill buildings, closure of window openings, and other measures to protect against the weather.

Fire protection

Fires are started by radiant heat and by secondary effects such as overturning of stoves and rupture of gas pipes. Fire-resistant construction and avoidance of fabrics and other light material of inflammable character are essential to reduce fire damage. The possible disruption of water supply and the tremendous demand for fire-fighting services in time of disaster must be kept in mind.

All of the proved methods of design to reduce fire damage are fully applicable in plans to minimize the effect of atomic bomb. Extreme fire-protective measures are indicated under certain conditions. The value of protection of steel columns and other steel members from fire is emphasized by the distortion of exposed structural steel frames in Japan. Narrow fire breaks in Japan were of little use. Fire breaks which may be provided in city planning, or by demolition once fires have started, must be adequate for a major conflagration.

The provision of an adequate water supply is probably the most important single element in control of fires. In Nagasaki, it was estimated that almost immediately after the detonation, fires were started in dwellings within a radius of 3,000 feet from ground zero. Beyond this distance, fires were caused largely by spread; nearly all fires were secondary. The water pressure was only 30 pounds per square inch at the time of the explosion and because of breaks in mains and house service lines, soon dropped to 10 pounds and on the following day was zero.

The experience at Nagasaki gives some idea of the area immediately affected and that in which some control may be possible. As indicated earlier, there are certain areas of most big cities that would contain probable targets. The enemy would probably want to damage facilities or plants most important to the war effort. However, there would be no assurance that the explosion might not occur at some other point because of errors by the attacking force. A reasonable approach would be to study the map of the city and make various assumptions as to areas in which large scale fires might be started by an atomic bomb with loss of water supply occurring in the same area. The objective would be to provide for the localization of the loss of pressure and water in order to assure adequate pressure and supply for firefighting in fringe areas.

Storage tanks for local supply would be of value in stopping incipient and local fires, but would probably have limited value in large-scale fire-fighting operations. Their installation should be considered where appropriate, particularly for manufacturing plants.

Assurance of adequate firefighting services is a separate problem. Within the scope of this section, it is only necessary to emphasize the desirability of locating a sufficient number of fire stations on the outskirts of the city, as well dispersed as possible. Joint fire defense planning among cities is highly desirable but, to be effective, mutual aid between cities requires standardization of hose couplings or use of adapters.

SHELTERS

Considerations involved in the provision of shelters are (*a*) warning to be expected, (*b*) time required for persons to reach shelters, (*c*) number of persons to a shelter, (*d*) period of occupancy, (*e*) degree of protection to be afforded.

If there is little warning, shelter must be found, in general, close to the place of work. In our large cities, an extremely large number of persons are concentrated in buildings that cannot be evacuated rapidly. The use of shelter areas in buildings therefore appears to be the most feasible scheme unless adequate warning can be assured. Even with adequate warning the practical problem of finding a place for shelters in a congested city would be difficult.

Plans for locating shelter areas in buildings should be given first priority. Principles involved are briefly as follows: First, select fireproof reinforced-concrete or steel-frame buildings that are resistant to collapse; next, find areas that offer acceptable protection against blast, radiation, flying glass, and debris. These areas will be found usually on the lower floors and in halls or the interior portion of the building. Avoid secondary hazards such as that from falling plaster or fixtures and inflammable materials. At least two means of exit are essential for safety. Since general evacuation will probably be necessary, an important requirement is a means of leaving the building without depending on elevators, which might be inoperative.

With regard to details of protection, table I indicates the blast pressure to be expected in the open. The reduction in pressure to be expected inside a building must be largely an estimate. The amount of glass and strength of intervening partitions would be factors. Around the shelter area, a 12-inch-thick reinforced-concrete wall well tied into the outer structure would, in most cases, be adequate to resist blast at a distance of one-half mile.

Basements of homes would offer reasonable protection against distant detonation. However, care must be taken to provide escapes to be used in case the house above catches on fire.

Outside shelters should, in the usual case, be built to resist the full effects of a near miss of a high explosive bomb and the blast effects from a nominal atomic bomb at a reasonable distance, say one-half mile. They should be located well clear of buildings to avoid hazard from debris and fire. A buried or semi-buried shelter will usually be the best choice (for protection from an *air* burst) as blast effect will be less than that on a surface shelter. Reinforced concrete is a good construction material and can be made strong enough to resist the forces involved. Alternatively, for a well-buried shelter corrugated sheet iron of the type used in culverts has strength and is capable of a high degree of distortion without failure. Wood is also suitable but less permanent.

Tentatively, shelters may be designed for a static load of 500 pounds per square foot with usual design stresses. This should provide protection against blast at one-half mile from ground zero if an earth cover of at least 2 feet is provided. This cover is necessary for protection against ionizing radiation; it also adds appreciably to the blast resistance. Dead load should be figured separately. Adequate drainage should be provided. The shelter should be capable of being closed up so as to be air tight. Doors should also be blast resistant and designed for static pressure of 500 pounds per square foot, and should close tightly against seals in the frame. A ramp entrance is preferred to one with steps. At least two means of exist are essential.

Shelters vary in capacity, and the equipment that can be provided will be more extensive in a large shelter than a small one. Generally, the following should be considered in design.

Ventilation

Mechanical ventilating system.
Hand-powered ventilating system if no power available.

General

Telephone between inside and outside of shelter.
Lights—battery operated.
Light system if power is provided.

Power plant with separate gasoline or Diesel drive, located in separate part of shelter accessible to outside air with operating switches in closed portion of shelter.

Benches.
Bunks were justified.
Chemical toilets.
Drinking water.
Emergency rations.
First-aid equipment.
Blankets.

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INVESTIGATION INTO THE UNITED STATES ATOMIC ENERGY PROJECT

HEARING

BEFORE THE

JOINT COMMITTEE ON ATOMIC ENERGY
CONGRESS OF THE UNITED STATES

EIGHTY-FIRST CONGRESS

FIRST SESSION

ON

INVESTIGATION INTO THE UNITED STATES ATOMIC ENERGY PROJECT

PART 7

JUNE 13, 1949

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INVESTIGATION INTO THE UNITED STATES ATOMIC ENERGY PROJECT

MONDAY, JUNE 13, 1949

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The joint committee met, pursuant to adjournment and subsequent postponement, at 10:35 a. m., in the Caucus Room, Senate Office Building, Washington, D. C., Senator Brien McMahon (chairman) presiding.

Present: Senator McMahon (chairman), Representative Durham (vice chairman); Senators Connally, Tydings, Vandenberg, Millikin, Knowland, and Hickenlooper; Representatives Holifield, Jackson, Cole, Elston, and Hinshaw.

Also present: David E. Lilienthal, Chairman; Sumner T. Pike, Commissioner; Lewis L. Strauss, Commissioner; Gordon E. Dean, Commissioner; Henry D. Smyth, Commissioner; Dr. J. Robert Oppenheimer, Chairman, General Advisory Committee; Carroll L. Wilson, General Manager; Dr. Walter F. Colby, Director of Intelligence; David B. Langmuir, Executive Secretary, Program Council; Joseph Volpe, Jr., General Counsel; Everett Hollis and Bennett Boskey, of the Office of the General Counsel; Dr. Kenneth S. Pitzer, Director, Dr. Ralph Johnson, Associate Director, and Dr. Spofford English, Division of Research; Dr. Paul B. Pearson, Division of Biology and Medicine; Fletcher C. Waller, Director, Division of Organization and Personnel; Morse Salisbury, Director, Rodney Southwick, and Shelby Thompson, Division of Public and Technical Information Service; Francis Hammack, Acting Director, and Edward Brosman, Division of Security; Frances Henderson, Assistant to the Chairman, all of the United States Atomic Energy Commission.

The CHAIRMAN. The committee will come to order.

Dr. Oppenheimer. Good morning, Doctor.

Dr. OPPENHEIMER. Good morning.

The CHAIRMAN. Doctor, before you start, I want to make a comment on an action the joint committee took the other day relative to closed hearings of personnel security cases. I did not get you in that chair to take part in this discussion. This is simply my own announcement.

I want to make it perfectly clear that there is not a member who voted in the minority who, in my opinion, is for full and open hearings on the personnel security cases. If there is anyone who is of such a mind, why, they can make it known for the record now.

The choice was between a part of an open hearing and a full closed hearing, not a full open hearing at all. I want to make that perfectly definite for the record. Not even the proponents of these charges have at any time asked this committee to hear these personnel cases, all of them, wholly in open session.

Mr. JACKSON. Mr. Chairman?

The CHAIRMAN. Mr. Jackson?

Mr. JACKSON. I am glad the chairman has made the announcement that he has made this morning in connection with the personnel security cases.

I think that in order for the record to be clear on this matter, the committee should meet in executive session this afternoon, and I propose to reiterate my previous announcement in public in these hearings to the effect that these matters either ought to be all in public or all in executive session.

The CHAIRMAN. You mean by that the security cases?

Mr. JACKSON. The security cases, yes; and that that matter should be disposed of by appropriate means, if we do have an executive session this afternoon.

The CHAIRMAN. I believe the reasons that motivate every member of the committee to be unwilling to proceed on total open hearings and the total files is primarily because of the irreparable injury that would be done to our investigating agency.

Mr. JACKSON. Mr. Chairman, no one wants to do any harm to the great work of the FBI, but, on the other hand, if we are confronted with a situation here of charges being made in public and no opportunity to reply in public, I think that is important.

At the same time, I am sure every member of this committee wants to do his part in seeing to it that the investigative work of the FBI is not jeopardized.

I would be the last to propound or to offer any motion that would result in that end.

The CHAIRMAN. I am sure of that.

Mr. JACKSON. Yes.

STATEMENT OF DR. J. ROBERT OPPENHEIMER, DIRECTOR, INSTITUTE FOR ADVANCED STUDY, PRINCETON, N. J.; CHAIRMAN, GENERAL ADVISORY COMMITTEE TO THE ATOMIC ENERGY COMMISSION

The CHAIRMAN. Now, Doctor, we have had some discussion here about radioisotopes and the export of them. You are chairman of the General Advisory Committee?

Dr. OPPENHEIMER. I am, sir.

The CHAIRMAN. You were director of the Los Alamos Laboratory during the war?

Dr. OPPENHEIMER. I was.

The CHAIRMAN. Doctor, I am familiar with your history and your background, but I think it would be well if you were to state for the record what that is.

Dr. OPPENHEIMER. My present job is director of the Institute for Advanced Study, which is in Princeton, N. J.

Befort the war, I held joint appointments in physics at the California Institute of Technology, Pasadena, and at the University of California in Berkeley.

My first full-time official employment on the atomic bomb project came in the spring of 1942 when I was put in charge of the development of the bomb task then assigned to the Metallurgical Laboratory in Chicago.

About 6 months later, General Groves and I started talking about Los Alamos, and early in 1943 I was formally appointed director.

I resigned 2 months after the war was over, and have since served in an advisory capacity only, the principal one at present, the one I guess in which I am here today, is as chairman of the statutory General Advisory Committee. Is that enough?

The CHAIRMAN. Now, you are at Princeton?

Dr. OPPENHEIMER. I am at Princeton now.

The CHAIRMAN. You are still connected with the project—working in nuclear physics, however, are you not, as well as being chairman of the General Advisory Committee?

Dr. OPPENHEIMER. We are working at the Institute not entirely, but largely on basic problems whose connection with practical aspects of atomic energy is not too clear, but which we hope and really know will in one way or another be useful in the future.

The CHAIRMAN. Now, doctor, we have been talking about radioisotopes. We have been talking about their export, and we have been talking about the policy. First, we talked about what the law meant. I would not expect any interpretation of that from you. We can get that from the lawyers, but we have been talking about the wisdom or the lack of it in exporting these shipments. Our talk has become more concentrated now on the Norway shipment with which, I presume, you are familiar.

Doctor, will you go ahead and tell the committee what your thoughts are on this policy.

Dr. OPPENHEIMER. I will be glad to try to do so.

The General Advisory Committee has been, I would say, less equivocal on the subject of the limited export of isotopes than on almost anything else that has been referred to it.

It at least twice has considered the problem. Each time it has come up with a firm and unanimous answer. The records of our deliberations are in your hands; some are public, and they are all available to you.

I think it important at this point to emphasize that in our first formal discussion of the foreign distribution of isotopes we told the commission that we regarded their program as somewhat too conservative; that we hoped that the problem of the export of certain fission products and of stable isotopes could be considered at a later date, but we were very glad to see that something was being done.

Since we have been so unequivocal, I believe it right to try to give you the background that was in my mind, and I believe, in the minds of the General Advisory Committee, in making these deliberations. Let me say first that you have every reason to want to ask me questions and to expect candid answers, and you are not here for a lecture. If I am talking about things that you already know or that are irrelevant, I hope you will cut me off.

What I would propose to do, since so many of the affirmative arguments have been given, is to take up the argument that the present policy involves some kind of danger; specifically that it involves danger of assisting other nations in the development of atomic energy, and that it involves the danger of assisting other nations in other military developments. These are two points I want to speak to.

Before I can do that, I think I may briefly outline the history of isotopes, what they are, how they are used, and in what way their export is circumscribed. If you have no objection, I will do that.

We are all, of course, composed of isotopes. They were discovered in the early part of the century by the English physicist, Aston. Shortly thereafter it was recognized that some isotopes, very heavy materials, were radioactive. This meant that at more or less at random, but on a fixed over-all schedule, they would undergo a change which signaled itself by the emission of a radiation which was easy to detect.

Taking advantage of that, the Hungarian chemist, Hevesy, who now works in Scandinavia, showed that one can use radioactive isotopes as tracers. This is the principal use with which we are now concerned.

The way a tracer works is that: Two materials which are isotopic with each other have essentially the same chemical behavior. If it is sulfur you are dealing with, all isotopes of sulfur will follow the chemistry of sulfur. If the material is radioactive, at a certain stage, having followed the history of sulfur, it will suddenly do something quite new; it will explode; it will disintegrate, and if you have the right kind of detecting equipment you can find out where it was at that time. In this way the very, very complex problems of chemical systems, of biological systems, of crystals, of metallurgical systems, can be explored. This is not a unique instrument, but it is an important one.

The radioactive isotopes increased very much in importance with the discovery in France early in the thirties that you could make ordinary materials radioactive, that you could get radioactive carbon, radioactive sulfur, radioactive oxygen; of course, few people are interested in the basic behavior of radium in the human body, but many people are interested in the behavior of carbon or oxygen.

The decade before the war saw innumerable examples, both of the discovery and of the application of isotopes. Much of this work was done in this country; some was done abroad.

I remember about 10 years ago, the distinguished Director of the Radiation Laboratory in Berkeley had to give a public lecture, and he wanted to use me as a guinea pig. He got met out on the platform, and he got me to put my hand around a Geiger counter, which is one of the instruments for detecting radioactivity, and he asked me to drink a bit of water in which a part of the salt had radioactive sodium in it.

For the first half minute all was quiet, but about 50 seconds after I drank it there was a great clattering of the Geiger counter. This was supposed to show that at least in one complex physiochemical system, the salt, the sodium ion had diffused from my mouth through my blood stream to the tip of my finger, and the time scale for this was 50 seconds. That is a prototype of one of the uses.

(Discussion off the record.)

Dr. Oppenheimer. The atomic energy project made a great change in the isotope situation, and in the following way: In the first place new heavy isotopes were discovered, the most famous being plutonium.

In the second place, the vast and otherwise often inaccessible array of radioactive materials from the fission process itself became available.

It is important for me to emphasize that the export program of the Commission does not include any of the heavy materials specific to the fission program. It does not include the fission products specific to the fission program.

The CHAIRMAN. Fission what?

Dr. OPPENHEIMER. The fission program, atomic energy program.

The CHAIRMAN. Oh.

Dr. OPPENHEIMER. It includes only those materials made by neutron bombardment, I believe all of which were well-known before the war, and which can be made by a variety of methods.

The great contribution of the United States atomic energy program to this work is that the quantities available and the cost have been changed. The quantities are enormously greater, the cost very much smaller.

The specific purposes for which the General Advisory Committee recommended the export of isotopes were for basic research, not only in medicine and in biology, but also in physics, in chemistry, in metallurgy. Basic research means research directed toward finding out about the nature of the world rather than research specifically directed toward achieving a practical goal. If you want to find out how strong nuclear forces are, that is basic research. If you want to design a reactor, which will propel a certain kind of craft, that is not a basic research; that is applied.

These are loosely used words, but that is what we had in mind.

The second purpose is for diagnosis. If human metabolism or animal metabolism is disturbed by disease, the way in which the body used certain things, iodine, for example, will be altered.

If you follow radioactive iodine, you may be able to find out what kind of an illness a man has.

The third purpose is therapy. The therapy is on a very limited scale. For years people have been looking for diseases that radioactive materials would cure, and I think two have been found: Certain thyroid disorders and polycythema vera. On a world-wide scale, this means quite a number of human lives.

This is background of information which the General Advisory Committee had as to the history of isotopes.

Let me turn to the special problems of the use in atomic energy, and the use in other military applications, and the extent to which the use of isotopes abroad could be controlled by us and could be favorable to us.

I need to say, first, that all the isotopes here considered are isotopes which would exist and which would be useful if there were no uranium, if the fission process were impossible, if the number of neutrons emitted were too small to sustain a chain reaction, or if the Government of the United States had not allocated a nickel to the atomic energy program.

On the use of these isotopes, and I leave out plutonium and fission products, because there are other factors which are involved in the development of atomic energy, I can testify as follows: At Los Alamos we never made use of these materials. I cannot speak with the same sharpness about the metallurgical laboratory in Chicago, and the radiation laboratory in California, but no use of these materials sufficiently interesting or important to come to my attention was made. I know of no such use, and it was certainly ancillary.

Senator HICKENLOOPER. Dr. Oppenheimer, what were you interested in at Los Alamos?

Dr. OPPENHEIMER. In making bombs, sir.

Senator HICKENLOOPER. Were you interested in high-speed steel for engines?

Dr. OPPENHEIMER. We will come to that later. We were interested in steel. You will soon get me to the point where secrecy does stop my answer.

Senator HICKENLOOPER. But your former interest was making a bomb?

Dr. OPPENHEIMER. Our exclusive interest was making a bomb, but you have no idea how many angles that can have. We will come back to the engines.

Senator HICKENLOOPER. All right.

Dr. OPPENHEIMER. The next point that I would like to make is that since the war I can recollect no application of these exportable isotopes to the atomic energy program of sufficient importance so that it came to the attention of the General Advisory Committee.

No one can force me to say that you cannot use these isotopes for atomic energy. You can use a shovel for atomic energy; in fact, you do. You can use a bottle of beer for atomic energy. In fact, you do. But to get some perspective, the fact is that during the war and after the war these materials have played no significant part, and in my own knowledge, no part at all. That is not true of all isotopes. Plutonium is a good one; that played a big part. It is true of the group of isotopes falling under the Commission's export policy.

Now, you have asked about other military applications. Here I am less knowledgeable, but the General Advisory Committee is collectively a very knowledgeable group, and we have had this in mind.

The statements that I made about the possibility of using a shovel for military purposes also apply here.

However, the principal characteristic of military use is that you do the work in secret, and one of the conditions for the use of these isotopes is that it be open and published, and subject to visit.

Going beyond that, I have had a search made to see what use we have made of these exportable isotopes in secret military research. We have made about 6,000 shipments of isotopes. I would argue that the defense effort and the research defense effort in the United States is of another order of magnitude of bigness than any efforts that are going on in western Europe, and I thought that we would probably find some cases where the National Military Establishment had requested for secret application to armament, jet engines, bacteriological warfare, or what have you, these exportable isotopes.

To my astonishment the staff of the Commission has come up with an answer that they have no recorded case. This seems to me a very strong argument.

There are few, if any, situations in which this country, with is $15-billion-a-year armament program, has found it possible to use these isotopes effectively in furthering our enormous defense establishment.

The next point that I would like to make is that it is, of course, not within our power to deny these materials to Europeans. They are available, not in every country, but in the collective area of western

Europe, from the British piles, and perhaps to a small extent from the French reactor, from cyclotrons which are spotted around, and from other accelerators. They are costly and they are a nuisance, but they are available.

Why, then, should we provide them at all? Well, I would say that that if there were a genuine military need, let us say, for radioiron or radiosulfur, that would be the need that would first be filled in a country which was concerned with military armament. What we are doing is making material available for the basic things which are not of high priority, and which contribute to general learning.

We are in a very good position, if discoveries are made in Europe, to profit by them. We are in a better position than the Europeans are because of our advanced technology, our good organization, of all the reasons which you know so well, in facing the problem of the rehabilitation of Europe.

The atomic bomb itself is based on fundamental published findings of European scientists, but it is not the Europeans who have the atomic bomb; it is the United States.

I am not saying that such discoveries will be made with these isotopes, but discoveries bearing on human health, bearing on the properties of materials, very likely will be.

These things were discovered in Europe; they were applied in Europe; they are available in Europe, and the positive arguments for making them available have been largely laid before you, and I do not want to repeat them. They lie in fostering science; they lie in making cordial effective relations with the scientists and technical people in western Europe; they lie in assisting the recovery of western Europe; they lie in doing the decent thing.

I am now going to speak as an individual and not on behalf of the General Advisory Committee. If you were to ask me the basic affirmative reason for distributing isotopes abroad, I would put it in these terms: There are many objectives of the United States foreign policy, that appear from the pronouncements of the Congress and the President and of the Secretary of State. One of them is that in the event of war we should be in a stronger position, and our enemy in a weak position. One of them is that we should have good trade relations. One of them is that we should enjoy the respect of as many of the people in the world as possible. But the two paramount objectives, as they emerge from public pronouncements, are the maintenance and extension of the basic freedoms to which this country is dedicated and on which it is built, and the preservation of peace.

I believe that the shipping abroad of isotopes is one of those many cases where it is right to reckon with the possibility that in these high objectives we will not fail.

Senator TYDINGS. Doctor, might I ask a question while this lull is on here so that I can clear up a little of my own thinking?

Dr. OPPENHEIMER. Suppose you do.

Senator TYDINGS. Suppose that any of these isotopes that have been shipped abroad have been shipped directly, let us say, to Russia, a great country and a potentially rich country. Could it have taken those isotopes and used them in any manner, shape, or form so as to accelerate its discovery of atomic fission, as we know it in this country from the atomic bomb, or in aiding its military potential?

Dr. OPPENHEIMER. Under the conditions of export, the conditions of export are that the work must be open, must be published, and must be accessible to qualified scientists, irrespective of nationality.

Senator TYDINGS. Let me put it to you this way: Suppose that Russia got some of these without complying with the open characteristics——

Dr. OPPENHEIMER. Right.

Senator TYDINGS (continuing). That you have in mind. To what extent, if any at all, would Russia then have improved its military potentialities actually or from the standpoint of possibilities?

Dr. OPPENHEIMER. Well, I have answered that the best I know how. We have not made very extensive use of these materials, either for the military applications of atomic energy or for any other military applications. I am not willing to grant that the Russians are so much smarter than we are, but, of course, I do not know. It is an iron curtain, and not iron 59 either.

Senator TYDINGS. Your answer, I take it, would be that even though we had shipped directly these isotopes to Russia, the inference is that Russia could not have employed them to advance the knowledge——

Dr. OPPENHEIMER. I would like to put in the word "substantially" just to protect the balance of the thing, but essentially that is right.

Senator TYDINGS. There would be a degree then to which your qualification—it would be a minor degree, but there would be a degree of aid?

Dr. OPPENHEIMER. Let me put it this way: I know of no way in which they could.

Senator TYDINGS. What is that?

Dr. OPPENHEIMER. I know of no way in which this would help them, but I do not know anything about Russia.

Senator TYDINGS. Thank you.

The CHAIRMAN. Doctor, you may feel as though you have more or less covered the Norwegian shipment in your general statement, but inasmuch as that was concretely before us and was the subject of rather extensive examination, would you please proceed to comment on this specifically?

Dr. OPPENHEIMER. I will. I learned of it really only as a result of its coming to public attention, and my knowledge of it is limited.

Senator HICKENLOOPER. Then, the matter had never been specifically submitted to the General Advisory Committee?

Dr. OPPENHEIMER. No; no specific shipment of isotopes has been.

The CHAIRMAN. Except the classification, Doctor. You say no specific shipment, that is true; but it is also true that you not only passed upon the general policy but you also laid down the general categories which should not be shipped.

Dr. OPPENHEIMER. No, that is not so. They were presented to us by the Commission. In many cases we understood the reason for the dividing line. In any case we approved of the Commission's dividing line with the suggestion that it could later be liberalized in certain directions.

The CHAIRMAN. Have you found an indication in your examination of the classifications that have been shipped to criticize those classifications or to criticize any particular shipment?

Dr. OPPENHEIMER. No, we have not; and I believe that the most we would say is that there are probably some materials which could safely be shipped, and which are not included, for one reason or another, in the shipping list that the Commission puts out.

As to the Norwegian matter, my understanding is the following: It was shipped to a national defense establishment, and this is the most damaging thing that could be said about it. This national defense establishment appears to have two functions: On the one hand it does military research. I do not know on what, and I do not know whether it is secret or not.

On the other hand, it is a contracting agency for the industries of Norway. The problem for which this shipment of radioiron was desired was the study of the diffusion of iron into low-iron alloys. This is a basic problem in metallurgy which is being studied on an open basis in several centers, Stevens Institute, Carnegie Institute, and one other place in this country, open and publishable.

The reason why the industry had an interest in the matter was in order to improve the performance of turbines for the generation of water power, not atomic energy, but water power.

The work is of interest. Dr. Smith, who is the metallurgist on the General Advisory Committee, expressed great interest in it and said that as a job of work it fell within the intent of the General Advisory Committee's recommendations.

The defense establishment seems to be a complex affair, not too unlike our own Navy. Much of the basic work in physics in this country is done by the Navy, and I would see no objection under those conditions to a foreign government sending to a naval contractor equipment for the study, let us say, of cosmic rays. In fact, that goes on.

I realize that the fact that it was a defense establishment, when one knows no more about it than that, raises the thought that it was in violation of the terms of the AEC agreement.

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

The CHAIRMAN. Senator Millikin?

Senator MILLIKIN. Assuming, just assuming, that it was for military purposes, in getting up the classifications, was it contemplated that any isotopes should be sent abroad in aid of military purposes?

Dr. OPPENHEIMER. It was not.

Senator HICKENLOOPER. Mr. Chairman.

The CHAIRMAN. Senator Hickenlooper?

Dr. OPPENHEIMER. Let me say another word: It was contemplated that they would be sent abroad only for basic research. No one can tell whether from basic research something of military value will emerge, but this country is an awfully good country to take advantage of those things.

Senator MILLIKIN. Dr. Oppenheimer, basic research does not operate in complete isolation, does it? I mean, if something were turned up in basic research that could be useful for a military purpose, it is reasonable to assume that it would finally evenuate that way, would it not?

Dr. OPPENHEIMER. Yes, but there is a long chain. The shortest chain and the longest and most dramatic——

Senator MILLIKIN. There is a long chain between the chicken salad and the gleam in the eye of the rooster, but they all have relation with each other.

Dr. OPPENHEIMER. You could not be more right, Senator.

[Laughter.]

Senator HICKENLOOPER. Mr. Chairman.

The CHAIRMAN. Senator Hickenlooper?

Senator HICKENLOOPER. I merely want to point out in his statement of understanding as to what use it could be put to, the application for the shipment was that this was to be used to trace the flow of molecules of iron in steel at high temperatures.

Now, as I say, you understand that they are seeking information on turbines or something of that kind?

Dr. OPPENHEIMER. I have seen a dispatch which says that. I do not know whether this information was in the hands of the Commission at the time the shipment was made.

Senator HICKENLOOPER. But it is your understanding that their primary purpose here is searching for information leading to better turbines for the Norwegians?

Dr. OPPENHEIMER. Yes.

Senator HICKENLOOPER. Would you consider the building of turbines and better steel for turbines building for industrial purposes?

Dr. OPPENHEIMER. I would think, looking at Norway, that it was a very important industry for Norway.

Senator HICKENLOOPER. And that, therefore, that information would be for industrial purposes, would it not, industrial information?

Dr. OPPENHEIMER. I see what you are driving at. May I——

Senator HICKENLOOPER. I do not care whether you see it or not. I am asking you a question.

Dr. OPPENHEIMER. This is a basic research whose results will be valuable to industry.

Senator HICKENLOOPER. Yes.

Dr. OPPENHEIMER. But I would like, if I may, to take this controversial piece of the Atomic Energy Act and say a word or two about it. May I do so?

The CHAIRMAN. Yes.

Dr. OPPENHEIMER. The Atomic Energy Act says, and you are the people who drafted it, so you know what it means, that we should not transmit information abroad for industrial purposes until safeguards have been provided.

Now, I know that at the time the act was written you had been exposed to a barrage of testimony from characters like me, and the upshot of this testimony was the following: That you could not have industrial power from atomic energy without danger of great military resources. You maybe could not have it cheaply anyway, but as soon as you set up an atomic energy power program you had an arsenal of atomic bombs. That is what I said and that is what everybody said.

It seems to me that the interpretation which the laity have made of this provision of the act is that if industrial power ever became a reality you wished to be advised of it, and in the meantime let us not help any other country to get industrial power because if we do we will at the same time help it get atomic weapons; I regard this as a very prudent provision. It is certainly not possible to take the definition of "atomic energy" and the prohibition against industry—helping other nations industrially, literally; it is certainly not possible to do that, Mr. Senator, because everything we do in this is contrary to it.

The CHAIRMAN. Everything we do is what?

Dr. OPPENHEIMER. Contrary to it.

The CHAIRMAN. What do you mean by that?

Dr. OPPENHEIMER. Atomic energy is defined—shall I look for it—the definitions must be some place.

Mr. HINSHAW. Page 21 of the act.

Dr. OPPENHEIMER. Thank you. [Reading:]

The term "atomic energy" shall be construed to mean all forms of energy released in the course of or as a result of nuclear fission or nuclear transformation.

That is the definition of "atomic energy," and the prohibition on export—where will I find that?

Mr. HINSHAW. On page 13.

Mr. DURHAM. You agree with that, do you not, Doctor?

The CHAIRMAN. Is that a good definition?

Dr. OPPENHEIMER. Well, let me take it a little further, and you can judge. [Reading:]

There shall be no exchange of information with other nations with respect to the use of atomic energy for industrial purposes.

Now, coal is atomic energy by this definition; oil is atomic energy by this definition; people are atomic energy by this definition, and surely one must do better than that if one wants to have a sensible export policy.

Senator HICKENLOOPER. But atomic energy is specifically defined in this act. It has a restricted meaning.

Dr. OPPENHEIMER. I just read the definition.

Senator HICKENLOOPER. But people certainly would not be construed as coming under that definition of atomic energy.

Dr. OPPENHEIMER. I would not wish to construe it that way, but you regard the shipment of isotopes for researches, the benefits of which may be the improvement of industry abroad, as precisely a marginal case which does not correspond to the very real dangers of helping a foreign nation to develop an atomic power industry and have in its backyard the makings of large numbers of atomic bombs. That is a real danger.

Senator HICKENLOOPER. Doctor, may I ask you, these isotopes which have been shipped abroad have been made in our own atomic piles, have they not?

Dr. OPPENHEIMER. To the best of my knowledge, yes, sir.

Senator HICKENLOOPER. I believe that it has been reliably testified here before by people who have had charge of it that that is the case. These isotopes, would you say that they are the result of nuclear fission? Would you say that with respect to these isotopes that have been shipped abroad, that come from our piles?

Dr. OPPENHEIMER. The indirect result of nuclear fission, yes.

Senator HICKENLOOPER. Would you say they are the result of nuclear transformation if they come out of our piles?

Dr. OPPENHEIMER. Whether they come out of piles or not, they are the result of nuclear transformation.

Senator HICKENLOOPER. I know you are not a lawyer, and I do not intend to argue the legal point, but those terms are specifically used in defining atomic energy, so that the law says what atomic energy is, and those things that come as a result of nuclear fission, as the result of nuclear transformation, therefore, regardless of what anybody says, are defined by law as being atomic energy.

Dr. OPPENHEIMER. But oil is a result of nuclear transmutation.

Senator MILLIKIN. Doctor, the difference is that the Atomic Energy Commission has the responsibility for this particular type of energy and does not have responsibility for oil, nor for irradiated man nor for any of the other things.

Dr. OPPENHEIMER. An unirradiated man is just as much, you see—[laughter]—it is, of course, for the Congress to determine what the intent of this provision is. My opinion is that if the determination were made that isotopes should not be shipped abroad, the Congress would be making a profound mistake; that the action would be resented, and that it would be unintelligent.

The legal point I will not debate because I am no lawyer, but I do know that this provision in the act has a very real purpose, and that is to prevent the accumulation of plutonium and fissionable uranium in foreign hands, and that is something that we ought to stick to.

Senator HICKENLOOPER. But, Doctor, I will call your attention to the fact that Congress has also determined that we will not furnish information to other nations on how to make atomic weapons. There are those in this country, as has been amply demonstrated by public statements at various places, who believe that that is a bad policy, too, and that we should give that information out, so we are not talking about necessarily what you believe the policy should be; we are not talking about what you believe the safeguards should be.

The point at issue here is what the Congress has determined and has decided, and what the policy as written by the act may be.

Now, it is entirely possible that your philosophy of shipping these abroad may be right. I have not raised objection at this moment to the over-all policy as originally set out, but if your policy should be correct, as I interpret it, from a moral standpoint, then I suggest that perhaps the Congress might consider changing the law to clarify it. But I would suggest——

Dr. OPPENHEIMER. I may say that the General Advisory Committee does not inquire as a routine thing as to whether proposed action is legal or not, but in this case we were informed that it did not appear to be in conflict with the law. That is not a matter we pass on. We pass only on whether it makes sense.

I am told by someone who is a lawyer that I am supposed to discuss the relation between two provisions. The two provisions are the ones prohibiting the exchange of information with other nations with respect to the use of atomic energy for industrial purposes, and the dissemination of "scientific and technical information relating to atomic energy should be permitted and encouraged so as to provide that free interchange of ideas and criticisms which is essential to scientific progress."

With the very strict interpretation of one, which you believe is the correct one, I will express some bewilderment as to how this Commission is to carry out these two objectives simultaneously.

Senator HICKENLOOPER. I think that is a matter for legal interpretation, as I also expected you to discuss the provision on page 9, although that is also a legal interpretation—you will find in parentheses the figure "2" under the term "distribution," an authorization from the Commission to distribute byproduct materials, but also, for your thinking, because it will come up sooner or later, also for your thinking, I will say that in my judgment this applies only to the distribution of byproduct materials within the United States; and I will call your attention to the fact that farther down in that section it says:

The Commission shall not distribute any byproduct materials to any applicant—

and shall recall any distributed materials from any applicant if certain conditions are not made.

I submit that the very important legal question involved there is that it must apply only to domestic distribution because only within the jurisdiction of the United States can we have any authority to recall and compel the return of isotopes.

Foreign nations, we can recall all we want to, but if they do not want to return, we have no power to do so. I think that is very——

Dr. OPPENHEIMER. In the drafting of the act was it explicitly decided by the committee that drafted the act—and most of you are still here—that all export of isotopes should be prohibited? I did not know this.

Senator HICKENLOOPER. I think the record makes it amply clear that the Congress, on passing this act, thought that no information nor aid whatsoever would go abroad until this troublesome problem of weapons and the safeguarding against the use of weapons in warfare had been reliably settled.

Dr. OPPENHEIMER. How then can one understand that you instruct the Commission to permit the dissemination of scientific and technical information relating to atomic energy?

Senator HICKENLOOPER. I think that can be done within the jurisdiction of the United States where we can control and retain control and retain supervision over——

Dr. OPPENHEIMER. Well, you see——

Senator HICKENLOOPER (continuing). That matter.

Dr. OPPENHEIMER (continuing). That goes beyond, so far beyond, any policy ever envisaged by the Manhattan District or the Commission that it would call for very thorough discussion. That means there will be no publication at all in unclassified form. That is going a long way.

Senator MILLIKIN. Doctor, I suggest that there is one overriding imperative in this act that is not technical, that is not legal, that controls every provision of the act, and that is as follows, in the very preamble, where it says:

Accordingly, it is hereby declared to be the policy of the people of the United States that, subject at all times to the paramount objective of assuring the common defense and security——

Dr. OPPENHEIMER. Right.

Senator MILLIKIN. Every consideration that has been mentioned here is subject to that overriding imperative.

Dr. OPPENHEIMER. It is with that in mind that the General Advisory Committee has made its many recommendations.

Senator MILLIKIN. And the doctor has stated that it did not contemplate that these isotopes would be used for military purposes abroad?

Dr. OPPENHEIMER. Pardon me.

Senator MILLIKIN. You have already testified that it was not contemplated in setting up classifications——

Dr. OPPENHEIMER. No.

Senator MILLIKIN (continuing). That isotopes would be sent abroad to aid military developments?

Dr. OPPENHEIMER. Absolutely right.

The CHAIRMAN. And the ones that have been sent abroad are the ones that we have not found it possible to use for our own military establishment?

Dr. OPPENHEIMER. That we have not in fact used for secret work.

The CHAIRMAN. Senator Vandenberg?

Senator VANDENBERG. Well, Dr. Oppenheimer, you are not only an expert in science, in nuclear physics, a field in which you have certainly rendered your country incomparable service, but you are also an expert in connection with the problems that are raised when we were writing this law, between those who wanted civilian control and those who wanted military control.

The civilian control wanted, and I think I ought to immediately say that I am one of those who unequivocally stands for continuing civilian over-all control——

Dr. OPPENHEIMER. You are right.

Senator VANDENBERG (continuing). But, Dr. Oppenheimer, you will recall that we composed that difference by the creation of a Military Liaison Committee which was supposed to be sort of a persistent and relentless watchdog in connection with security matters.

Will you give me your conception of what the responsibility of the Military Liaison Committee is? Perhaps that is too broad a question. Let me narrow it. When the Atomic Energy Commission confronts for the first time a shipment of isotopes abroad to a military establishment, would you not think it was elementary prudence, if not anything else, to ask for an affirmative advice of the Military Liaison Committee before it was done?

Dr. OPPENHEIMER. I am tempted to say "Yes," but to answer a question like that, I would have to——

Senator VANDENBERG. But you do not yield to your temptation.

Dr. OPPENHEIMER (continuing). Know more about the detailed working relations between the Military Liaison Committee and the Commission. My knowledge of these relations is that they are very good, but there is an understanding, as they get to be within any two organizations as to matters in which it is important for the two to consult, and as to matters in which the Military Liaison Committee is willing to waive its scrutiny.

Certainly, the main functions of the Military Liaison Committee are not the negative ones of guarding secrets, and so on, but the main functions are to be sure that the Atomic Energy Commission knows what it needs to do to increase the military strength of this country; what the priorities are, what the importance is, and that the services are prepared to take advantage of every new development and every improvement which takes place in the Commission laboratory.

It is this affirmative, purely military function, which is the principal function of the Military Liaison Committee, and I would think that in the light of the enormous number of problems that arise in this area, that you would have to go directly to the Commission or the Military Liaison Committee to see whether the referral of a specific case of isotope shipments should or should not have been made.

My temptation is to say "Yes" to you because it sounds like common sense.

Senator VANDENBERG. Well, if your overriding interest was not scientific, against which I do not complain, do you not think you would very definitely yield to the temptation to say yes, without reservation?

Dr. OPPENHEIMER. That proposes a hypothetical problem, rather difficult for me to grapple with.

Senator VANDENBERG. I think your answer is entirely satisfactory to me.

Senator MILLIKIN. The Doctor is also an expert in semantics. [Laughter.]

The CHAIRMAN. Are there any further questions?

Senator KNOWLAND. I have a question, Mr. Chairman.

The CHAIRMAN. Senator Knowland?

Senator KNOWLAND. Doctor, the other day we had some testimony before us which was testimony, as I recall it, which went to the point that in the event we had not shipped these isotopes abroad, they could be secured in other ways, and mention was made of the French pile and the British pile.

Leaving aside for the moment the desirability or lack of it in shipping either in the broad field or in the specific military usage, if that is posssible, in that field, I would like you to clarify the point as to whether, as a matter of fact, the French pile, keeping to that for the moment, concentrated on that, would have been in a position to have supplied substantial quantities of radioisotopes of this nature?

Dr. OPPENHEIMER. My knowledge of the French pile is meager. I was there at Chatillon in September, and it had not yet been put into operation.

I believe that the answer is the following: It does not have a capacity comparable to the Oak Ridge, or the Harwell piles of the British.

If concentrated on any one specific objective it could probably meet—that is, it could have given the Norwegians several millicuries of iron, but it could not have done that at the same time as it did other things, as we do.

Senator KNOWLAND. Just for the record, Mr. Chairman, I would like to read at this point from the fourth semiannual report of the Atomic Energy Commission, page 10, wherein it relates to wartime development. It says:

> But the cost and scarcity of isotopes would long have prevented their use in most laboratories had it not been for the wartime development of the nuclear reactor or atomic pile. These can manufacture radioisotopes in hitherto undreamed of quantities. For example, the Oak Ridge pile in a period of a few weeks has produced more than 200 millicuries of carbon 14, millions of times more than the amounts previously available. The operating cost was about $10,000. Theoretically it would take 1,000 cyclotrons to equal this output, and the operating cost would be well over $100,000,000.

I merely wish to ask this additional question: As I understood, you said that so far as you know, Norway, in this specific instance, or any other country, was not using radioisotopes for secret military purposes.

I would like to ask whether in the over-all picture of national defense and the defense of a country and its ability to either defend itself or if engaged in war to conduct a successful war, if defense in its broader term does not mean more than merely secret military development? It means the adequate hydroelectric resources, perhaps; it means adequate industrial resources; it means new types of weapons, to be sure, and new types of metals that go into weapons.

Now, in that broader——

Senator HICKENLOOPER. I suggest for the record—this is very important—that the reporter is not able to get the assenting nods of Dr. Oppenheimer's head. I merely suggest for the sake of the record that we get a verbal "yes," if we can, to these various categories of the question.

Dr. OPPENHEIMER. The nods indicate that I understand.

Senator HICKENLOOPER. But the nods—I see. [Laughter.]

Senator KNOWLAND. I will try to specify and give the doctor a chance to go over it.

Is it not true, Doctor, that the over-all national defense of a country rests on more than secret military development alone?

Dr. OPPENHEIMER. Of course it does, and in the case of this country, whose military strength is the prime military factor in the world today, it is far more true than in any other.

My own rating of the importance of isotopes in this broad sense is that they are far less important than electronic devices, but far more important than, let us say, vitamins, somewhere in between. [Laughter.]

Senator KNOWLAND. Now, taking the question that was raised in the application by Norway—and again I want to reiterate that no one on this committee complains of Norway, because she is a fine country, has an able record for freedom; she is a North Atlantic Pact nation, and there is nothing meant in criticism there—but assume for the moment that any country, by the use of research with radioisotopes, could discover a better way of making steel that would stand high temperatures, which ultimately, as Senator Millikin points out, could be translated into the building of a better type of jet engine. Would not that knowledge be of tremendous value in the military defense of any nation?

Dr. OPPENHEIMER. From what I know of the situation, such a discovery would be of very slight use to the Norwegians; of enormous use to us, and of intermediate use to the British, because the ability to use basic information is largely a question of the vigor of your technology.

History again and again shows that we have no monopoly on ideas, but we do better with them than most other countries.

Senator KNOWLAND. All I am trying to develop, Doctor, at this point is, assume for the moment that a country with a substantial industrial background far brighter than Norway—let us take Russia as an example—if she were able to discover a better way of producing steel that could withstand high temperatures, would that be of value to her in her over-all national defense, in your judgment?

Dr. OPPENHEIMER. I think it was obvious that it would be of some value, but my understanding of the situation in Russia is that even when the basic facts are known, they have, and I think we have cause to be grateful, some difficulty in making practical application of them.

The CHAIRMAN. Mr. Holifield?

Mr. HOLIFIELD. Dr. Oppenheimer, the General Advisory Committee is composed of nine members appointed by the President, I believe?

Dr. OPPENHEIMER. That is correct, sir.

Mr. HOLIFIELD. At this time, Mr. Chairman, I would like to have these nine members' names put into the record, and then I will pursue the question.

(The General Advisory Committee referred to consists of the following members:)

Dr. J. Robert Oppenheimer, director, Institute for Advanced Study, Princeton, N. J., Chairman.
Dr. James B. Conant, president, Harvard University, Cambridge, Mass.
Dr. Lee A. DuBridge, president, California Institute of Technology, Pasadena, Calif.
Dr. Enrico Fermi, professor of physics, Institute for Nuclear Studies, University of Chicago, Chicago, Ill.
Dr. I. I. Rabi, chairman, department of physics, Columbia University, New York, N. Y.
Hartley Rowe, vice president and chief engineer, United Fruit Co., Boston, Mass.
Dr. Glenn T. Seaborg, professor of chemistry, University of California, Berkeley, Calif.
Dr. Cyril S. Smith, director, Institute for the Study of Metals, University of Chicago, Chicago, Ill.
Oliver E. Buckley, president, Bell Telephone Co., New York, N. Y.

The CHAIRMAN. I do not know what the subject of Mr. Holifield's question is, so let me put this question to you, Doctor:

Senator Knowland said if the information could be developed that would be helpful to the making of jet engines, whether that would become of value to a greater country like Russia. Now, under the terms of these shipments, the Norwegians are honor-bound to make the knowledge that they secure available to everybody which, of course, includes us?

Dr. OPPENHEIMER. Yes.

The CHAIRMAN. So that if they do get something of value, presumably we would know it as quickly as anybody.

Dr. OPPENHEIMER. That is exactly the point, and be in a far better position in 999 cases out of a thousand, to make real use of it.

The CHAIRMAN. Mr. Holifield?

Mr. HOLIFIELD. Dr. Oppenheimer, I wanted to ask you to what extent has the Atomic Energy Commission availed itself of the services of the General Advisory Committee?

Dr. OPPENHEIMER. Rather completely. We meet 2 or 3 days every 2 months or so. We get a good many communications from the Commission in between.

I would say that there were few, if any, cases where we wished the Commission had asked our advice, and they did not. In many fields we have a very great sense of responsibility because, whether the Commission would have followed the policies it has or not otherwise, I do not know, but its policies coincide with the recommendations of this committee.

Mr. HOLIFIELD. The Atomic Energy Commission has followed the recommendations which the General Advisory Committee has given them?

Dr. OPPENHEIMER. Yes.

Mr. HOLIFIELD. Your General Advisory Committee is, of course, completely independent of the Commission. Its members are appointed for varying terms of years by the President?

Dr. OPPENHEIMER. That is right, and they do not see eye to eye on many questions, so that we have a bit of breadth and debate.

Mr. HOLIFIELD. I see.

Now, have there been any important recommendations which your General Advisory Committee has made which the Commission has been diametrically opposed to?

Dr. OPPENHEIMER. I testified on this, I think, 2 months ago, and I think I testified "No," and I think the committee agreed with me.

We have often contradicted ourselves, but fortunately the time lag between the adoption of a recommendation and actual action is long enough so that these contradictions in what we have said have not been serious.

Mr. HOLIFIELD. In the evaluation of the work of the Atomic Energy Commission, has your General Advisory Committee considered that they have made progress and substantial accomplishment?

Dr. OPPENHEIMER. It is, of course, not our statutory job to evaluate the Atomic Energy Commission.

However, we met about a week ago, and we knew that the Commission was under criticism, and we felt that it was likely that one or another member of the committee would be called on to testify, and a statement was drafted at that time, which constitutes a kind of evaluation, and it was drafted with the idea that it could be presented by any member of the committee who was asked the question you just asked.

I would be glad to read it or have it read into the record. It is not very long, and it is a statement which was drafted by two members of the committee, but unanimously concurred in by every member of the committee, not only as a statement of what they believed, but as a statement that we would like to make to you.

May I read it?

Mr. HOLIFIELD. Proceed, please.

Dr. OPPENHEIMER. The General Advisory Committee, in accordance with its statutory obligations, has followed the scientific and technical activities of the Atomic Energy Commission with considerable care since January 1947. We have seen at first hand the grave difficulties which the Commission faced in assuming responsibility for an extremely complex enterprise which had been disrupted by the ending of the war and by a year of uncertainty pending the establishment of the Atomic Energy Commission.

When the Commission took over, the future of the whole enterprise was uncertain, the continuity of production of fissionable materials was far from assured, the design and development of improved weapons was nearly stagnant. In each of these respects, the picture has radically changed. Better weapons have been developed and tested, the production of materials has been substantially increased and assured, and a sound and forward-looking program has been established.

There have been occasions on which the Advisory Committee has criticized the Commission and offered suggestions for the improvement of its program, which suggestions have largely been followed. In all of our examinations of the Commission's activities we have seen a frank recognition of the problems of management inherent in any new undertaking and a steady progress in their solution. The improvement which has been achieved during the Commission's administration appears to us to offer clear proof of competence and devotion to duty by the Commission.

I make this statement available to you for your records.

Senator VANDENBERG. May I ask a question at that point?

Dr. Oppenheimer, is that presumed to include an evaluation of security and the problems related to it?

Dr. OPPENHEIMER. It says that it is based on our knowledge of the scientific and technical aspects of the work.

Senator VANDENBERG. That is what I understood.

Dr. OPPENHEIMER. Some parts of security are scientific and technical; for instance, declassification, the sending of isotopes abroad; these aspects are included. Personnel security is something that we have no first-hand knowledge of. Guarding is something that we have no first-hand knowledge of, and any statement that we make refers, (A) to the things that we see at first-hand and, (B) to the over-all impression we get by knowing the projects. They cannot be a specific indorsement of the nonscientific and nontechnical things.

The sense of this statement is that if a management were bad the progress could not have been good.

Senator VANDENBERG. But your committee pays little or no attention to the problem of security, as such; your discussions are essentially in the field of science.

Dr. OPPENHEIMER. We talk about declassification policy; we talk about things touching security, but personnel security, guarding, these are matters which we have either not touched at all or very, very little.

Senator VANDENBERG. Thank you.

The CHAIRMAN. In other words, your concern is directed primarily to security by achievement rather than security by concealment.

Dr. OPPENHEIMER. We also have to worry about security by concealment, but the sense of what we wanted to say was that the job was in good shape as a positive job, and that this showed that there was pretty good management.

Mr. HOLIFIELD. On those points, where scientific secrecy is necessary, such as the declassification of documents and the shipment of isotopes and such other related matters as do come under your scrutiny, are you in a position to say that the Atomic Energy Commission has followed your advice?

Dr. OPPENHEIMER. It has been a little bit more conservative than we would have been, but otherwise it has followed our advice.

Mr. HOLIFIELD. If they have erred, they have erred on the conservative side rather than going beyond your——

Dr. OPPENHEIMER. I am not sure we are right, but comparing the recommendations of the committee with the actions of the Commission, their actions have always lain within our recommendations.

Mr. HOLIFIELD. Now, many of the members of this committee, I am sure, feel that we owe a duty to the American people to carry to them an over-all true evaluation of this program.

In your opinion, is it necessary to reveal secret data or secret methods or secret projects in order to get that evaluation over to the people?

Dr. OPPENHEIMER. Let me answer that by an analogy. I was once a member of a group of which Mr. Lilienthal was chairman, which wrote a report on the international control of atomic energy.

In the preface to that we said that we had had access to a great deal of secret information which could not be revealed, and that this information had been important to us in arriving at our conclusions.

Nevertheless, we thought that the conclusions could stand without revealing the secret information.

I think a similar situation obtains here.

Mr. HOLIFIELD. In other words, conclusions as to the——

Dr. OPPENHEIMER. And evidence, too.

Mr. HOLIFIELD. And accomplishment of the atomic energy program can be made available on substantially authoritative grounds to the American people without resorting to secret information in order to either support it or detract from it?

Dr. OPPENHEIMER. I believe that there is enough in the public domain or that could and should be in the public demain to make an inquiry sound.

I think there is a lot that is not in the public domain, and that will limit the exhaustiveness of any public inquiry.

Mr. HOLIFIELD. Thank you, Doctor.

The CHAIRMAN. Mr. Cole?

Mr. COLE. Doctor, what was the recommendation of the General Advisory Committee with respect to the Commission's granting of scholarships, fellowships, to avowed Communists?

Dr. OPPENHEIMER. We made no recommendation.

Mr. COLE. Was the proposal of the commission with respect to fellowships submitted to the General Advisory Committee?

Dr. OPPENHEIMER. The initial proposal long ago?

Mr. COLE. Yes.

Dr. OPPENHEIMER. It was, and we commented on it favorably. That is all in your records.

Mr. COLE. What is your own opinion with respect to granting fellowships to avowed Communists?

Dr. OPPENHEIMER. I stated that—well, I stated my general opinions in a letter to the chairman, which was read into the record. I think if the problem were as straightforward as picking among two equally qualified people, one who is an avowed Communist and one who is not, it would be a very easy problem.

The problem is, how much trouble you take to find out whether a man is a Communist, and what do you do in the course of this, and there I have rather strong views, that a fellowship program which brings with it the investigative machinery that we use for secret things had better be dropped. It will do more harm than good.

Mr. COLE. You feel that the withholding of fellowships to avowed Communists is an invasion of academic freedom?

Dr. OPPENHEIMER. No.

Mr. COLE. Going back to isotopes, I would like to have your interpretation of the recommendation of the General Advisory Committee which is quoted to us as being as follows:

> The conditions under which these materials will be sold at cost to an individual scientific laboratory are such as to insure that the sole purpose for which they will be used is for research or medical treatment.

Now, is it your opinion that that research to which reference is made in the recommendation is only research related to or in connection with medical treatment?

Dr. OPPENHEIMER. That was not our intention. In other places we said, "basic research."

Mr. COLE. Well, that partially answers my next question. What kind of research was intended when we used that expression?

Dr. OPPENHEIMER. Research directed at the discovery of the nature of the world of nature and man, and not research directed at the solution of a practical problem. There is no hard line, but there is such a great difference between development and engineering on the one side, and science on the other, that I think it is a pretty clear-cut thing.

Mr. COLE. Then, it is the recommendation of the committee that isotopes may be shipped for basic research even though that research——

Dr. OPPENHEIMER. That was our belief.

Mr. COLE. May have some relationship to eventual practical use?

Dr. OPPENHEIMER. Well, there is, I believe, no research in the world, of which anyone can guarantee that it will never have any relationship to eventual practical use.

It is awfully easy to tell in specific cases whether a man is busy developing a gadget and wants to improve a piece of it, or whether a man is curious about how things work, and is pursuing that curiosity.

There are borderline cases, and no words will ever cut that border absolutely clean.

Mr. COLE. That prompts me to make my final inquiry and to ask my final question: I am wondering how difficult it would be for the General Advisory Committee to enumerate the particular isotopes for which shipment abroad the committee recommends, or is the field of isotopes so completely variable and innumerable that it would be impossible to identify them and to list them?

Dr. OPPENHEIMER. I think that even the General Advisory Committee would assume a rather conservative use. You would not ship isotopes if you saw any danger, and you would not ship any isotopes unless you had a pretty good feeling they would be useful.

I believe we could extend the Commission's list. I know of no way in which we need to cut it back, but this is an undertaking which one member of the General Advisory Committee, Dr. Seaborg, who is one of the authors of this [indicating a pamphlet]—this is what is known about isotopes—could perhaps do better than the committee, as a whole. A committee is a bad agency to do any really useful work, as you know. [Laughter.]

Mr. COLE. The trouble with your statement that the committee is satisfied with permitting the shipment of isotopes except those which might have a dangerous use is that when you have to rely upon somebody's determination of what is dangerous and what is not dangerous.

Dr. OPPENHEIMER. Sure.

Mr. COLE. What I am wondering is if it is not possible for the General Advisory Committee to enumerate the isotopes which, in the opinion of the General Advisory Committee, are not dangerous.

Dr. OPPENHEIMER. I believe we could do that. My impression is that Dr. Pitzer, who is Director of Research, and Dr. Aebersold, who is in charge of the isotopes program, are probably better persons to do it than the General Advisory Committee. They are our colleagues who are scientists, and they have been living with these things for years.

I believe you would not get as good a job out of the General Advisory Committee, but there is no reason in principle why we should not take a day off and do it.

Mr. COLE. I should like to emphasize or make certain that I understand your statement. There have been no instances in which the

Commission has failed to observe the recommendations of the General Advisory Committee?

Dr. OPPENHEIMER. That is too broad a statement. I think I need to qualify it by saying that there are none sufficiently prominent so that any member of the General Advisory Committee remember it in the field that we are supposed to advise on.

Mr. COLE. Thank you.

The CHAIRMAN. Mr. Hinshaw?

Mr. HINSHAW. Mr. Chairman, before asking two or three questions of Dr. Oppenheimer, I should like to acknowledge, as I am sure the committee does, that the law, as agreed to and as enacted, is probably, and I might say no doubt is, an imperfect instrument in many, many respects, but assuming that the law is a law, the questions I would like to ask are as follows:

First, are radioactive isotopes included within the definition of atomic energy as contained in the act in section 18 (a), in your opinion?

Dr. OPPENHEIMER. The law was written by other people, and I do not know the answer to that question.

Mr. HINSHAW. Well, the law is in section 18 (a), and I thought, perhaps, having read it that you might be able to——

Dr. OPPENHEIMER. Let me say, if I take those words strictly, I include every source of energy except tidal power. If you say that does not make common sense, then I have got to ask you what is common sense?

Oil is made as a result of the absorption of sunlight which is generated by the reaction of nuclei in the sun. If you want me to take the law strictly, you have got a very broad kind of definition. If you want to define atomic energy in a practical way, I will understand your definition, but do not ask me to make it.

Mr. HINSHAW. Mr. Chairman, I would assume that the committee in drafting the act, and I was not a member of the committee at that time, called upon competent scientific personnel in the drafting of section 18 (a). I do not know whether Dr. Oppenheimer was one of those who was called upon to help draft that section or not.

Dr. OPPENHEIMER. I was not.

Mr. HINSHAW. But in all events, would your answer to the question in its strictest sense then include the radioactive isotope as coming under and within the definition as contained in section 18 (a)?

Dr. OPPENHEIMER. If I were to define atomic energy for the purposes of this act, I would exclude radioactive isotopes from the definition.

Mr. HINSHAW. Well, I acknowledge that we, perhaps, should amend the act accordingly, but I just asked a question.

Dr. OPPENHEIMER. I would also exclude oil and human beings and coal.

Mr. HINSHAW. Section 18 (a)——

The CHAIRMAN. Everything?

Dr. OPPENHEIMER. Well, tidal power, you may be able to get by.

The CHAIRMAN. Tidal power?

Dr. OPPENHEIMER. Yes, I am not sure.

The CHAIRMAN. The movement of the ocean?

Dr. OPPENHEIMER. Of the tides; yes, sir. It is not known whether that results from nuclear transmutation.

The CHAIRMAN. Is that the only exception?

Dr. OPPENHEIMER. It is the only exception I know of.

Mr. HINSHAW. Section 18 (a), if I may be privileged to read it again, is very short, and reads as follows:

The term "atomic energy" shall be construed to mean all forms of energy released in the course of or as a result of nuclear fission or nuclear transformation.

Now, that term applies directly to energy and does not apply to matter, as such, as I understand it, and its energy relations; therefore, under the terms of that definition, would radioactive isotopes constitute a form of energy released in the course of or as a result of nuclear fission or nuclear transformation?

Dr. OPPENHEIMER. An isotope is not energy. It is a source of energy, just as oil is not energy but a source of energy. I am not a lawyer, and the advice I give the committee on these matters will be of no use. I do not mind chatting with you about them, but I advise you against taking my remarks seriously. [Laughter.]

Mr. HINSHAW. Well, I am sure the committee always takes the doctor's remarks seriously, as he is considered to be one of the outstanding authorities on the subject.

My second question follows by virtue of the fact that under the Commission's Fourth Semiannual Report, there begins on page 14 a long dissertation under the general heading "Distribution of isotopes."

On page 28 there begins a section on industrial utilization which runs for two pages in the Fourth Semiannual Report.

Now, the question is, does the shipment of radioactive isotopes to a foreign military establishment constitute in your judgment a transmission of information with respect to the use of atomic energy for industrial purposes?

Dr. OPPENHEIMER. I have already testified that in my opinion the intent of the law should have been different than to exclude these, but what the intent of the law is you cannot get by asking me.

Mr. HINSHAW. Mr. Chairman, I submit that it is very difficult indeed to find out what the law means when we would like very much to know.

Dr. OPPENHEIMER. I think the law needs to provide that we should not encourage or help development in foreign countries which will lead to the accumulation of large numbers of atomic weapons. That is a big point. Let us keep our eyes on that ball.

The CHAIRMAN. And that the intent of the act in that respect as far as you know has not been violated, has it, Doctor?

Dr. OPPENHEIMER. It certainly has not.

Mr. DURHAM. Well, there is a possibility, Doctor, that we may be struggling with this problem beyond this element; we may be struggling with it in all of the elements, a good part of it.

Dr. OPPENHEIMER. I regard the isotope problem which I have talked about this morning as really very slightly affecting security, and for that reason it is one of the few areas in which we are free to act the way we would like to act, generously, imaginatively and decently; in the things that involve security we are inhibited from doing that and, our friends abroad understand that.

Mr. HINSHAW. Mr. Chairman, in conclusion, I submit that perhaps the law should be amended, but that it is very difficult in the meantime to find out what a proper interpretation of the law is in respect to the subject of the shipment of isotopes for industrial purposes.

The CHAIRMAN. Mr. Jackson?

Mr. JACKSON. Mr. Chairman, I would like to ask a couple of questions, I think, which may be slightly repetitious and with respect to which there may be a slight reiteration, but I want to get to the heart of this problem.

The committee has been discussing isotopes in public hearings.

I think the American public would like to know whether the conduct of the Commission in connection with the dissemination of isotopes abroad, as related in the hearings this morning, jeopardize the security of this country.

Dr. OPPENHEIMER. I believe that it was in the interest of the security of this country, and I will spell that out. I believe that for a country of the size and wealth of Norway, to establish its own atomic energy program is both a discouraging process and a temptation. I believe that if we took an absolutely rigid attitude with regard to noncooperation in places where security was not involved, we would be encouraging all agencies abroad to make themselves totally independent of us.

They would have trouble doing that, but it certainly would not be in the interest of the security of the United States for us to follow that line.

Mr. JACKSON. I am glad, Dr. Oppenheimer, that you mentioned the place of Norway because it has played a rather prominent role in the discussion of the exportation of isotopes.

You feel, then, that the exchange of information, of technical information, that may come from the export of isotopes to Norway, may ultimately benefit the United States?

Dr. OPPENHEIMER. Oh, I have no doubt of it.

Mr. JACKSON. You have no doubt of it.

Do you know of the scientific personnel in Norway? Do you know something about them?

Dr. OPPENHEIMER. I know some. A number of Norwegian mathematicians and physicists have visited the Institute in Princeton. They are excellent workers. I do not know the people involved in this iron 59 job.

Mr. JACKSON. Getting away from legal semantics, Dr. Oppenheimer, and to again get to the heart of the Atomic Energy Act, do you feel that possibly the real purpose of the restrictive provisions of the act, dealing with exportation of certain matters, were for the purpose, the overriding purpose of protecting the secret of the bomb and to prevent a potential enemy or other countries, other foreign countries, from getting information that would result in the accumulation or the development of atomic bombs?

Dr. OPPENHEIMER. That is just about it. I do not see why the United States should take actions whose effect will be to stimulate atomic energy for military purposes abroad.

Mr. JACKSON. Dr. Oppenheimer, I am sure there is not any man living who can possibly assure the people of this country from a technical standpoint like you could at this time. In connection with this isotopic problem, as far as exportation is concerned, can you assure the people of this country that we are not jeopardizing our security in the way the program has been handled up to this time?

Dr. OPPENHEIMER. I certainly can.

Mr. JACKSON. And, Dr. Oppenheimer, some mention was made of the fact that in connection with the isotopic research, that it might result in certain improvements in materials that could be used for war purposes. Is it not true that we are engaged in the United States in open research that is available to other countries, that likewise could be used for——

Dr. OPPENHEIMER. Of course.

Mr. JACKSON (continuing). Military purposes?

Dr. OPPENHEIMER. There are three open users of iron 59 for studying the diffusion of iron in alloys. All of this work will be published.

Mr. JACKSON. And that situation is comparable to the isotopic problem we are discussing here?

Dr. OPPENHEIMER. It is that. It is the same isotope as in Norway.

Mr. JACKSON. Dr. Oppenheimer, you were the wartime Director of the Los Alamos Laboratory?

Dr. OPPENHEIMER. Yes; I was.

Mr. JACKSON. I wonder if you would care to comment on the present caliber of the laboratory at Los Alamos as compared with the situation that you had to face possibly under the Manhattan project? What improvements, if any, have been made, and what progress has been made?

Dr. OPPENHEIMER. I will not testify against myself. During the war we had the best laboratory in the world there. But I think that it is generally regarded by my colleagues that Los Alamos is the best Federal laboratory and the best laboratory working on a military job that there is in the country. And I feel, with all the confidence in the world, that it is a very good laboratory. Its morale is good; its product is good; it has learned a number of things; and it has the courage to try out a number of new things and it is air-borne.

This being air-borne is the result of many things, but it is very largely a result of the understanding, the encouragement, the babying if you want, that the Commission has given it. The laboratory could have gone to pieces. It has not. Its director is a fine fellow.

Mr. JACKSON. I know that you did a fine job in the laboratory during the war. We have been throwing words around here so much this morning that possibly my intent was not clear.

But what I want to get from you is whether or not you could say that we were making real progress at Los Alamos, and are you satisfied with the progress, if any, that has occurred since the Atomic Energy Commission has taken over?

Dr. OPPENHEIMER. I am very much satisfied. Quite a number of very important improvements in atomic weapon design and atomic weapon manufacture have been worked out. The present program of the laboratory is to carry this further and to get into some new and more difficult things.

It is a sound program; it is soundly conceived; and it is going forward full steam ahead. It is not a wartime effort. It is not the kind of 100 percent, everybody-in thing that we had in the war; but we would not expect that. And it is a very, very good laboratory.

Mr. JACKSON. Considering all the factors, then, that exist today, you feel that every reasonable and prudent effort is being made to protect the security of our country?

Dr. OPPENHEIMER. Every possible effort.

Mr. JACKSON. One or two other matters, Dr. Oppenheimer. Mr. Lilienthal has testified from time to time in connection with security problems that security involves more than guards, fences, and personnel clearances.

I wonder if you would care to comment, if you might—if you feel free to do so—on the security program very briefly of the Commission.

Dr. OPPENHEIMER. I think the Commission has had a very, very difficult time reconciling the provisions of the act and the needs for reliability on the part of its personnel with the kind of freedom and spontaneity which is required if real progress is to be made.

My feeling is that the Commission has sweated blood over that one and come up with about as good an answer as it is possible to get. I do not think anybody can be happy at the fine-tooth combing that has to be given to every man that has to work on the atomic energy program. But one understands why it is; and as long as it is restricted to those places where there are some secrets to be kept, people will stand for it.

I think the Commission has balanced very carefully, in the few cases I know about, the requirements of security and the requirements of progress and of humanity. It has not been easy.

Mr. JACKSON. Considering the problem of a secrecy, in the first instance, being foreign to our democratic way of life, and the conflicts that arise in the field of science: Do you feel that they have struck a balance that, as its ultimate result, will provide for real security for our country?

Dr. OPPENHEIMER. I think they can go further toward making information public which is now secret. But I think that since that is an irreversible step, they have been very prudent and very good in handling it. I do not think they have gone far enough.

Mr. JACKSON. Has the General Advisory Committee made a statement in connection with the shipment of isotopes?

Dr. OPPENHEIMER. Oh, yes. Your records are full of statements.

Mr. JACKSON. I mean recently?

Dr. OPPENHEIMER. Recently it simply said that it agreed with itself.

Mr. JACKSON. Including the Norwegian shipment?

Dr. OPPENHEIMER. It did not say anything about Norway, largely because the detailed evidence of what that case was, was not available to us. But the most qualified member of our committee, the metallurgist, expressed the opinion that it did fall within the intent of the Commission's work.

Mr. JACKSON. One last question, Dr. Oppenheimer. Considering the knowledge and information that you have of the over-all program of the Commission, and bearing in mind the work that you have done in connection with the Manhattan project, are you satisfied as a whole with the program of the Atomic Energy Commission and with its management?

Dr. OPPENHEIMER. I certainly am. As a member of the General Advisory Committee, it is my job not to be satisfied. Here it is my duty, and my pleasure, to be satisfied.

Mr. HOLIFIELD. Will the gentleman yield?

Mr. JACKSON. Yes.

Mr. HOLIFIELD. Dr. Oppenheimer, in regard to the shipment to Norway of these isotopes, is it not true that the atomic energy project and the scientists of this country owe a great deal to a Norwegian scientist by the name of Neils Bohr and some of his associates?

Mr. JACKSON. He is Danish.

Mr. HOLIFIELD. My Norwegian colleague is very zealous.

Dr. OPPENHEIMER. Even the disputes to which this committee has been host are trivial compared to those as to the relative merits of the Danes and the Norwegians. If I could keep out of those, I would appreciate it.

Mr. HOLIFIELD. I will grant you to keep out of them. But there is a well-developed scientific group in Norway.

Dr. OPPENHEIMER. That is quite true. Hillaraes was one of their most well-known people at the Princeton Institute last year.

Mr. HOLIFIELD. They cooperated with this country freely and frankly without reservation as far as you know?

Dr. OPPENHEIMER. As far as I know; yes, sir.

Mr. HOLIFIELD. Thank you.

Senator KNOWLAND. Mr. Chairman, I have a few questions to pick up matters in relation to the committee other than the scientific end—leaving aside security—which you have already made abundantly clear.

What I would like to ask, being familiar with the law as to its drafting, of course as you gain experience under a law, regardless of what it is, you perhaps can find ways of improving it, has the Commission, for instance, ever considered in the set-up of the Commission and the General Manager, where the General Manager is appointed by the President directly and confirmed, rather than being directly responsible to the Commission which might otherwise appoint him and hold him responsible to them—has the General Advisory Committee given any thought from an organization chart point of view where the existing law might be improved?

Dr. OPPENHEIMER. On this point we have certainly not. Occasionally, when you follow a technical point, you ask the question: Why are things not going better? And sometimes this refers to organization. This is usually organization on a lower level, and the question you have raised is not one that we have discussed.

Senator KNOWLAND. It has not come up before?

Dr. OPPENHEIMER. My impression is that the individual members of the General Advisory Committee have very different views—separately different views—on how the Atomic Energy Act should have been written.

Senator KNOWLAND. Secondly I should like to ask: You are familiar with the testimony before the committee regarding the loss of some material at Argonne, which they believe they have found substantially all of, perhaps with the exception of 4 grams, I believe.

Could you, from your expert knowledge, tell the committee—assuming just for the moment that the 4 grams did get into hands where they should not be—how valuable the loss of that amount of material, or the gain of that amount of material, might be to a country that was embarking on a program that you were working with a few years ago?

Dr. OPPENHEIMER. It doesn't seem to me decisive. But in order to judge it, I need to know what country had it. At Los Alamos we were very glad to get the first samples of material. But that was because our mission was to interpose no day's delay between the arrival of the material and the readiness of the bomb.

If we had had another month or so, I don't think we would have been affected. That is the thing which makes these even small samples valuable, a very tight—tight by weeks and months—time schedule. I do not think it would affect the time schedule by any appreciable time, whether we did or did not have it.

Also, 4 grams is not a precisely critical amount; and my understanding is that it was not even isotopically pure. The general feeling I have is that even if the evidence before us is misleading, and material had been abstracted, it would not be something to ring the bell about.

Senator KNOWLAND. My recollection is that the report of the Canadian Royal Commission has amply shown, I believe, that two milligrams was the amount which had been——

Dr. OPPENHEIMER. You see, that is, on the one hand, material which does not exist in nature and which is pretty hard to make by cyclotron bombardment. On the other hand, it was 4 years ago.

Finally, the point there was not how valuable this would be to the enemy, but what a terrible thing it was that it had been given to them.

Senator KNOWLAND. There are both phases of it.

Dr. OPPENHEIMER. We were certainly, at Los Alamos, very glad to get our first plutonium. Uranium-235 was never such a thing. Plutonium was a new substance. We had the feeling—perhaps wrong—that 100,000 lives, maybe more, might depend on whether this thing was ready August 1, September 1, October 1.

Senator KNOWLAND. In other words, as I understand your testimony, it would be of value but not decisive.

Dr. OPPENHEIMER. That is right.

The CHAIRMAN. Senator Hickenlooper?

Senator HICKENLOOPER. Dr. Oppenheimer, the production of weapons and the application of materials, for instance, at Los Alamos is not done by the Commission, is it? It is done by a contractor—the University of California?

Dr. OPPENHEIMER. It is also not done by the contractor. It is done by some fellows. The contractor during the war years was an extremely helpful and able contractor, but was really distinguished primarily by his absence. Since then the university has been allowed to take a somewhat more active part.

But the Commission is dealing with technical people who are paid and protected by the University of California, but who are not normal employees of the University of California, who are not doing a normal thing for the University of California to be doing.

And the policies under which the laboratory is run, the technical directives for the laboratory, the employment policies, the conditions of work, are not determined by the contractor. They are determined by the Commission.

Senator HICKENLOOPER. You mean to say that the University of California does not have a contractual responsibility for the completion of those activities out there?

Dr. OPPENHEIMER. I do not know. During the war the University of California never saw the directives and had no idea what the directives said.

Senator HICKENLOOPER. We are talking about now.

Dr. OPPENHEIMER. I do not know the answer to that question. But my guess is that the directives are agreed to by the laboratory staff and the Commission, that they are written out, and that the role of the contractor is very minor.

Senator HICKENLOOPER. And that the laboratory staff is paid by the University of California. Is that correct?

Dr. OPPENHEIMER. It is paid through the university.

Senator HICKENLOOPER. Reimbursed by the Commission.

I again want to clarify the issue that at least I raised the other day. The issues are not any criticism of the country of Norway, in any way, shape, or form. I did not raise the issue of any criticism of the general isotope programs announced. I state no position either for or against the general isotope program.

The criticism I raised was the opening wedge, as I believe it, of the furnishing of isotopes to a foreign power over whom we have no ultimate control. We may have argumentative influences on our side, but once the isotope is gone, we have no legal control over it; we have nothing but the so-called good faith to go on in any of these countries, after the isotope gets out of our hands.

The criticism was raised that this could be the opening wedge in a policy for the furnishing of isotopes which could supply information which would operate in war potential, whether it is atomic bomb making or high-speed steel or high heat-resistant steel for jets, or any other thing which could be used in war.

Now, that was the sole issue that I raised, and I still do not raise objection or agreement to the general program of isotope distribution for humanitarian purposes.

Dr. OPPENHEIMER. You merely say it is illegal.

Senator HICKENLOOPER. No. I say it is more than illegal. I take the position that when we furnish isotopes that are the tools for the discovery of new laws or new uses or new applications of things such as steel in a military institute, or other things, that we are embarking on a program which I believe is outside the purview of the law, and which is inimical to our national defense because of the lack of control we have over the use of those things.

The CHAIRMAN. May I interject a question?

Senator HICKENLOOPER. Surely.

The CHAIRMAN. Assuming your state of mind to be as you have related it here, would it be possible to serve the proposition of the dissemination of these radioisotopes for medical and biological research abroad, as you have indicated that you would like to do, without coming within the prohibition of the law as you understand it?

Senator HICKENLOOPER. I have repeatedly said that I am neither approving or opposing, at this time, the question of the over-all isotope policy. I may reach that point at a later date when our definitions are better.

But I do not care to get into that particular phase because it is getting afield from the specific thing that I wanted to raise.

May I ask you, Dr. Oppenheimer: Do you know Dr. Shoupp, head of the nucleonics department of Westinghouse Laboratory?

Dr. OPPENHEIMER. I know him, but he is not a close friend of mine.

Senator HICKENLOOPER. It was reported here— I have not seen the clipping myself—that he a few days ago, or in the immediate past, stated in effect—the statement is in the hearings of June 9——

Dr. OPPENHEIMER. I have seen the statement.

Senator HICKENLOOPER. That isotopes are helpful and are being used for heat-resistant steel at high-temperature investigations and for gas turbines, jet engines; and I believe it has come out that isotopes are valuable in research in biology; and I believe it has been stated that isotopes can be used in connection with the mutations of bacteriological forms in that study.

Dr. OPPENHEIMER. I was unable to make head or tail of that statement. I may be wrong, but I was told that there is not a single case where exportable isotopes are being used for military secret research.

Senator HICKENLOOPER. How would you know?

Dr. OPPENHEIMER. From the records of the Commission.

Senator HICKENLOOPER. How would the Commission know, except from the statements that are being made by the users?

Dr. OPPENHEIMER. I am not talking about abroad. I am talking about America. And Dr. Shoupp notwithstanding, Westinghouse proposes to publish the results of its research. This is "scuttlebutt" and should not be in testimony; but I am told that Dr. Shoupp regrets the misinterpretation of what he said.

Senator HICKENLOOPER. I do not know about that.

Dr. OPPENHEIMER. I do not know either. It is hearsay.

Senator HICKENLOOPER. We do not export all of the isotopes that we produce, do we?

Dr. OPPENHEIMER. No.

Senator HICKENLOOPER. Why don't we?

Dr. OPPENHEIMER. The reason we do not export plutonium is that its properties are of interest in the manufacture of atomic weapons.

Senator HICKENLOOPER. It furnishes information?

Dr. OPPENHEIMER. It furnishes information about a highly secret undertaking. If we will take the isotopes separately, I may be able to give you the answer; I may not. I do not know the reason why certain ones are not exported.

Some radioactive isotopes have been used at Los Alamos, but both the nature of the isotopes and the quantities have no relation at all to what is being shipped abroad.

Senator HICKENLOOPER. Doctor, may I ask you this. You are perfectly at liberty to answer it or not, as your judgment dictates.

Have we made, in our atomic energy program, the progress and the accomplishment in the production of atomic weapons that we would have made had the Commission vigorously accepted the program and the recommendations in general of the General Advisory Committee?

Dr. OPPENHEIMER. I think the answer to that question is "Yes."

Senator HICKENLOOPER. Has your General Advisory Committee ever, as a committee, been critical of the administrative procedures and the administrative actions of the Commission?

Dr. OPPENHEIMER. Not as a committee, sir; no.

Senator HICKENLOOPER. Have you ever communicated, either as an individual or as chairman of the committee, substantial criticism of the Commission?

Dr. OPPENHEIMER. I have; and the Commission has responded, I believe, wholly to that criticism. Do you wish me to describe this?

Senator HICKENLOOPER. Not necessarily. I do not want you to describe anything——

Dr. OPPENHEIMER. It is a perfectly well-defined point. We felt that some of the activities of the Commission would prosper more if the lines of authority were functional rather than regional; and I so advised the Commission and stated that this was the individual opinion of a number of members of the General Advisory Committee.

Subsequent to that—but I think not entirely as a result of it—the Commission in fact adopted a more functional organization. That is the only case that I can remember.

Senator HICKENLOOPER. That is all I have at this time.

The CHAIRMAN. Mr. Jackson, do you have another question?

Mr. JACKSON. I would like to see if we can clarify the issues on this. What phase of the program related to isotopes was the Commission being criticized for?

As I understand it, the shipments of isotopes started in 1947. That has been known for a long time, and maybe the statute of limitations will start running, as far as any mismanagement of that phase.

Am I to understand that the criticism was directed solely to the shipment to Norway, or is to go to the whole program of the dissemination of isotopes?

Senator HICKENLOOPER. Do you want me to answer that?

Mr. JACKSON. Yes.

Senator HICKENLOOPER. I have repeatedly said it is the principal shipment to Norway that is illustrative. I have nothing against Norway; no one has anything against Norway. They are our allies and our friends.

But it is the principle of opening the gates, if you please. It is the camel getting its head under the tent and the shipment of isotopes which can be used and which, if this policy is continued, undoubtedly will be used for industrial investigation which in turn can be used in various parts of the world inimical to our own national defense.

It is a question of having it carried step by step to further release of information in a policy which I think should not at this time, without a change in the law, at least, and good consideration, be adopted.

Mr. JACKSON. The shipments prior to the Norwegian shipments, then, are satisfactory?

Senator HICKENLOOPER. I have said repeatedly that I am not raising that question at this time.

Dr. OPPENHEIMER. I think there is a general point. The attempt to maintain a monopoly of atomic weapons is a holding operation. It is an important holding operation. It is not an operation that can go on indefinitely.

The British have powerful reactors; the French have a weak reactor; and presumably will have a powerful one.

We have a great interest in not overstimulating the development of atomic energy abroad. If we try to act as though 1950 were 1945, we will be defeating the very security we are trying to achieve.

It is not that it would not be desirable to hold this monopoly; it is that it is not possible.

Senator HICKENLOOPER. But, Doctor, we have talked a great deal about building atomic weapons abroad. This does not necessarily go to the building of atomic weapons. It goes to industrial potentials which can kill people just as well as atomic weapons can kill people and which can defeat a nation in war if they have a superabundance of them or better equipment, just the same as atomic weapons can kill people in war.

And this is that point and not the fabrication of atomic weapons that I believe is one of the vital and important points involved in this particular new policy.

At least, I consider it a new policy.

Mr. JACKSON. Mr. Chairman, I have one last question.

The CHAIRMAN. All right, Mr. Jackson.

Mr. JACKSON. Mr. Chairman, I believe there have been some statements made here to the effect that when you ship isotopes abroad, we have no control over them; that there is always a possibility that instead of being used for medical research, they might be used for research in basic metals and so on.

I would like to ask this question: If that is true, how can we carry on any phase of the isotopic program if we do not have faith in the countries that we make these agreements with?

Senator HICKENLOOPER. Mr. Chairman, I would answer that: If we could control the situation with absolute assurance, the same argument could be used in favor of giving away the entire scientific methods and details and techniques of making atomic bombs.

Mr. JACKSON. I do not think it applies at all, Mr. Chairman, for the simple reason that Dr. Oppenheimer has testified that the materials that are being shipped do not have anything to do with the bomb, that their purposes are for basic research. As long as the fissionable products are not exported there is no danger. Is that correct, Dr. Oppenheimer?

Dr. OPPENHEIMER. That is about it.

Mr. HINSHAW. Mr. Chairman?

The CHAIRMAN. Mr. Hinshaw, may I interject a question?

Mr. HINSHAW. Certainly.

The CHAIRMAN. As I understand it, doctor, the basic proposition you advance is that the radioisotope is not the source of atomic energy as we have heretofore considered it. Is not that the basic proposition?

Dr. OPPENHEIMER. On the legal side, I think that atomic energy should be so defined. On the substantive side, I think the procedure of making materials for basic studies abroad contributes to the security of this country in innumerable ways, and that the record of our own use of these materials shows how insignificant and illusory the dangers are.

The CHAIRMAN. Radioisotopes, it is claimed, are useful for industrial purposes. It is atomic energy for industrial purposes that we intended to prohibit by law.

Dr. OPPENHEIMER. I think this mean kilowatts.

The CHAIRMAN. Now, radioisotopes, not being atomic energy, as it is scientifically defined, are not connected with the prohibition that is contained in the statute against the dissemination of information with respect to the use of atomic energy for industrial purposes; am I correct about that?

Dr. OPPENHEIMER. That is an interpretation of the law which strikes me as sound common sense. I do not know what more I can say. Atomic energy is not a scientific phrase.

The CHAIRMAN. As the author of the act, that was my interpretation.

Dr. OPPENHEIMER. Good.

The CHAIRMAN. Mr. Hinshaw?

Mr. HINSHAW. Doctor, for the purposes of our information, in science what is the definition of 1 millicurie?

Dr. OPPENHEIMER. It is one one-thousandth of a curie. And a curie is defined as a rate of disintegration. It is the rate of disintegration of one gram of radium. It is the number of nuclear events occurring per unit of time. A millicurie is one one-thousandth of a number of nuclear disintegrations occurring when you have a gram of radium.

Mr. DURHAM. What part of a grain, Doctor?

Dr. OPPENHEIMER. A gram. A gram is a thousandth of a kilogram, about one four-hundredths of a pound.

Mr. HINSHAW. May I ask, then: Quantitatively, can one point out what I millicurie of carbon 14 is in terms of weight of carbon 14?

Dr. OPPENHEIMER. I can figure it out, but it will take a little while.

Mr. HINSHAW. I wouldn't ask you to do that here. But on page 10 of the Commission's Fourth Semiannual Report, as read by Senator Knowland, it refers to the fact that—

> In the Oak Ridge pile more than 200 millicuries of carbon 14 were produced; millions of times more than the amounts previously available. The operating cost was about $10,000—

which, as I figure, would be about $50 per millicurie.

Dr. OPPENHEIMER. The answer is roughly one one-thousandth of a gram, a millicurie.

Mr. HINSHAW. A ten-thousandth of a gram?

Dr. OPPENHEIMER. Roughly.

Mr. HINSHAW. Then it says:

> Theoretically it would take 1,000 cyclotrons to equal this output. The operating cost would be well over $100,000,000—

which I figure to be $500,000 per millicurie. That is a very expensive little item.

Dr. OPPENHEIMER. It certainly is. It was discovered just before the war. The normal carbon isotope that was used in research was carbon 11, which is cheap to make, but it lasts a very short time. And in studying the growth of plants, where processes are slow, and the natural times of the orders of days, it was very hard to make progress.

The discovery of carbon 14 is one of the great events in the history of biochemistry and biology. And it does not take much because you do not detect the material by weighing it; you detect it by the radiation it emits. And that is a very sensitive way of detecting material.

Mr. HINSHAW. I take it it would be worth about $5,000,000,000 a gram at the amounts you produce it.

Senator HICKENLOOPER. Mr. Chairman, I would like to ask Dr. Oppenheimer: These comparisons, when people say "A milligram is so little you can hardly see it," in dealing with this particular nuclear science submicroscopic amounts have been very, very important to many of these things, have they not? And very, very small amounts, almost unseeable smears, have been very important, and give very important answers?

Dr. OPPENHEIMER. In precisely the sense in which I spoke to Senator Knowland. If you have a rising production and you want to be ready on A-day and not have any loose ends, then you have got to take advantage of the first time you get a little smudge of something.

If you do not care whether you are ready in February or in April, I do not think the small amounts have any great consequence.

Senator HICKENLOOPER. But in determining rates of decay, for use in bombardments that give you certain answers, infinitesimal amounts almost are very important in those researches, are they not? You do not have to have a pile as big as a teacup.

Dr. OPPENHEIMER. Let me testify that infinitesimal amounts of some of these materials got us so thoroughly confused that we might have been better off if we had not had them. You get information, but what you get is not always right.

Senator HICKENLOOPER. You started some of the original studies, when this enterprise began as an enterprise, with very, very small amounts, and you had to run cyclotrons for a long period of time to develop even 1 millicurie or less.

Dr. OPPENHEIMER. That is absolutely right. I want to emphasize the importance of this was in meeting a deadline, rather than in accomplishing a successful project.

Senator KNOWLAND. Doctor, if a person, or country X, did not have the bomb, they might consider that they were trying to meet a deadline and therefore might put top priority on getting their hands on a very small amount. Is that not correct?

Dr. OPPENHEIMER. It is certainly conceivable.

The CHAIRMAN. Doctor, we do not want to keep you unduly, but I want to ask you a question about the morale of the scientists associated with the atomic energy program, compared to what it was in the past. Is it good, better, or worse? What is your estimate of that?

Dr. OPPENHEIMER. I think the first years of the Commission's administration were in many places a period of great solidification of morale. The laboratory that is closest to me is Los Alamos, and it has certainly changed from the laboratory that was insecure and rather hesitating in its technical work, to a forward-looking, vigorous establishment.

The morale of the scientists engaged in making weapons of war is always going to be an unstable thing. We know that. We do the best we can.

A fair, considerate administration is one indispensable thing, and it is my belief—I would like to testify to this—that one of the real reasons for the success of the project is that the Atomic Energy Commission, the Comissioners under the Chairman of the Commission, have understood that the program was only so good as the morale of the men that were doing the work.

The CHAIRMAN. One final question, Doctor. Are you satisfied with our weapon progress since the end of the war?

Dr. OPPENHEIMER. It is my business not to be satisfied, but I am. It is my business to try to find points where it should be criticized. But it is far better than I thought it would be.

The CHAIRMAN. Senator Hickenlooper?

Senator HICKENLOOPER. Doctor, you spoke a while ago about new weapons being tested. Is it not a fact that the new weapons that have been tested were weapons the basic design of which had been developed under the Manhattan District, and that this was merely going forward and improving those basic designs?

Dr. OPPENHEIMER. Some features of the weapons tested were features which I asked General Groves to let me incorporate in the bomb that did not go to Japan because the war was over. Other features were features which we did not then know how to realize, though we knew very well that we ought to try.

The realization of these is a technical achievement which is not trivial. The present work of the Los Alamos Laboratory is on a series of things, all of which were somewhere in the air, surely, but which looked very hard to do and very tough to the wartime Los Alamos Laboratory.

I think this is just the way it ought to be. They have cleaned up things left over from the past, and they have found new things to do; and this is the root of progress.

Senator HICKENLOOPER. One other question about the morale, the scientific morale.

After the bomb dropped on Hiroshima, and the war was coming to an end, there was a period there of very substantial doubt when no one knew what the future of the atomic energy program would be.

Dr. OPPENHEIMER. Of course.

Senator HICKENLOOPER. In fact, no one knew what we were going to do about it at all.

Dr. OPPENHEIMER. Right.

Senator HICKENLOOPER. So in the last phase of the Army operation people were merely marking time; is that not true? Because they did not know what the plan for the future was. And it was not until the Atomic Energy Act was passed and the policy of this country was written into law, and they knew that a civilian group was going to be appointed to take it over, that anybody could really rely upon what the policy of the country would be.

Dr. OPPENHEIMER. That is right.

Senator HICKENLOOPER. Now, then, during that period of time, and up until the time that the Commission took over, there was still a marking of time until the policies to implement the law had been put into effect by a new Commission.

Dr. OPPENHEIMER. Right.

Senator HICKENLOOPER. So that to that extent is it not that the main extent to which the so-called morale was a little shaky, the uncertainty and the period——

Dr. OPPENHEIMER. That is one of the factors. I think that it can be put awfully simply: When the war was over most scientists hoped, as did most Americans, that we would not have a cold war next, but that we would have peace. And that year, during which the Commission was being established and the law written, was also the year in which it was becoming clear that we were not going to have peace, and that we were going to have to have a lot of talented young American scientists working on atomic energy problems for destructive purposes.

I do not believe that you could have expected a very flourishing performance between the summer of 1945 and the fall of 1947. And it was not the intention of the General Advisory Committee, nor mine, to reflect on the administration of the project then, but only to indicate that what the Commission inherited was a tough cookie.

Senator MILLIKIN. Mr. Chairman?

The CHAIRMAN. Senator Millikin?

Senator MILLIKIN. Dr. Oppenheimer, scientists are willing to adjust themselves to the security necessities of these situations, are they not?

Dr. OPPENHEIMER. Many are. I think some prefer, if they can, to work on other things.

Senator MILLIKIN. I remember very well when we were having our hearings, many of the scientists were willing to make a world-wide dissemination of the whole subject, in theory and in practice. That gave me the impression that scientists were probably not as conscious of the security angles or not as appreciative of the security angles as the rest of us were. But aside from that, there is an overriding security interest in this subject established by law.

I come back to my simple question: Are the scientists willing to adjust themselves to the necessities of that until we get this world fixed up for peace?

Dr. OPPENHEIMER. I can not really speak for all scientists. I think there are a lot who are. There are many who are not, and who keep out of the atomic energy business. There are some who are not today ready and who may be willing to do it in the future. But I think all of them would address to you the plea that you proceed with the business of getting the world fixed up for peace.

Senator MILLIKIN. I quite agree, and of course that is our main objective.

Dr. OPPENHEIMER. Of course.

Senator MILLIKIN. But until we have that, doctor, that overriding security provision will continue to exist, and I respectfully suggest scientists must adjust themselves or they should not be permitted to take part in the program.

Dr. OPPENHEIMER. I fully agree, and so do all of us.

The CHAIRMAN. Doctor, I have only one observation to make on Senator Millikin's remarks. To my recollection there was no scientist of reputation in 1945, or during the progress of the hearings in 1946, who took the attitude that there should then and there be world-wide distribution, and dissemination, of the knowledge and information about atomic energy. It is true that there were a few crackpots. We always have those in every profession. But as for the men whose testimony I now review in my mind—Bethe, Smyth, Seaborg, and yourself, and I think reference to the hearings will develop many others that I do not recall—I think it is important that the people of the United States understand that this responsible, mose valuable element of our community did not take that position. Am I correct?

Dr. OPPENHEIMER. I am glad you said that, Senator. I think that scientists are no different than any other people. They want a world in which they can be free. And that is what we all want.

Senator MILLIKIN. Mr. Chairman?

The CHAIRMAN. Senator Millikin?

Senator MILLIKIN. I recall very well I had a pet question that I asked every witness when we were conducting those hearings, as to whether they favored doing what they wanted to do prior to the time that we got the world—my phrase—"postured for peace."

It was very, very difficult to get an affirmative answer to many of those questions.

The CHAIRMAN. Senator, only a reference to the hearings—your recollection may be, probably is, a good deal better than mine—but my recollection of the hearings disclosed that scientists participated before us in a discussion as to the technical means and methods by which effective international control of atomic energy could be accomplished.

The scientists participated in the formation of our international policy. Dr. Oppenheimer was a member of that committee. He was also assisted by other members of the scientific fraternity in the formulation of those proposals. And I do not think we want to lose sight of the fact that these men of science probably appreciated more than we could the terrible problem that had been raised, and their belief that atomic energy must be effectively controlled if there is ever to be permanent peace in the world. Do you agree with that statement?

Dr. OPPENHEIMER. I certainly do.

Senator MILLIKIN. Mr. Chairman, I quite agree that they thought it should be controlled, but I think that some of the views as to who should participate in the control were quite naive.

The CHAIRMAN. Senator, it is useless, of course, to pursue this debate, because a reference to the hearings will disclose what the facts are. But at least I can say with assurance about the witness who is before us that never for one moment—and I guess I know him about as well as any Member of Congress—has he ever deviated in the slightest degree from the proposition that effective international control of atomic energy along the lines which we have made a basic policy of this Government was necessary, was just, and was right.

Dr. OPPENHEIMER. That is right.

Senator MILLIKIN. Mr. Chairman, I had raised no question about Dr. Oppenheimer.

The CHAIRMAN. I was just using his name. I said a representative and a most outstanding representative of the scientific community, in order to differentiate between what might be termed a blanket denomination of the attitude of the scientists and the one I recall.

Mr. HOLIFIELD. Mr. Chairman?

The CHAIRMAN. Mr. Holifield?

Mr. HOLIFIELD. Dr. Oppenheimer, I would like to pursue a short line of questioning which would draw the line between the origination of a program or a new scientific procedure or a new project development. The responsibility for that origination is in the scientists' hands, in the laboratories, and in the technical people's hands, is it not?

Dr. OPPENHEIMER. Very largely. It works both ways.

You cannot start to work on an idea before you have had it.

Mr. HOLIFIELD. That is true.

The point that I am trying to get at is that under wartime conditions the project was originated, the designs for procedure and so forth were set up, by scientists. The Army was placed there in the capacity of a management group, and as a security group, to carry out projects in designs which had originated in the scientists' laboratory. Is that a true statement?

Dr. OPPENHEIMER. It underestimates the contribution of the Army. The Army found and got contractors and helped contractors to build plants.

Mr. HOLIFIELD. That is true.

Dr. OPPENHEIMER. The Army built communities; the Army did a lot of things without which the job could not have been done.

Mr. HOLIFIELD. That is true.

Dr. OPPENHEIMER. The Army did not invent atomic bombs.

Mr. HOLIFIELD. In peacetime, the Commission, the Atomic Energy Commission, is responsible for the management of this tremendous project; but it does not originate any scientific developments or procedures, any more than the Army did. It is responsive to your General Advisory Committee and to suggestions made by leading scientists and laboratory heads, and so forth, as to development of projects, is it not?

Dr. OPPENHEIMER. That is a little of an oversimplification. The Commission has had on it an eminent and practical physicist, Dr. Bacher. It now has on it an equally eminent and practical physicist, Dr. Smyth. They are not foreclosed from making suggestions. And in Dr. Bacher's period of office he often did. The staff of the Commission includes many excellent and famous scientists. They are not kept from originating things.

But the Commission, as a corporate entity, of course, is unlikely to make a scientific discovery.

Mr. HOLIFIELD. I will accept that qualification because, of course, I did not mean to preclude any scientific suggestion, particularly from a scientific member of the Commission.

There is a dual responsibility for administering the program and for maintenance of security. And when I speak of security, I am speaking of all that goes along with the word "security" in this development, the establishment of the guards, the clearances, and the limitation of shipment of isotopes, and so forth.

Has it ever occurred to you, or to your committee, that the responsibility for management should be separated on the part of the Commission from the security by management? In other words, here we have the Commission responsible for management of the projects, and here we have a different entity responsible for security.

The reason I bring that question up is this: I do not know whether it is possible or not that they can be divorced; but I can foresee in the future accidents happening whereby fissionable material is lost, strayed, or stolen. And in each case, this is a highly inflammable thing from the standpoint of public opinion. A few grams goes down into the sewer and immediately somebody thinks it is on a fast boat to Russia; so immediately the whole question of atomic energy is called into question, the efficiency of it, because of some mistake made, or some deliberate violations of security.

It seems to me that if security could be separated from business management, that we would have at least a divorcement of throwing the whole atomic energy program into a turmoil, taking the time of the Commission for days and days and weeks on end, away from the work of managing this project, and place that security angle strictly on a security group.

Now, has the General Advisory Board ever considered the possibility or the practicability of divorcing those two items?

Dr. OPPENHEIMER. The straight answer to your question is: No, we have not considered it. It strikes me as a rather dangerous idea because the art of management in a job like this is to retain security and still keep alive, that is, to do some positive things, to get some work done.

The danger of two organizations, one of which says no and the other of which says yes, is that they are in constant deadlock. The best security is that of the grave. And the cure for the disease which you have brought up, namely, a morbid preoccupation with the commission's stewardship of security, seems to me to lie in a far better perspective on all of our parts as to what security is, what it can achieve, how important the alleged lapses are, a perspective in the light of which I would predict that most of the preoccupations of the past years will appear to have been addressed to the wrong problem.

Mr. HOLIFIELD. That is the point that I wanted to develop, whether there was a possibility or not. You tell us that there is not a possibility, a practical possibility, of divorcing security from business management.

Dr. OPPENHEIMER. There is a practical possibility, but I think things would be worse.

Mr. HOLIFIELD. You think it would bring about such conflict of authority in the handling of documents——

Dr. OPPENHEIMER. The best personnel security is to hire no one. There is then no possibility that any dangerous person will be hired. But yon cannot run a program that way.

The best guarding is simply to lock everything up and not let anyone in. But you cannot run a plant that way. These conflicts are always bound to come at you.

Mr. HOLIFIELD. Then it is the considered judgment of men like yourself that this must proceed on the present basis. As you say we must have an understanding of what is security and what is not security, and what is a calculated risk and what is not a calculated risk?

Dr. OPPENHEIMER. And what it can achieve.

The CHAIRMAN. Doctor, as I understand it, you are to depart for the west coast on a business trip?

Dr. OPPENHEIMER. I am going to teach summer school at the University of California.

The CHAIRMAN. How long will you be gone?

Dr. OPPENHEIMER. Probably a period of 10 weeks. It is not a business trip; it is actually to teach school.

The CHAIRMAN. That is business.

Dr. OPPENHEIMER. I need hardly say that the matters before you are of such moment that if in any way I can be of help to you I regard it as an obvious duty.

The CHAIRMAN. Thank you very much There is one field that I wish to explore with you in executive session that to me is extremely important. I will try to make it at your convenience, but certainly before this investigation concludes.

If there are no further questions, I will recess this meeting. We will meet this afternoon in executive session at 3 o'clock in the usual meeting room.

I cannot let you go, doctor, without extending my own personal thanks for your intelligent testimony that you have given here today.

Dr. OPPENHEIMER. Thank you.

(Thereupon, at 12:55 p. m., the joint committee adjourned, to reconvene at 3 p. m. in executive session.)

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Bulletin Office copy Bacher's Testimony

INVESTIGATION INTO THE UNITED STATES ATOMIC ENERGY PROJECT

HEARING

BEFORE THE

JOINT COMMITTEE ON ATOMIC ENERGY
CONGRESS OF THE UNITED STATES

EIGHTY-FIRST CONGRESS

FIRST SESSION

ON

INVESTIGATION INTO THE UNITED STATES ATOMIC ENERGY PROJECT

PART 19

JULY 6, 1949

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INVESTIGATION INTO THE UNITED STATES ATOMIC ENERGY PROJECT

WEDNESDAY, JULY 6, 1949

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The joint committee met, pursuant to adjournment, at 10:40 a. m., in the Caucus Room, Senate Office Building, Washington, D. C., Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Vandenberg, Millikin, Knowland, and Hickenlooper, and Representative Jackson.

Also present: Senator Russell B. Long.

David E. Lilienthal, Chairman; Sumner T. Pike, Commissioner; Lewis L. Strauss, Commissioner; Gorden E. Dean, Commissioner; Henry D. Smyth, Commissioner; Carroll L. Wilson, General Manager; Carleton Shugg, Deputy General Manager; Frances Henderson, Assistant to the Chairman; Joseph Volpe, Jr., General Counsel; Bennett Boskey and Everett L. Hollis, Office of the General Counsel; Morse Salisbury, Director, and Rodney L. Southwick, Division of Public and Technical Information Service, all of the United States Atomic Energy Commission.

Robert F. Bacher (former Commissioner, AEC), chairman of the division of physics, mathematics and astronomy, California Institute of Technology.

The CHAIRMAN. The meeting will come to order.

Now, this is the first meeting that the committee is having for the purpose of hearing from the Commission on their stewardship of the Atomic Energy Commission.

Who will be the first witness for the Commission?

STATEMENT OF DAVID E. LILIENTHAL, CHAIRMAN, ACCOMPANIED BY JOSEPH VOLPE, JR., GENERAL COUNSEL, UNITED STATES ATOMIC ENERGY COMMISSION

Mr. LILIENTHAL. Mr. Chairman and members of the committee, the principal witness this morning will be a member of the original Commission, Dr. Robert Bacher, who, on May 10, resigned his position and has returned to teaching, to the teaching profession from which he came originally.

The purpose of my statement this morning, preceding this, will not be to testify on substantive matters but to seek to develop in 15 minutes or so a setting for the witnesses who will follow. These witnesses will be relatively few in number so far as the Commission's volition is concerned. They will endeavor to be as brief and succinct as is consistent with the subjects on which they will testify, because of the committee's desire not to have these hearings longer than is necessary.

We believe, these witnesses, beginning with Dr. Bacher, will provide the country with a report and a perspective by which to judge the grave charges of "unbelievably bad management" that have been leveled against the Commission and against its Chairman.

What I shall discuss this morning is by way of perspective and the testimony of these witnesses can be summarized in this way, in respect to this question: About what is it relevant for the witnesses to be testifying at this juncture in the proceedings?

It has been so many weeks ago since these hearings began that it seems to me useful to recall how we happen to be here.

On a Sunday evening, the 22d of May, Senator Hickenlooper, the ranking minority member of the joint committee and its former chairman, issued a statement which concluded by requesting, by suggesting, that the President should call for the resignation of the Chairman of the Commission.

In that statement were very extreme and strong remarks. One of them was that "the Atomic Energy Commission is now staggering under daily disclosures of evidence of incredible mismanagement."

Another was that—

In my opinion—

quoting from the Senator's statement—

there is now perhaps even more serious evidence of maladministration. Our atomic program—

he said—

is suffering from equivocation, misplaced emphasis, and waste.

And he concluded—

It is my considered opinion in the light of the record of the past 2 years that the interests of the Nation can best be served by the President's requesting the resignation of Mr. Lilienthal.

Some days later, Senator Hickenlooper made a further statement or series of statements, one which on May 28, contains these sentences:

I have made these charges on my own responsibility. I am prepared to produce proof. I will go before the joint committee on Tuesday of next week and request that Mr. Lilienthal be called before the committee in public hearings beginning Wednesday morning, so that I may confront him with my evidence.

These were later elaborated in a statement in which this sentence was used:

I was in very intimate touch with the unfolding and development of these programs which, in my opinion, became cumulatively worse, until I feel that now is the time when drastic changes must be made or the consequences will be much worse yet.

Now, it is well to remind ourselves—because in the intervening weeks matters that, perhaps, are not in themselves of the greatest import have been discussed, that these charges were of the gravest possible character, and they were so regarded by the country.

I think it is quite difficult for the Commission to present its affirmative accounting or stewardship unless that fact is constantly borne in mind. Nothing that has happened since these charges were made have made them any less grave.

It was said by some in editorial comments, to indicate how gravely these charges were regarded, that my conduct was "bordering on treason." There were others that indicated that the Chairman of the Commission should be impeached.

There were more extreme comments than these in responsible quarters which indicated how clearly grave and serious these charges were. I quote from only one, and that is an editorial in the highly respected Washington Star on May 27, 1949:

The charges—the gravest of them accusing the AEC of "incredible mismanagement"—have left the impression in many minds that Mr. Lilienthal has been making a mess of the atomic project, and that maybe the security of the Nation has been grievously affected. As yet, however, none of this has been convincingly substantiated; the true facts—whatever they may be—have been obscured by a kind of emotional mist creating doubts and suspicions which actually may be wholly unjustified.

Our atomic project, after all, is a thing of overshadowing importance to the safety of our own and like-minded nations in this period of dangerous international tension. If it has been subjected to "incredible mismanagement," that fact had better be established now and corrective action taken before it is too late. On the other hand, if it has been well managed, charges to the contrary ought to be specifically dismissed, not merely to vindicate Mr. Lilienthal, but to put an end to the unwarranted uneasiness among Americans and to make clear to other countries—including Russia—that we are not falling down on the job in any degree.

On the 25th of May, I transmitted to the chairman of this committee a letter which is in the record, a few passages from which I believe should be read as a preliminary to the series of witnesses whom we requested to appear before this committee.

The letter begins:

DEAR SENATOR MCMAHON: A full, complete, and speedy report on the charges that the United States atomic energy program is virtually a failure is a matter urgently necessary; the investigation initiated by the McMahon committee and to be carried out by it is welcomed.

The charges by Senator Hickenlooper of "incredible mismanagement," "misplaced emphasis," and "maladministration" involve nothing less than the security of this Nation and the peace of the world. If it is true that the atomic energy program is in an almost bankrupt condition then this country—this Nation—far from being the custodian and the trustees of a substantial stock pile of atomic weapons and in a favorable production situation, is in a sadly weakened condition. If this were true, it is difficult to imagine any single fact more disturbing to the peace of mind of the people of the country or to the security of the world's democracies.

Then, it continues:

But the chief question, I believe, is this: Is this country weak today in atomic weapons and materials, and in their production and improvements as implied by the broad and grave charges leveled against the Commission?

And the final paragraph:

In order that the fears and misapprehensions on this score may be settled beyond peradventure and as promptly as it is possible, it is urged that the joint committee call before it immediately not only the Commission, its staff, its principal industrial and university contractors, but also citizens of the highest renown and technical standing, including the distinguished members of the General Advisory Committee and other advisory groups for their testimony and appraisal. In this way, the dangerous cloud of uneasiness resulting from these charges will be dispelled.

The testimony of the witnesses we are suggesting appear before you, Senators, will relate chiefly to an accounting of the stewardship of what we regard, rightly or wrongly, as the most vital areas, that is to say, they will testify as to what have been the results of the last 2½ years.

The question has been raised as to whether these over-all results are relevant to the charges of "incredible mismanagement."

I should like to present the Commission's views on this matter at the outset. I gather from things that Senator Hickenlooper has said in the course of the hearings that he has doubts as to whether they are relevant.

On May 26, in the course of a statement the Senator made, quoting from him:

From the standpoint of actual production the atomic energy program has gone forward due to the zeal and the loyalty of the scientific and technical personnel in charge of the various projects. The point of my objection—

it continues—

is not to the activities of these people, but to the administrative policies which the Commission, under Mr. Lilienthal's guidance and influence, has followed and continues to follow. These, I believe to be harmful and not in the best interests of a continuing development of the basic programs outlined by the Congress.

It seems to us that one can hardly say that one is not interested in or regards as irrelevant whether the results, the important results are good, where the charge is maladministration of a project.

There is a lot of ancient wisdom, Mr. Chairman, behind the idea that one judges by results.

In the teachings of Jesus in the Gospel, according to St. Matthew, chapter 7, verses 16 through 20—one of the great statements to this effect is as follows:

Ye shall know them by their fruits. Do men gather grapes of thorns or figs of thistles?

Even so every good tree bringeth forth good fruit; but a corrupt tree bringeth forth evil fruit.

A good tree cannot bring forth evil fruit, neither can a corrupt tree bring forth good fruit.

Every tree that bringeth not forth good fruit is hewn down and cast into the fire. Wherefore, by their fruits ye shall know them.

It is the theme of our presentation that very bad management can hardly produce over-all good results.

Now, how can these over-all results and the quality of management reflected in them be presented without injury to security? We touched on this in the opening session of these hearings. We suggested that one of the ways is by the appraisal of outstanding men, and I should like to indicate a partial list of the men whom we hope the committee will hear. They begin with our former colleague, Dr. Robert Bacher, who is now the chairman of the division of physics, mathematics and astronomy at California Institute of Technology; Mr. James W. Parker, the president and general manager of the Detroit Edison Co., and chairman of the Commission's Interim Committee on Cooperation of Industry; Mr. Isaac Harter, chairman of the board of the Babcock & Wilcox Tube Co., a distinguished industrialist; Dr. Mervin E. Kelly, vice president of the Bell Laboratories; Dr. Norris E. Bradbury, director of the Los Alamos Laboratory; Dr. L. A. DuBridge, the president of California Institute of Technology, who is the chairman of the General Advisory Committee Subcommittee on Basic Research; Dr. Enrico Fermi, Institute for Nuclear Studies of the University of Chicago, and one of the great pioneers in this field.

What is it that the Commission should have been preoccupied with and concentrating upon at the time it began its duties in April of 1947, the time of the confirmation of the Commission, or on January 1, when the Commission formally took over the custody and the responsibility for the Manhattan District? There were thousands of things to do, and there still are. What were the most important things to concentrate on? In an effort to establish a basis for perspective here, it is important to discuss this for the moment.

This matter of what the Commission should be preoccupied with—what the Commission as an organization should be preoccupied with—is something that will occur a good many times in the testimony to follow, and I think it is important that we refresh our recollections about this.

On June 14, 1946, which is somewhat over 3 years ago, 10 months after Hiroshima, Bernard Baruch, in an address that, in my opinion, will live as one of the great state papers of all times, summarized where mankind stood, and because we still stand there, and because this throws a great deal of light on the conclusions of the Commission as to what to concentrate on, upon the many things that might be done, I should like to read a few lines from that memorable statement. It was, of course, the statement of Mr. Baruch, acting in behalf of the United States, to his fellow members of the United Nations Atomic Energy Commission set up to seek an answer to the question of how can we eliminate atomic energy from warfare.

He began by saying:

> We are here to make a choice between the quick and the dead.
>
> That is our business.
>
> Behind the black portent of the new atomic age lies a hope which seized upon with faith, can work our salvation. If we fail, then we have damned every man to be the slave of fear.

At the conclusion of his statement——

The CHAIRMAN. We have failed so far, have we not?

Mr. LILIENTHAL. We have indeed.

> All of us are consecrated to making an end of gloom and hopelessness. All of us want to stand erect with our faces to the sun, instead of being forced to burrow into the earth, like rats.
>
> The light at the end of the tunnel is dim, but our path seems to grow brighter as we actually begin our journey. We cannot yet light the way to the end.

What Mr. Baruch said in June of 1946 is at least as true today—I would say, even truer today. In a way, it is mankind's way to seek to ignore things that are uncomfortable, but it is certainly, it seems to me, true.

In any case, nearly a year later, in April of 1947, when the Commission began its work, that light, that dim light, at the end of the tunnel, which this distinguished American citizen believed he saw in June of 1946, was so dim as to be no light at all, and it is no light at all today.

Russia, and Russia only, among the great nations of the earth, has been unwilling to take those steps which might make that dim light at the end of the tunnel, which this hopeful man saw in June 1946, somewhat less dim and brighter.

Well now, confronted with this situation which every realistic man would have to recognize, that the dim light at the end of the tunnel had gone out, the light of hope of early international agreement, an early end of fear, what should the United States Atomic

Energy Commission do, having as its paramount objective, as defined by the Congress, the common defense and security of this country, and the promotion of world peace? What should we concentrate on? What should we be preoccupied with? We believe as one man, and the President, our immediate superior, believed that we should let nothing stand in the way of arming this country atomically in such a way as to erect a great deterrent to aggression in the world; that we should establish unquestioned and unmistakable leadership, and in this way thus buy time for reason to prevail.

What did this mean? It meant that production must be drastically stepped up; that from being a nation vertually unarmed atomically, which was our condition at that time, we must become a nation which had a leadership unmistakable and unquestioned. The country had to be told again and again that the monopoly and the knowledge in the making of atomic weapons was one that could not last indefinitely. The country had been told, and correctly, that Russia will in time be able to make an atomic weapon.

The phrase "when Russia gets a bomb" was repeated again and again; but the country had not been told, because at that time it was hazardous to speak out, so weak were we, that numbers and not simply the first atomic weapon are the crucial item in providing a great and impregnable deterrent to aggression; that numbers, that level of production and quality could provide what a dwindling monopoly lost us.

Numbers meant added production; numbers meant a change in the raw-material situation. Numbers meant new facilities; numbers meant research must be stepped up; quality of production meant improvements had to be made in processing, in fissionable-material production, in weapon design, in weapon engineering, and in weapon field testing.

Right or wrong, Mr. Chairman, we concentrated on that, and we refused, as best we could, to be distracted by the thousand and one useful things that in a normal enterprise and under normal conditions one's attention might well have gone to.

We believe that urgency was required then and, I believe, it is required today. We believe that the chances should be taken, that boldness was necessary. We did not believe that the bureaucratic rule "Don't stick your neck out; don't take a chance on making a mistake" had any application to the situation that our beloved country faced.

Well, the witnesses will devote themselves, not so much to charges, because in the course of these hearings we have, with the courtesy of the committee, its members, Senator Hickenlooper, been able from time to time to indicate the answer to most of these charges insofar as the shortness of notice in some cases permitted.

These witnesses will devote themselves to those things which we believe had to be done, and done fast and done hard, and still need to be done fast and to be done hard and desperately. Those things that we believe—to which we believe every moment of time and every ounce of energy should be concentrated.

Whether what has been presented will substantiate the charges as far as they go, is for the country to decide and for the committee to decide. We believe that none of the matters presented measure up to the charges. Nevertheless, whatever cloud has been cast over the project can and must be removed if it should be removed. A healthy program, Mr. Chairman, requires confidence; it requires boldness and a sense of urgency. These we cannot carry forward under existing circumstances until the committee has reached its conclusion and these hearings have concluded.

We make no claim to perfection. Over 60,000 people, as we are meeting here, all over the country, are engaged in this work. It would be very extraordinary if at this moment some one of them or more of them were not doing something that was careless, something that was stupid, something that was negligent, something that was contrary to his instructions, or just contrary to good sense.

We say there are inadequacies in the atomic energy program, and I have some very strong feelings about what those inadequacies are. They would differ rather sharply with what some of our critics would regard as inadequacies.

We do not seek to escape responsibility for stupidity or the carelessness or the negligence or the perfidy of any of these 60,000 people scattered through the country who are on the work at this hour. But if the charge is that we as a Commission, or your witness, or any one of the 60,000 is not perfect and not always right, judged as of the time or by hindsight, then the answer is "Guilty as charged."

But this is surely not the standard where "incredible mismanagement" is the charge. The legality of the atomic energy program and the security of the United States is the important thing. We believe we have tried hard to make it so. We believe that there has been progress.

Dr. Robert Bacher, you will recall, was one of the original members of the Atomic Energy Commission. His background at Los Alamos is, I think, familiar to the members of this committee and to the country. If it is the wish of the committee, it is Dr. Bacher's wish and that of the Commission that he proceed along the lines indicated by the statement I have just made.

The CHAIRMAN. All right, Mr. Lilienthal.

Mr. LILIENTHAL. Thank you, Mr. Chairman.

STATEMENT OF DR. ROBERT FOX BACHER, CHAIRMAN, DIVISION OF PHYSICS, MATHEMATICS, AND ASTRONOMY, CALIFORNIA INSTITUTE OF TECHNOLOGY

The CHAIRMAN. Doctor, it is a pleasure to see you again under any circumstances and you may proceed.

Dr. BACHER. Thank you, Mr. Chairman.

Mr. Chairman and members of the Joint Congressional Committee on Atomic Energy, I hope you will realize that during the past 2 months I have been doing my best to forget everything I did know about classified matters of atomic energy, and I fear that I may not have some of the things at my fingertips that may be necessary for a presentation of what we carried on during the past 2 years under the Atomic Energy Commission.

However, I was a little bit surprised to find, when I made a few notes on this on the plane coming down here yesterday, that there were at least a few things I did remember still about the project.

Unfortunately, I have not followed very carefully the proceedings in these hearings since they were not available to me where I was, and

I hope I may ask your indulgence if I do not show the amount of familiarity with these proceedings which you might otherwise expect.

When the Atomic Energy Commission took responsibility for the atomic energy project in January 1947, our job was largely determined by what we found at that time. We had to adjust what we proceeded to do by what the state of the project was.

Our conclusion was immediately that first things had to come first, and that vigorous action on the production of atomic weapons and their development, and assuring the production of fissionable material had to be our first responsibility.

This continued to be our first responsibility during the period of my membership on the Commission, and I am sure continues today to be the first line of responsibility of all people who are engaged in that work.

When we took over in January 1947, as a representative of the Commission, I went to Los Alamos to make an inventory of what we had. I made a rather complete inventory—this is at the end of December in 1946. This was directed primarily at making an inventory of the vital components of weapons and fissionable material in our stock. This was not something which I or any other members of the Commission took lightly at that time. We took it very seriously.

I spent 2 days as a representative of the Commission going over what we had. I was very deeply shocked to find how few atomic weapons we had at that time. This came as a rather considerable surprise to me in spite of the fact that I had been rather intimately associated with the work of the Los Alamos project—roughly, a year before.

It might be interesting just to tell a word about how we conducted that inventory. I actually went into the vaults where material was kept and selected at random cartons and various containers to be opened. These, I then inspected myself, using suitable counters and other methods to determine to the best of my knowledge and observation that the materials were what they were declared to be.

In addition to that, I was accompanied by Colonel Gee, Dr. Bradbury, and other representatives of the various departments at Los Alamos, whom I questioned on every piece examined as to whether, to the best of their knowledge and belief, the materials were as represented on the inventory cards which we carried with us.

Judging by the consternation which appeared on some of the faces around there, I concluded that this must have been about the first detailed physical inventory that had been made; and I think I can say without any doubt, that this was about as thorough inventory as could be made without actually tearing things completely to pieces.

Our work during the year 1947 was largely determined by what we found at that time.

Our first effort had to be devoted primarily toward changing the weapon position; and before going into that in any detail, with your indulgence, I would like to go back and give a little bit of background as to how the project operated during the war.

The atomic energy project under the Manhattan Engineering District was a very complex organization. The fundamental scientific and technical work was carried on in a number of universities under contract, and in a certain number of special laboratories that were primarily devoted to one phase or another of the work.

As you may recall, there was a large laboratory at the University of Chicago for the study of atomic piles, or nuclear reactors as we call them today. At Columbia University was a large project for studying the diffusion process for separating uranium 235. At the University of California there was a large laboratory devoted to the study of the electromagnetic process for the separation of isotopes.

In addition to this, a great deal of work was carried on in industrial laboratories at the General Electric Co., Westinghouse, Kellex Corp., and a large number of other companies that participated in the technical developments that were needed for the atomic energy project.

In addition, the industrial contractors carried that technical development into the pilot-plant stage and they carried it on further into the construction of enormous plants to accomplish these ends. This was a tremendous step forward.

In reactors, for example, one had to go from the construction of a small reactor operating at a few watts to reactors operating at enormous power, and the same thing was true in almost every other phase of the work.

The industrial know-how which American industry possessed was a vital part of that transition, and the industries went further in that they set up the plants, put them into operation, and kept them in operation.

Many times, of course, this was augmented by help and advice, consultation from scientists and technical people who had participated in these developments from their earliest stages.

Now, at the end of the war, after the project had been carried through successfully to the development of the atomic bomb and the materials had actually been produced which were necessary, much of this organization that had been built up melted away.

Many of the people who had worked on the project had been obtained on loan from industries, from universities, from other research organizations, and there was a definite commitment that they would go back to their normal pursuits, and this was the basis on which they had been obtained.

Similarly, many industrial contractors had been promised that they would be relieved of responsibility as quickly as possible at the end of the war. It was more or less inevitable then that at the end of the war the atomic energy project would go into a very dramatic decline, and it did.

This is no reflection whatever on the Manhattan Engineering District and on the stewardship under Lt. Gen. Leslie R. Groves. They did a fine job, and it was more or less inevitable that at the end of the war the project would come crashing down, and it did.

During 1946 there was unquestionably a very serious deterioration in the atomic energy project. Los Alamos, for example, suffered a series of calamities of one sort and another which were very discouraging to the personnel there. Many people became disheartened and left, and a few hardy souls elected to stay with the project and fought it through.

Some of the calamities might just be recalled to you mind. In December 1945, the project ran out of water. All the water that was obtained on the Los Alamos project for a period of some months or more was obtained by hauling it in tank trucks.

The Chairman. At a cost of $8,000 a day.

Dr. BACHER. I am not quite sure of the cost, Mr. Chairman, but I do know that a good deal of it tasted of kerosene.

Senator HICKENLOOPER. The pipes froze; did they not?

Dr. BACHER. The pipes froze up; water reservoirs ran low; the project very nearly came to a dead standstill, and part of this experience I lived through myself. I came home from a trip to the East to find my family living in a place with no heat. I am sure I did not get any fraction at all of what many of the other people got who stayed there longer.

During the spring of 1946, water was extremely short. I think it is only by the greatest of luck that a serious calamity in fire did not occur during that period. I was not at the project during the early months of 1946, in the summer, but I am told by people who were there that it was pretty grim and people were very greatly disheartened.

You may recall that it was during the same months——

Senator HICKENLOOPER. Do you mind being interrupted, Doctor?

Dr. BACHER. Not at all.

Senator HICKENLOOPER. I was going to say that the fire hazard still exists, except that you have more water.

Dr. BACHER. Senator, I would say that the greatest fire hazard came from the fact that there was not any water with which to fight a fire.

Senator HICKENLOOPER. I mean the buildings are the same type, generally. They have not been replaced.

Dr. BACHER. The buildings have in part been replaced, in sense that there are now at Los Alamos critical buildings which are fireproof, and in most of the buildings, there exists a sprinkler system which, I believe, is quite an adequate way of fighting a fire provided you have got some water to back it up.

Senator HICKENLOOPER. Well, at least, last September when I was out there, the buildings seemed to be about the same buildings that had been there a year or so before.

Dr. BACHER. The technical buildings are very much the same. It has seemed unwise to interrupt the work too much in this critical period of 1947 and 1948 to get new buildings, when action at the moment was what was needed.

I believe also that the fire hazard in those buildings, while still existent, is very much diminished by the presence of water in sprinkler systems.

During the fall of 1946, after the passage of the McMahon Act and the setting up of a Commission, spirits began to pick up at Los Alamos, and I would like to say just a word or two, if I may, about some of the conditions at some of the other sites.

At Hanford during that period up to the end of 1946, the pile deterioration had become a very serious matter, and our attention had to be focused on ways of getting around the difficulties which, at that time, seemed to be technically insurmountable. This was a serious matter.

There were also many uncertainties at the Hanford Works which came out of the uncertainties about the contractor.

As you may recall, the plant had been built and put into operation by the du Pont company; at the end of the war the du Pont company asked with vigor to be relieved. This gave rise to great uncertainties in the technical personnel, but to a very considerable extent people who had been actively engaged in the project stayed with it through these rocky times, and a great many of them are there today.

At Oak Ridge, the production situation at the end of 1946 was in the process of rather serious adjustment, but I think one can say that it was in considerably better shape than most of the other things on the project.

The laboratory at Oak Ridge, which had served as a pilot plant for the reactor development during the war, had largely passed through the phase for which it had been built, and at the end of the war the reactor was beginning to be used as a research tool and the laboratory was beginning to be set up around that reactor, directed primarily at fundamental experimentation.

Also the reactor was beginning to be used for the production of radio isotopes which have more recently made such an important contribution and played such an important part in various research projects.

I could go on into the recalling of the status of some of the other parts of the project in 1946, but let me just try to summarize a little bit what the status was when we took over on January 1, 1947.

With weapons, the situation was very bad. We did not have anything like as many weapons as I thought we had, and I was very deeply shocked at what I found when I made an inventory of what we really did have.

The CHAIRMAN. Was the inventory correct?

Dr. BACHER. I made the inventory, and to the best of my knowledge, Senator, it was correct.

The CHAIRMAN. Well, I did not refer to that, Doctor. I meant, you were furnished with the inventory files, cards? You went into the vaults?

Dr. BACHER. I found no discrepancies.

The CHAIRMAN. You checked it physically?

Dr. BACHER. I found no discrepancies whatsoever.

The CHAIRMAN. That is what I wanted to find out.

Dr. BACHER. The status of the Los Alamos Laboratory was depressing to me. I had the greatest admiration for the people who were there and who were trying to build a laboratory anew out of what they had, but it was a difficult job and a heartbreaking job.

At Hanford the stories on the estimated life of the piles out there were distressing, and no one at that time knew how these piles could be prolonged in life. I will not go into a numerical estimate of what the life was supposed to be, but it gave me a very deep shock.

Our production of fissionable material at Hanford had been reduced primarily because of this deterioration which had set in. Our technical work at Hanford and elsewhere, too, had been very greatly slowed down at the end of the war.

At Oak Ridge, K–25 production—that is, at the diffusion plant—was good. They were, however, in the middle of a new test to determine new operating conditions for the plant.

At that time, when we took over, the Y–12 electromagnetic plant was still operating, and there had been considerable success in cutting the costs to moderate figures, but it was perfectly clear that more changes were in store for us.

The laboratory at Oak Ridge was being set up as a general-research laboratory, as I indicated before, and also as a training school for getting more people, particularly from industry, acquainted with the fundamentals of the atomic energy project.

To summarize it in a word, the technical developments during 1946 had slowed not to a stop but were so slow that motion was hard to detect.

Now, just one more word about the technical developments at that time: One other subject that has been very important to us is the subject of reactors. At the end of the war there was a great deal of optimism about how nuclear reactors could be designed and built overnight, and a big power industry was going to come out of this in a great hurry.

The years 1946 and 1947—particularly the former—brought us a great deal of technical information which was in the nature of a surprise. Looking back at this, we probably should have anticipated some of it a little bit more, and, of course, the optimism of one person is never quite the same as the optimism of another, but the fact is that the serious way in which materials would deteriorate in a reactor and the problems that this would cause in designing and building reactors to operate at high power and under conditions of high specific power were greatly underestimated.

These problems were serious, and they had to be overcome, and it set the whole reactor development project back a great deal. This was a disheartening fact at the end of 1946; and at that time it was not even possible to assess completely how serious a matter this would be.

One could only see that there were big problems that had to be tackled and overcome.

This is more or less the background that the Commission had when it came in and assumed control of the atomic energy project on January 1, 1947.

What we did during 1947 and 1948 was largely conditioned by that state of affairs, and that is the reason that I have gone into it in some detail. I am sure I have overlooked a number of points. If this turns out in the course of further discussion, I shall be glad to amplify these previous remarks.

Our first attention had to be directed toward the production of atomic weapons and to the development of new atomic weapons and to the production of fissionable material to go into atomic weapons, and this is what we did.

Furthermore, we felt it our first responsibility to do everything in our power to build the Los Alamos Laboratory as a solid research and development and production center, because on that laboratory everything depended during that period, so we did our best in that direction.

I think I can say without being immodest, since most of the credit goes to the members of that laboratory who went through that period, that success has been very marked. The Los Alamos Laboratory during 1947 went through a change that I could scarcely believe, and I believe today it stands as a very strong development and research laboratory, with a remarkably high morale.

On the production of fissionable material at Hanford, the problems associated with pile deteriorations were attacked vigorously. These were both the technical problems and the problems of replacement reactors in case the technical problems could not be solved.

Both lines were attacked. The technical problems have been rather successfully solved in the course of the past 2 years, and in the meantime, as you know, replacement piles have been under construction, and this has been carried through to a state of completion.

During that same period, we went rather carefully into the subject of how we might get out more fissionable material from a given amount of raw material, since raw material, as you know, is at a premium, and our objective is the production of fissionable material and to get as much fissionable material as we can from a given amount of raw material.

There has been during the past 2 years a very considerable success in these efforts, and we can today get more fissionable material out of a given amount of raw material, and I am confident that the success will be even more marked in the future.

Furthermore, at Hanford during that critical year of 1947 the first steps were made to figure out how the actual production could be raised, and the first steps, the first actual steps in this direction, were made. Of course, the most important thing that occurred at Hanford was probably that the project was transferred from being a temporary project to being set up on a permanent basis. This made a great deal of difference in the morale of the people who are there and in their outlook on their work.

At Oak Ridge during 1947, the operations at Y–12 were considerably reduced. This was in keeping with the higher costs of the electromagnetic process, and the improvements and developments in the diffusion process for the separation of uranium 235.

The operations at the diffusion plant, K–25, during this same period were stepped up, and there has been continued technical improvements which by the end of 1947 had led to increased production, with a decreased number of people carrying on that production.

During that same period, 1947, we frankly did not have very much success in stabilizing the laboratory at Oak Ridge, at X–10. We had a very difficult situation which arose because of changes in personnel, people who had been on loan, and also which had arisen because the contractor wished to be relieved of responsibility for the operation of the plant.

These introduced unsettling conditions in the laboratory, and, I believe, that the laboratory has only recently recovered from some of the shocks which it had received during that period.

Remarkably enough, during 1947, and still during 1948, the laboratory has continued in scientific output to be a major source of fundamental information about atomic fission and various nuclear processes, and has produced a remarkable series of publications in the technical journals which, I think, are a very great credit to the project.

To speak more directly on the subject of research and development and the problems during 1947, our course during this period was guided to a very great extent by the advice which we received from the General Advisory Committee which had been appointed by the President at the beginning of the year.

This committee, as you know, is composed of distinguished scientists and technical people from the universities and industry, and the Commission has relied very much on their advice on general technical questions.

Also during that same period, we set up an ad hoc committee on biology and medicine to give us some advice as to what we ought to do in these subjects.

This committee was under the chairmanship of Dr. Robert Loeb, and it seemed to us advisable to get an outside committee to offer us some advice as to what we ought to do on this subject.

As you gentlemen are, I am sure, aware, during the war only those subjects in biology and medicine which were of the utmost urgency in the manufacturing and technical problems were studied at all. There was a very great shortage of doctors and of all people with research experience in biology and medicine.

At the end of the war we found ourselves in the position of being unable to understand in any great detail the fundamental question of hazards associated with radioactive materials and particularly with the production and handling of fissionable materials.

We did not understand very well the effects of radiation, and there had not been time to do the fundamental work that was necessary in order that such an understanding of these effects could be obtained.

We tried as soon as possible in 1947 to expand the work in biology and medicine so that there might be a better understanding of the effects of radiation, and so that also some of the beneficial effects of atomic energy and its products might be enjoyed by the country at the earliest possible moment.

Subsequently, a permanent advisory committee on biology and medicine was set up, and this committee, composed of distinguished doctors and biologists, meets regularly and offers advice to the Division of Biology and Medicine on its conduct of work in that field.

During this period of 1947, the advances in the research laboratories were very considerable.

At Berkeley, the research laboratory had quickly gone into high gear at the end of the war under the enthusiastic leadership of Dr. Ernest Lawrence, and considerable new work was being carried on, new machines were being developed, and subsequently, rather startling new results have been achieved with these machines.

At the Brookhaven Laboratory on Long Island, the laboratory actually came into being during this period as a going concern, and today, I think, can be numbered among the strong research laboratories of the country.

At the Argonne Laboratory in Chicago the problems of continuation at the end of the war were indeed very serious. The laboratory had been housed to a very considerable extent in buildings that had been loaned to it by the University of Chicago. Its buildings in the country where the reactors were housed were on borrowed land where I believe commitments had been made for evacuation at the end of the war.

But during this period and in spite of the scattered facilities that were available, good reactor work was going on and good fundamental research was going on. Fortunately, the people at the University of Chicago cooperated on a very thoroughgoing basis with the Argonne Laboratory, and there is today, as you know, the closest exchange of ideas and interchange of personnel. Many of the people at the University of Chicago played major roles in the development of this project during the war.

At the Knolls Laboratory at Schenectady most of the work had to be carried on in temporary buildings that were set up during this period, but the project got ahead with reactor design work and there were during this period some significant advances.

One of the big problems that the Commission had during 1947 was the problem of adequate raw material. There was not as much raw material available as we wanted and needed. We had to figure out how to get along with less and get more out of it. We also had to figure out how we could get more raw material.

I believe this constitutes, Mr. Chairman, a summary of what happened during 1947. I would like to go on to amplify that a little bit further with some of the accomplishments during 1948.

Probably the most outstanding accomplishments during 1948 were the advances which were proved in the Eniwetok tests which were carried out in the spring of 1948. The importance of these tests to the atomic energy project, I believe, cannot be overestimated. I believe we learned more about how atomic bombs work and what we might do in further design work from these tests than had ever been learned before.

You may recall that the test at Alamogordo was accompanied by numerous physical measurements which were carried on to find out how the bomb exploded and what it did when it exploded. Subsequent tests at Bikini and, indeed, those bombs which were exploded over Hiroshima and Nagasaki, were accompanied by a minimum of physical measurement.

The purpose of the Bikini tests was military, not technical. The purpose of the Eniwetok tests was to find out how better bombs might be built, and to that end a great many measurements were made. These measurements were, for the most part, very successful. Our conclusions of the results of the development which led to the design of the bombs used at Eniwetok gave us great heart for new future development.

Senator HICKENLOOPER. Doctor, the design of the weapons tested at Eniwetok were really designs that were conceived during Manhattan District days and laid aside for testing later under a little more peaceful atmosphere; is that not right?

Dr. BACHER. No, Senator Hickenlooper, they were not.

Senator HICKENLOOPER. I think there is some dispute on that subject. I would not dispute your word on it, of course, but there is some dispute about the fact that those designs were generally conceived in the Manhattan District but were not used in the war efforts over Japan.

Dr. BACHER. Senator, if by "conceived" you mean that there was a gleam in the eye, then I would be inclined to agree with you. In developing an atomic bomb there is a long distance between the gleam in the eye and the actual design of the weapon.

Senator HICKENLOOPER. I understand that. I meant to go further and say that even some of the mechanical ideas involved in the tests at Eniwetok were actually proposed under the Manhattan District. I am not quarreling between the Manhattan District and the Commission, but just to get the order of things properly set up.

Dr. BACHER. One of the principles incorporated in the Eniwetok tests had been thought of and planned for prior to the end of the war.

Senator HICKENLOOPER. Yes.

Dr. BACHER. But one of the major developments—I would say the major development—that was tested at Eniwetok we would not have dared to do at that time.

Senator HICKENLOOPER. Yes. That is the point. It was the examination into that phase of it which was left for more proper peacetime atmosphere to develop.

Dr. BACHER. I think one can say, Senator, that there just had not been enough research and development work done at the end of the war to lead to the design of weapons of the sort that were shot at Eniwetok; and on this basis I would say that the Eniwetok test was not the test of weapons which had been designed a long time before, but represented the test of weapons which had been designed on the basis of the research and development work which had been carried out at Los Alamos during 1947 primarily.

Senator HICKENLOOPER. Manifestly, we cannot discuss details about those things at the moment. Excuse me, go ahead.

Dr. BACHER. One of the main results of the Eniwetok tests was that it has led us, in the analysis of the results that were obtained from the measurements that were taken, to the design of new weapons which will make considerably better use of fissionable material than any weapons we knew about before.

This point, Senator, is completely new and even contrary to some of the ideas that we had during the war.

Senator HICKENLOOPER. There was even a school of thought during the war in the early days that the thing would not blow up at all.

Dr. BACHER. I believe some people had that idea. I did not share it.

Senator HICKENLOOPER. There were some eminent people who believed that it would not blow up at all, as I understand it. There was a difference of opinion on the matter. I think it is immaterial now.

Dr. BACHER. I believe I can say that during 1948 the status of the Los Alamos Laboratory, with some fluctuations, to be sure, steadily improved, and I believe it is a very great credit to the members of the laboratory that they were able to design weapons, produce them, and carry through the tests at Eniwetok.

On the production front—that is, production of fissionable material at Hanford—there were some major accomplishments leading to the increase in pile life. I had mentioned before that at the end of 1946 we were confronted with the serious problem of pile deterioration. During 1947 and more particularly during 1948 there were some major technical accomplishments at Hanford which gave us more information on the nature and origin of this deterioration and how it might be circumvented.

Other developments at Hanford led to still further increases in the production of fissionable material from a given amount of raw material, and these improvements are still in the course of development and test. But we are beginning to reap the benefits of this technical work.

There were considerable improvements in chemical processing both in the efficiency of the present process which is used and in the development of new processes which we hope can be installed in the future and which will contribute still further to the conservation of raw material.

A major construction project, as you know, was undertaken at Hanford. In fact, I guess it is probably the largest peacetime construction project that has been undertaken in the country. A replacement pile, which was designed to be ready as quickly as possible for operation, was set up, and this construction has been completed.

The construction of further units, which were diverted to an increase in our production of fissionable material as new technical developments came along, was also undertaken.

We had established as a general Commission policy that we should increase our supply of fissionable material by every means at our disposal within reason. In addition, during 1948 steps were taken to establish metal production facilities at Hanford. The problem of taking the output of a chemical separation processing plant and producing plutonium element is a very difficult one and involves many problems of remote handling because of the toxic qualities of plutonium.

A plant for the production of plutonium metal was started during this period and largely brought to completion on one of the most rush schedules that the Commission undertook to carry out. Part of the need for this plant came because we felt there should be alternative production facilities for this material and part of it came because in the problem of fabrication and refabrication of weapons there was a major drain on production facilities for fabricating metal and new facilities were needed. That was particularly the case after the Eniwetok tests when new designs came along.

At Oak Ridge the diffusion plant at K–25 continued with its production, and during this same period both increased its production and decreased its staff. The continued high efficiency operation of the diffusion plant has been very cheering.

The plant at Y–12 early in that year was thrown completely into stand-by condition and subsequently, as you know, has been put in even more remote stand-by condition. This goes back to the point that the developments of the diffusion process have outstripped the developments in the electromagnetic process.

Whether subsequent scientific and technical developments will lead in this same direction I think no one can guess. But so far the diffusion process has certainly outstripped the electromagnetic process.

On the subject of reactors, during 1948 the main reactor responsibility at the beginning of 1948 was transferred to the Argonne Laboratory. As you know, reactor work was also carried out at the Knolls Laboratory at Schenectady and was also carried out at the Oak Ridge National Laboratory, and some reactor work was carried on at Los Alamos. By and large these four laboratories have been the main centers of new development work.

I mentioned before that we had been greatly disappointed by some of the things that we found, about some of the obstacles, I guess I might say, that we found had to be overcome in the development of new reactors. During 1947 and particularly during 1948 many of these came a little closer to solution, and while all of the answers are by no means clear even today, certainly some of the answers look much closer to being obtained.

The success at the Argonne Laboratory in going ahead with their designs of a fast reactor have been very considerable, and they have also carried the main responsibility in the development of the materials-testing reactor or high-flux reactor as it has been sometimes called. This reactor, you may recall, was initially designed by the Oak Ridge Laboratory, and they are now cooperating with the Argonne Laboratory in its design for construction.

The Argonne Laboratory is also carrying the main responsibility in the development of a Navy reactor which is being designed for the propulsion of a ship or submarine and which is being carried to completion with the cooperation of the Westinghouse Electric Co., who have recently taken a contract for this work.

The other reactor, which has been under development at the Knolls Laboratory, has been largely carried on by the General Electric Co., though here, too, they have obtained a great deal of information and know-how from the people who have been engaged in this work for a long time at the Argonne Laboratory. The reactor at the Knolls Laboratory is an intermediate reactor designed with two aims in mind: One, the production of usable power and, two, the accomplishment of the breeding principle with which you gentlemen are familiar.

I think I can say that the reactor program has not gone ahead as fast as we had hoped it would. I think there are a great many reasons for this. Certainly, one reason is that it had to take second place during 1947 to the problems of weapon production and development and the problems associated with the immediate production of fissionable material.

Also there were technical problems which had to be solved before design work could go much further. But I believe today we stand on the threshold of a very great development in this field. I am sure that if we—and by "we" I mean the people of the United States—are not timid in going ahead with this work, I believe that major successes will come to us, but timidity and playing things safe simply are not a background for atomic energy development. If we wait until everything is going to be sure in these developments, we will suffer a major setback of the atomic energy program in this country.

Senator HICKENLOOPER. Doctor, may I interrupt again and ask you: Do you believe that we have been timid in the past? In other words, if I may use a phrase, do you believe we have moved with mincing steps?

Dr. BACHER. I believe, Senator, that during the past 2 years we have taken some pretty considerable steps forward. I believe the best example of this comes from the accomplishments of the Eniwetok tests.

Senator HICKENLOOPER. I just used the term "mincing steps" with the hope that it might strike a responsive chord in your memory.

Dr. BACHER. I certainly remember the phrase "mincing steps." I recall, I believe, using those words in a hearing with the joint congressional committee some months ago, when I said that I hoped we would not move ahead in this development with mincing steps, but strike out in a bold fashion, and I feel that we are on the verge of those strong steps at the present time. A program has been set out for the development of reactors. This was formulated by the Commission in the fall of 1948 and has formed the background of all steps in this direction which have been taken since then.

The CHAIRMAN. Doctor, if it works, what will it mean to the people of the United States?

Dr. BACHER. Mr. Chairman, it is always very difficult to look too far ahead. With the development of the first steam engine, it would not have been possible to envision the railroad system we have today.

But I think one can be sure that a long-range development of nuclear reactors will have a very great effect upon the lives of the people in this country, upon their living standards, upon the location of their houses, and upon the conditions which generally serve as boundaries to their lives.

There are great areas of this country today which are essentially uninhabited because of the absence of power and water. Atomic energy will not solve all of these problems, but it at least does not have some of the limitations to which we have been subject in past years such as promixity to coal or oil.

In connection with the formulation of a reactor program by the Commission in the fall of 1948, we found that some of the bold steps that needed to be taken would require the setting up of a remote site, remote not only from major cities and other installations, but also remote from any other manufacturing installations which were vital to the project itself.

Accordingly, as you know, steps have been taken to set up such a project in southern Idaho near Arco. It is my own belief, as I think I have expressed to you before, that the establishment of such a project so that the development of reactors may go ahead without that extraordinary excess and overweighting caution, which would inevitably govern it were it to be located elsewhere, would be a necessary part of a reactor program.

Two other points on reactors: There has, during the past year, been a considerable amount of success in the early stages of design and critical assembly tests of the reactor at the Knolls Laboratory at Schenectady. These results which have been obtained have made us understand that there were some problems in the operation of intermediate reactors which had not been fully understood before, and a great deal was learned. This will undoubtedly change in some ways the plans for that reactor.

This is the course of a normal development in a new field and should be expected. It has occurred, and I am sure it will occur again in the future.

Senator HICKENLOOPER. In other words, Doctor, there will be no such thing as a static reactor which is the last word. You will always learn things from every new reactor you build.

Dr. BACHER. I would most certainly be disappointed, Senator Hickenlooper, if we did not learn from each reactor that was built and each reactor will contribute to the building of new reactors, and as far as I can see, the horizon on this is a very, very long way ahead.

Senator HICKENLOOPER. So that there is no such thing as building a reactor and saying, "This is the final word." One has to take a step and build a reactor that encompasses all of the lessons that have been learned at some time and then go forward from there. Is that about the program that has to be followed?

Dr. BACHER. Well, perhaps, I might say it this way, Senator: If you build a reactor then, within the bounds of what you can get into that reactor, you try to incorporate all of the technical advances of the past. If you are building an intermediate reactor, you can incorporate only part of the advances that have been obtained in the building and operation of a reactor which is greatly different from that.

Senator HICKENLOOPER. But the point is that we do not build reactors and keep saying, "Well, we will study a little more and next year we will learn more," and next year we say, "We won't build a reactor this year because next year we will know more." We would never get any reactors built.

Dr. BACHER. I believe one could only agree with that, Senator.

Senator HICKENLOOPER. That is the point. There must be a point where design is frozen and construction begins and then learn from there for future activities.

Dr. BACHER. There is always a question of balance involved and it is my own conviction that in development of reactors a certain amount of boldness is needed. We must go ahead with the design and the construction of reactors at a time which is long before all of the problems are understood. If we do not do this, we will most certainly lose out in the development of atomic energy.

Senator HICKENLOOPER. I think I agree with that, and I may say also that, as you already well know, I am not at all qualified to discuss reactors with you. I am not a scientist. I am clear out of my element on those things.

Dr. BACHER. I enjoy discussing reactors with you very much, Senator.

Senator HICKENLOOPER. I think it would give you a great deal of pleasure if I undertook to discuss them with you. My ignorance would immediately become apparent.

Dr. BACHER. At Los Alamos during this past year a fast reactor, which was designed at the end of the war, has been constructed and put into operation, and more recently has been operated at the power for which it was designed.

I have been very much interested to learn of the success of that operation, particularly at the designed power, and feel confident that there will be very much scientific and technical information learned from that reactor which will be of benefit to the reactor program as a whole.

It should, of course, be clearly understood that this reactor is a relatively small reactor compared to those which are needed for preliminary units for high-powered reactors, but it is the first operating fast neutron reactor.

Senator HICKENLOOPER. The fuel of that reactor varies somewhat, does it not, from the normal fuel heretofore used in reactors?

Dr. BACHER. This is the first reactor which has been designed to operate with plutonium as a fuel.

Senator HICKENLOOPER. That is what I meant.

Dr. BACHER. The information, Senator, which can be obtained from that reactor will be applicable to other reactors as well.

Senator HICKENLOOPER. I think I saw it shortly after it started up. They were just beginning to get some data out of it.

Dr. BACHER. At the Brookhaven Laboratory, there has been under construction during 1948 a reactor for research use of that laboratory. This reactor is generally modeled on the reactor which is located at Oak Ridge, although it incorporates a number of advances and improvements and will operate at somewhat higher power. We believe that this reactor, when in operation, will be a major research tool and will provide for that laboratory facilities for research in nuclear physics and neutron physics and general pile technology which will bring to that work many people who would otherwise be working on subjects which are quite unrelated to atomic energy.

I might add that it has been one of the central ideas in the development of the regional laboratories for atomic energy, to provide facilities for the carrying out of more research and for the training of many new people in this field, since I am quite sure that in the days to come the limitation of trained people will be a very serious one.

On the subject of research and development at the end of 1948, I would like to review just a few major accomplishments. At the Berkeley Laboratory where the development of accelerators was undertaken with vigor at the end of the war, they have been successful in completing and putting into operation the big cyclotron, incorporating the frequency modulation principles which were initiated at the end of the war. With this instrument in the spring of 1948, there was the first laboratory production of mesons. These particles which seem to be transitory and with a relatively short life, we believe are intimately related with the origin of the nuclear forces. These are the forces which hold the particles of the atomic nucleus together.

Now, it has been one of the principal ideas in research of the Atomic Energy Commission to promote research and development work aimed at the achievement of a better understanding of the atomic nucleus. It would be impossible for me to come to you and say that I am sure this will lead to the production of better fissionable material or more fissionable material or better weapons or more weapons, but I can assure you, without any qualification at all, that if we are to have a sound atomic energy project, we must have a sound, vigorous, and all-inclusive general research program in the country behind it, lest otherwise we will not be able to make the technical developments which would grow out of these fundamental discoveries.

Senator HICKENLOOPER. This meson business to a layman—is that in the nature of creation of matter, creation of something, rather than splitting or destruction? Is it not sort of putting reverse English on the disruption of matter?

Dr. BACHER. We believe, Senator, that the mesons originate when there is a change of a neutron into a proton, or vice versa.

Senator HICKENLOOPER. I thought that it was the reverse from a fission, more or less the combination of something or in the nature of the creation of something rather than out of these energy forces.

Dr. BACHER. In the sense that mesons appear only when you have a very great concentration of energy, this is most certainly correct, Senator. This is the fundamental reason why in order to study these particles, large and expensive machines are needed in order to accelerate particles to these extremely high energies.

That is the reason why we have been undertaking this sort of work only in a limited number of places.

Senator HICKENLOOPER. What do they call this machine that is bigger than a cyclotron, a bevatron or something?

Dr. BACHER. There are two names for this machine, depending on whether you are an easterner or a westerner.

Senator HICKENLOOPER. I live halfway between.

Dr. BACHER. I do not know what the Iowa term for this machine is.

Senator HICKENLOOPER. We do not have them in Iowa.

Dr. BACHER. The same principles which have been incorporated in the frequency modulation cyclotron at Berkeley have been extended into a machine which at Brookhaven has been called a cosmotron and at Berkeley is called a bevatron.

The reason for the Berkeley name, I believe, is that it is hoped that this machine, when constructed, will accelerate particles to several billion electron volts. At the present time the Berkeley cyclotron is the largest machine in actual operation.

One other machine has been constructed at Berkeley, and this is at the present time the largest machine for the acceleration of electrons. The cyclotron, the bevatron, and the cosmotron are primarily of use in accelerating heavy particles—that is, protons, helium nuclei, or other nuclei.

Senator HICKENLOOPER. They will make a stack of pennies stand on edge, I know that.

Dr. BACHER. The synchrotron developed at Berkeley is a machine for the acceleration of electrons, and this machine was successfully operated early in 1948 and has also subsequently been used for the— I beg your pardon. The synchrotron at Berkeley was brought into operation at the end of 1948 or early 1949 and subsequently has been used to produce mesons from the gamma rays or X-rays, which are produced when electrons collide with material after acceleration.

I think these can be said to be major milestones in the subject of nuclear physics and the origin of nuclear forces, which are behind the atomic energy project.

In addition, the Commission has during 1947 and 1948 had a long and vigorous cooperation with the Office of Naval Research in promoting projects in a great many universities. Most universities at the end of the war found that it was quite impossible for them to go into those subjects with the vigor that would be needed in order to have any significant accomplishment if they had to do it entirely with the funds at their disposal.

The Office of Naval Research performed a great service to the country, in my opinion, in helping the universities to get started with this work at the end of the war. The Commission has been cooperating with the Office of Naval Research, and during the past year furnishing, I believe, somewhat more than half of the funds for carrying out the nuclear physics projects which they had undertaken and in undertaking new projects.

In addition, the Commission has undertaken a considerable number of new projects by direct contract. I do not believe that the importance of these projects can be overestimated. They form the foundation stone on which future work will be built. They form the means by which new people will be trained with that information which is necessary for a strong and vigorous atomic energy project.

To sum up where we stand today, I think it is safe to say that today the bomb production is in the best shape ever. Bomb development is now in progress which will make a major improvement in the utilization of fissionable material. This work is based primarily upon the results of the Eniwetok tests.

On the production of fissionable material, the efficiency in the production of U–235 is still increasing, and Y–12, the electromagnetic plant, is no longer in active stand-by condition.

The plutonium production is today increasing and greater than it has been, and we can expect more in this direction in the near future, based on steps that have already been taken.

New facilities for production are now ready. There has been a major accomplishment in prolonging pile life. How far that may go, I do not believe we can hazard a guess today.

In the operation of a reactor you may always have some unforeseen difficulty arise tomorrow. But we have had extraordinary good success so far. We are now producing more plutonium from a given amount of raw material than ever before, and facilities at Hanford are now available for metal production and fabrication.

On raw material, the limited facilities for the production of raw material in this country are now expanding, and I believe that I can say there have been major successes in the technical work which should lead to the utilization of low-grade ores. I believe this is a major accomplishment.

On reactors today, the problems on materials which go into reactors, both the structural materials and the fuel elements, are beginning to be licked. We have learned a great deal about the use of liquid metals in the cooling of reactors.

This is a major step toward the production of power, and I think one can say, without being overoptimistic, that we are getting to the point where we might consider this really feasible. We are beginning to see our way through some of the problems which existed 2 years ago.

There has been a major advance in the fabrication of unusual metals. Fabrication of many of the metals that are needed in reactors has been extremely difficult and has involved metallurgical problems which 4 or 5 years ago were thought to be impossible and which 2 or 3 years ago looked extremely difficult.

The successful operation of the Los Alamos reactor at its designed power is, I think, very heartening. Critical experiments on the model of the Knolls reactor have led to many new results in reactor development. The consummation of a contract with the Westinghouse Co. for carrying out the development of a reactor for the propulsion of a naval vessel in cooperation with the Argonne Laboratory is, I believe, a major step forward, and will, I hope, lead to the early development of a land-based nuclear reactor which could serve as a prototype for a unit actually to be installed in a ship or submarine.

On the general subject of research, I think I could say that the results of the postwar encouragement of research are now beginning to show in a major increase in the output of the scientific laboratories and in the number of competent scientists that are available. The scientific journals are full of important articles reporting work which has been carried out with the help of funds that have been provided by the Commission and materials that have been produced in Commission-operated reactors.

This whole question of research, of course, is a long-term job, and I do not mean to imply in any of the optimistic statements I have made about research that you can expect the ultimate tomorrow, but research must be carried out over a long period of time. Many experiments will be done which will not lead to results that will be of any help in the project, but occasionally there will be that unusual experiment which will give a surprising result that will just turn the tide in some new development. This is the history of all scientific and technical developments in the past, and I am sure one can rely on this in the future.

I did not mention while discussing the Los Alamos Laboratory some of the significant developments of recent months at the Sandia Laboratory which operates in close cooperation with the Los Alamos Laboratory and also in very close cooperation with the armed forces. This laboratory, as you know, carries on certain development, engineering, and production jobs at the present time.

Recently the Commission has had a thoroughgoing survey made of this work of this laboratory, as well as a survey of the work of the Los Alamos Laboratory.

Based on this report, which was in many respects most flattering to the people at Los Alamos, certain new advances and new plans are being instituted at the Sandia Laboratory. Many of these have been carried on in the time since I have left the Commission, and I am not familiar in detail with them, except that I heartily concur in the report which was prepared and on which these plans are based.

In conclusion, Mr. Chairman, I would like just to emphasize one or two points. I do not believe that you can examine one small fraction of the atomic energy project by itself and hope to come up with any conclusions or answers which are definitive. You must look at the project as a whole. You must look to the results which are obtained.

The project is technically very closely tied together, and the participation by the Commission here in Washington is not just a participation on paper, but it is an actual participation. The decisions which must be made and the plans that must be developed must show an integration of all of the work of the project.

This is true in the development of atomic weapons, it is true in the production of fissionable material, it is true in all the research and development work, and it is most certainly true in the development of nuclear reactors.

Furthermore, I believe that the people who work on the project must have some confidence in the stability of this project. That is what keeps them on the job. It was the uncertainty and instability of the project at the end of the war which sent many people away from the project. We must at all costs avoid that instability and loss of confidence.

Our real strength for the future depends upon progress. Many people say, "Let's lock up the secret of the atomic bomb." Nothing could put the United States in a poorer position in the future. We depend not upon locking things up, but upon new developments and new progress. This is the only way we will get ahead. Speed and competent development we depend upon.

The Commission must be charged with the job of getting ahead as fast as possible with the development of atomic energy and anything that detracts from that speed will endanger this country.

Thank you.

The CHAIRMAN. Senator Hickenlooper?

Senator HICKENLOOPER. I do not have very many questions to ask the doctor, if any. I might have one or two.

I am glad to see you back again. I am always glad to see you back. I am sorry you saw fit to leave.

Dr. BACHER. Thank you. I am glad to be back, Senator.

Senator HICKENLOOPER. I want to assure you, as I have in times past, I have tried to make utterly clear that I feel the scientific people who are engaged in this process, this whole program, have done a tremendously fine and integrated job. I believe their integrity has been high and within the limitations of the tools and the programs that they have to work with; I think they have done a reliable job for the country and for the whole atomic energy set-up.

I, therefore, have no particular questions. I would like to ask you just this question, or these three.

Are you satisfied with our progress in the waste-recovery end of this program?

Dr. BACHER. The atomic energy project in general, Senator, is not one to be satisfied with ever, regardless of what the accomplishments are, because satisfaction indicates that you cannot pour on more oil, and I think we ought always to be pouring on more oil.

Senator HICKENLOOPER. I am just wondering if you are satisfied with the progress we have made on the waste-recovery end of this matter.

Dr. BACHER. I think in any phase of the project, waste recovery included, Senator, we could always do better.

Senator HICKENLOOPER. Are you satisfied with the progress we have made on the chemical separation processes?

Dr. BACHER. I think I would give the same answer to that.

Senator HICKENLOOPER. I shan't try to press that further. What I am interested in, Doctor—and I think you are, too—is to keep our atomic energy program generally as far out in front as possible with its most efficient operation. That goes into general over-all policies as well as operational policies outside of the scientific and technical developments.

Scientific and technical development, I think, has gone forward, after the hiatus that occurred after the dropping of the bomb on Hiroshima, which I believe is a natural let-down because of the uncertainty and because of the quarrels between those who advocated miltary control of atomic energy and those who advocated civilian control; I think there was a period when no one knew what the future of this program would be and I think a great many people, scientists and technicians and others, went back to their normal work. There was a disruption during that period of time which was probably quite normal after the development of this bomb for the purpose of winning a war.

Therefore, I would not be technically able to dispute you on technical ends of this thing, and I am perfectly willing to agree that the progress has been made on the scientific and the technical end.

I have in mind that when we talk about the Manhattan District and the Commission, a great many of you composed the Manhattan District. You were part of the Manhattan District. Dr. Bradbury was part of the Manhattan District. Dr. Lawrence was a part of the Manhattan District. A great many other famous scientists and technicians were the Manhattan District, who did this job. I think they are still carrying on at a very high level of integrity and a very high level of accomplishment.

That is all I have.

The CHAIRMAN. Mr. Jackson?

Dr. BACHER. Mr. Chairman, might I add just a word to this point? I have a very great respect for many of the people with whom I worked during the war. Many of the people who are in responsible positions now for the Atomic Energy Commission in the technical work were colleagues of mine during the war. There was Dr. Bradbury, Dr. Zinn, and Dr. Haworth at the Brookhaven Laboratory, as well as many others; and I think they deserve a great deal of credit.

Senator HICKENLOOPER. My omission of names did not mean I did not want to credit a great many other people with these accomplishments.

Dr. BACHER. There are many of them who deserve a great deal of credit for this.

I think, Senator Hickenlooper, that it is not possible to draw a sharp line between the technical developments of the project and other developments of the project or between the planning of some of these developments that I have just been discussing this morning and other questions of management. It is my belief that these are the questions of management which are most vital and that other decisions are made so that these may go ahead with the utmost speed.

Senator HICKENLOOPER. My interest is that the other decisions of management, outside of the scientific and technical—that the other decisions of management involved are such that the scientific and technical can go ahead with the greatest possible efficiency and the greatest possible progress.

The CHAIRMAN. Mr. Jackson?

Mr. JACKSON. Dr. Bacher, I take it from what has been commented on by Senator Hickenlooper, that the technical management of the Commission has been in good hands. What is your feeling as to the over-all management of the program insofar as it affects the very vital program of atomic weapons, something which the American people are interested in, in view of these hearings that have been held during the past few weeks?

Dr. BACHER. Mr. Jackson, I think one can only judge this project by what is produced and, accordingly, in trying to give some over-all summary of it this morning I have tried to say what I thought the situation was today.

I believe that the decisions of management that have been taken during 1947 and 1948 have led to a very much stronger project today than we had before. A great deal of effort has been put in, and I believe there is a very considerable measure of success. I am not at all ashamed of where we stand today on the production of fissionable material and the production and development of weapons.

The CHAIRMAN. Mr. Jackson has yielded to me, Doctor. You say that we can tell by the results. You also say that you are not ashamed of the final results—namely, the production of fissionable materials and the number of weapons.

It has been heretofore the policy of the committee not to inquire into or to get reports on those two measures of the Commission's work and, of course, that will only be done after full consideration by the committee itself, a decision with which I heartily concur.

I take it that in your opinion if the results were made known to the American people, you would be satisfied to have those results made known as composing a test, a very definitive and concrete test, of the success of the Commission's activities.

Dr. BACHER. Well, Mr. Chairman, this poses, of course, many problems, because one must evaluate the importance of that information in the defense of our country. I would not propose to set myself up as a judge of the importance of it.

The CHAIRMAN. I am not talking about the wisdom of doing it or not doing it, Doctor. I am pointing out my belief that if that information could be known, it would be the best test of all as to the success of the Commission in its primary work for the last two and a half years.

Dr. BACHER. I think, Mr. Chairman, that in order to make that single piece of information carry the amount of knowledge to the people of the United States that it should, they would need to know considerably more about what the effects of a given bomb would be, how the bomb was constructed, what went into it, what it might do, how it would be used, and, indeed, a whole lot of things about the fundamentals of atomic energy, so that this might be evaluated against some background.

Let me give an example. I have read from time to time in the press about how it is advocated by one person or another that material be devoted to the development of reactors and production of power and not to the production of weapons. I do not believe that anyone can offer a sensible comment on that unless he knows how much material goes into a bomb, how much material there is, and how much material might be used in a reactor. If you knew these simple things, one might be able to give an evaluation of it.

I am afraid that on these subjects we have, by reason of the security which is imposed on the project, a great deal of misunderstanding and, therefore, a great deal of misinformation is put out, and this gives rise to the jitters and hysteria which we find on all sides at this time.

The CHAIRMAN. Thank you.

Mr. JACKSON. Doctor, would you say that the scientific portion of the atomic energy program is the heart of it?

Dr. BACHER. I would most certainly say that the scientific and technical development work is the heart of the program, and all future progress will depend on these developments.

Mr. JACKSON. In other words, the security of our country, so far as atomic weapons are concerned, does not rest alone with the weapons that we have today but with the possibility of exploiting the best brains and scientific know-how that this Nation possesses?

Dr. BACHER. You are most certainly correct, Mr. Jackson.

Mr. JACKSON. If the scientific know-how that is available is in good hands, I assume the only other danger would be the question of dissemination of the knowledge we now have and the knowledge that we acquire from time to time in the field of science, if that dissemination is not properly managed.

Do you feel that proper steps have been taken in the field of security, consistent with the over-all aim of providing adequate protection to this country in developing new weapons and the new devices that must be constantly developed if we are going to be secure?

Senator HICKENLOOPER. Mr. Chairman, I have no hesitancy whatsoever in discussing the security program of this Commission, but I call your attention to the fact that I was stopped on discussing security methods, and if we are going into security and having opinions of various people, then I certainly would like to open up the security question, because I think it is unfair to Dr. Bacher to ask him to give an opinion on security when I will not be able to confront him with various instances and various situations.

I am perfectly willing to go into it, but if we go into it, let us take the whole ball of wax and look at it. I am in no position to cross-examine Dr. Bacher on this thing as to his opinion, one way or the other, and I feel as long as this security matter has been taken away from me and the committee now has it, that until the committee decides what it wants to do with it, that is a field which in fairness cannot be discussed on one side alone, as a matter of pure opinion of a witness.

Mr. Jackson. Mr. Chairman, my understanding was that as far as security is concerned, the question of individual cases has been held in abeyance or at least the committee has taken action suggesting that those matters be handled in executive session.

But I do think that in view of the discussion that has taken place for at least a couple of days here and possibly more than that on the broad subject of security, that it would be in line for the witness to make a general comment on the over-all situation regarding security.

The Chairman. Do you, Senator Hickenlooper, believe that the security is barred from discussion by the fact that individual cases have been withdrawn for action in executive session?

Senator Hickenlooper. I most certainly do.

The Chairman. As I understand it, your charges on security rest in the main part upon the individual cases of some individuals who were in the project. As I understand Mr. Jackson's question, he is asking a general question as to whether he believes that the security aspects of the program have been properly attended to. Am I right?

Mr. Jackson. That is right. Over-all.

Senator Hickenlooper. Then I will just say that if the chairman permits Dr. Bacher to answer that question, I expect to ask Dr. Bacher about a great number of individual cases and about individual situations and see whether he approves. I just feel that this whole security situation as it now stands is one that has to be resolved so that we know what we can talk about in public hearing and what we cannot.

I have been staying completely away from that out of respect for the joint committee's authority in these hearing until it decides what it wants to do about them. I do not have any hesitancy about discussing security at all, except that I would not be content to have Dr. Bacher give just a general opinion here without going through a great many things with him, and I feel in the rather nebulous situation that security is in at this time it might even be unfair to him in his answer, it might be unfair to the committee in its final determination.

The Chairman. In other words, Senator, your contenton is that you would be restricted in the scope of your cross-examination, assuming that Dr. Bacher would say that the security of the project has been given proper attention, that you then feel you should be allowed the fullest scope of cross-examination on individual cases.

Senator HICKENLOOPER. The whole field of security, I believe, if that is the case. In other words, I have attempted to stay completely away from the security end of this thing as a matter of discussion or opinion since the action was taken on certain security files, and I have been holding that in abeyance until the joint committee has had an opportunity to determine its own policy on that matter.

Mr. JACKSON. Mr. Chairman, I am not going to press the question now. I just thought that in view of opportunity that was given to the Senator sometime ago in which even one case was discussed at considerable length, that a general statement might be in order, but I am not going to press it at this time.

The CHAIRMAN. I presume that if you do not press it, there is no occasion for me to rule on admissibility of the question. If Senator Hickenlooper believes that that particular question should of necessity give him a right to open him up for cross-examination on these individual cases, it would result in defeating the will of the joint committee as it was expressed in a session that it had about 3 weeks ago. So if you do not press the question, we are not faced with the problem.

Dr. BACHER. Mr. Chairman, I have just one small remark.

The CHAIRMAN. Make it small now, Doctor.

Dr. BACHER. I was reading awhile ago the hearings on the confirmation of Dr. Smyth, and I find, unless my memory serves me wrong, Senator Hickenlooper agreed at that time that on the over-all question of security a pretty good job had been done, but this is not my opinion. I am only quoting his. I am giving no opinion.

Mr. JACKSON. Doctor, how much of an investment was involved in the reactor problem at Hanford as it affected the very serious problem you had of deterioration awhile back? How much money was involved if you had to bring about a replacement?

Dr. BACHER. Mr. Jackson, I think those figures ought to be furnished to you separately, since I do not recall them accurately at the moment, and I do not want to give you something that is misinformation. But I will see that the Commission furnishes it.

Mr. JACKSON. Roughly was it $10,000,000 or $50,000,000?

Dr. BACHER. It was more nearly on the order of a hundred million or more. As a result of new developments it has been possible to defer indefinitely over $150,000,000 worth of Hanford construction that was considered essential in 1947 to keep the production program going and to meet the new goals.

Mr. JACKSON. And as a result of the work that the Commission had been engaged in, it found it not necessary to replace the reactors?

Dr. BACHER. The plan is not to let that work go but to utilize the facilities which have been built to increase the production of plutonium and, in fact, when the reactors were planned, this idea was already incorporated in selecting their location.

Mr. JACKSON. Doctor, you worked with some of the British and Canadian scientists during the war?

Dr. BACHER. I did.

Mr. JACKSON. I wonder if you would be good enough to comment on our policy in connection with the British and the Canadians very briefly and whether you think it has been properly handled.

Dr. BACHER. Just to make a few remarks on this, Mr. Jackson, the cooperation with the British and Canadians during the war was quite complete. It did not cover all parts of the project, but many parts of the project it covered with considerable thoroughness.

For example, with reference to the heart of the project, the laboratory at Los Alamos, the first discussions with the British were undertaken, if I recall correctly, in August of 1943. Subsequently, a sizable British mission came to Los Alamos, headed by Sir James Chadwick and composed of a number of eminent British scientists.

These men worked in many parts of the project. Several of them were in the Theoretical Division there and contributed ideas to the development of the bomb which were very important. As members of the Theoretical Division, of course, they had quite general access to work that was going on in the rest of the project and they had access to the work in experimental physics, in experimental chemistry, to the general metallurgical work that was going on there, to the ordinance development work, and to the bomb physics work. In fact, they had general access to all of the information that was developed at Los Alamos.

Many of them were in these various sections of the laboratory at Los Alamos and participated in that work. One of them was a very close associate of mine in the Bomb Physics Division and was responsible for and participated in many of the critical assemblies of vital materials which were made in the development of the bomb. So they had a thorough and complete knowledge of all the bomb work.

On other parts of the project I cannot speak from quite such close association, but I know that, likewise, they were associated intimately with the development of the electromagnetic process of separation, with the diffusion process in its early days. The Canadians in particular were closely associated with the development of the piles at the metallurgical laboratory at Chicago. The extent of the knowledge which was exchanged during that period of cooperation between the British and Canadians with the United States was very deep.

Mr. JACKSON. What has their participation been since that time?

Dr. BACHER. Their participation in 1946, of course, with the passage of the Atomic Energy Act, was cut to zero; and there has been no participation by them directly in the United States atomic energy project since then. There have, as you know, been established, certain areas of technical cooperation which have been spelled out in considerable detail in papers that have been furnished to the joint congressional committee. There are, I believe, nine areas, some classified, some unclassified.

Mr. JACKSON. Do you feel that their participation assisted materially in the work that you were engaged in at the time at Los Alamos?

Dr. BACHER. There is no question of that, Mr. Jackson.

Mr. JACKSON. As far as the over-all program is concerned, do you feel that every reasonable effort has been made by the Commission to place this country in a superior position as far as atomic weapons are concerned?

Dr. BACHER. That has been the aim of the Commission in everything that it has done. Certainly every decision that the Commission has taken has been toward increasing our position with respect to other nations of the world in the development of atomic energy. I think, again, that the success can only be judged by what the results are. I believe these results are pretty good.

The CHAIRMAN. As a commission you functioned as five men?

Dr. BACHER. Yes.

The CHAIRMAN. You distribute, I take it, the credit equally among the five?

Dr. BACHER. I think I would like to say just a word about this point, Mr. Chairman, if I may. As a commission, we had a great many meetings. We had many formal questions on which decisions were taken, formal votes. We had a great many informal meetings and we had a great many individual discussions.

I think if there are any questions of management or mismanagement leveled at the Commission or at any member of the Commission, all of the members of that Commission are equally responsible. At least, this is my own view. We participated in all decisions and if these decisions are found to be incorrect, all members are equally responsible.

Now, just a word about how we functioned as a commission.

Mr. Lilienthal, of course, was appointed as Chairman of the Commission and as its head. At the same time, four other members of the Commission were appointed and in general it was our policy to talk over all questions rather much in detail. Inevitably, if you find five people with different backgrounds, they do not have the same opinions on every subject. We rather quickly gained a respect for each other's opinions. I certainly gained a very great respect for my former colleagues and their opinions. When I expressed an opinion and they had some disagreement with it, I took that disagreement seriously because I usually realized that there was something behind that that should be considered very deeply.

Inevitably this meant that in formulation of a Commission policy there would, after discussion, be some view which would emerge. I think this is an inevitable conclusion of the operation of a group of people who have respect for each other's opinions; and it was in this way that most of the Commission's decisions were arrived at.

Now, as you know, there were some points on which we did not have complete unanimity, but I believe it was clear even on these points where there was not complete unanimity of opinion, that there was a thorough-going respect in both directions for the opinions that were expressed.

Mr. JACKSON. I take it from what you have stated here today, Dr. Bacher, that we are making every reasonable effort to do the job that was incumbent upon the Commission during the time you served.

Do you feel that, considering that that has been the objective, it is going to be very easy for any other foreign power to catch up with the United States, considering the productive facilities that we have available and the efforts that are now being made?

Dr. BACHER. How fast other countries will move, Mr. Jackson, depends primarily upon how vigorously they pursue their atomic projects. In some cases we have a rough idea how vigorously their projects are being pursued, and in other cases we have no information at all.

Mr. JACKSON. I think the American people are anxious to know whether we are lagging behind, considering the potential that other countries might be able to develop and at the same time knowing the great industrial potential that this country has. If those goals are reached by our country each year, do you feel that it will be a very short time or will it be easy for other countries to catch up with the progress that we are normally capable of bringing about?

Dr. BACHER. Let us take a specific example. I think maybe we can do this without getting on too delicate ground.

The British have an atomic energy project. They are setting about the production of fissionable material and have announced that they are developing and intend to produce atomic weapons. I am sure they will be successful in this undertaking. They have all of the technical know-how, all of the scientific background that is necessary for such a development, and I believe it is only a question of time until they do produce bombs.

Now, it is a long step from the production of the first fissionable material to the production of the first atomic weapon. It is another long step from the production of the first atomic weapon to the production of atomic weapons in quantity. It is also another long step from the development of the first reactor to the development of reactors which produce fissionable material in quantity. It is a still further step to the production of reactors which will produce useful power and possibly even breed fissionable material. It is a series of steps, and one must be achieved before the last step can be taken.

Mr. JACKSON. In other words, from what we know now, we are way out in front?

Dr. BACHER. I hope we do not pat ourselves on the back too much for that, Mr. Jackson.

Mr. JACKSON. I appreciate your feeling about the word "satisfaction," that we should never be satisfied, but I mean, speaking now of facts, what we know of other countries—is it not true that we are way out in front?

Dr. BACHER. I believe there is no question at the present time that the United States is ahead in the development of atomic energy.

Mr. JACKSON. I mean we are not just a little ahead but we are way out in front.

Dr. BACHER. It is my belief we are.

Mr. JACKSON. That is all.

The CHAIRMAN. All right, Doctor. Thank you very much indeed. It is nice to see you again and I hope that future occasions will come about when we can take advantage of your knowledge on this subject.

The Commission has another witness to produce tomorrow morning?

Mr. VOLPE. Mr. Chairman, we have several witnesses that we will produce. There is a little difficulty in travel. Many of these witnesses have to come a long distance and they are very busy men and they have had long-standing engagements. We will have witnesses tomorrow morning. It is a little difficult to say who they will be right now. The names have been mentioned before.

The CHAIRMAN. You do not know what order they will come in?

Mr. VOLPE. That is right.

The CHAIRMAN. We will meet at 10:30 tomorrow morning in this room.

(Whereupon, at 1:22 p. m., the joint committee adjourned, to reconvene at 10:30 a. m., Thursday, July 7, 1949.)

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INVESTIGATION INTO THE UNITED STATES ATOMIC ENERGY PROJECT

HEARING

BEFORE THE

JOINT COMMITTEE ON ATOMIC ENERGY

CONGRESS OF THE UNITED STATES

EIGHTY-FIRST CONGRESS

FIRST SESSION

ON

INVESTIGATION INTO THE UNITED STATES ATOMIC ENERGY PROJECT

PART 21

JULY 8, 1949

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INVESTIGATION INTO THE UNITED STATES ATOMIC ENERGY PROJECT

FRIDAY, JULY 8, 1949

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D. C.

The joint committee met, pursuant to adjournment, at 10:40 a. m., in the Caucus Room, Senate Office Building, Washington, D. C., Senator Brien McMahon (chairman) presiding.

Present: Senators McMahon (chairman), Vandenberg, Millikin, Knowland, and Hickenlooper; and Representative Holifield.

Also present: David E. Lilienthal, Chairman; Sumner T. Pike, Commissioner; Lewis L. Strauss, Commissioner; Gordon E. Dean, Commissioner; Henry D. Smyth, Commissioner; Carroll L. Wilson, General Manager; Frances Henderson, Assistant to the Chairman; Joseph Volpe, Jr., General Counsel; Bennett Boskey and Everett L. Hollis, Office of the General Counsel; Morse Salisbury, Director, Rodney L. Southwick, and Robert Tumbleson, Division of Public and Technical Information Service; and Dr. Walter Colby, Director of Intelligence; all of the United States Atomic Energy Commission.

James W. Parker, president and general manager of Detroit Edison Co.; and chairman of the Industrial Advisory Group, United States Atomic Energy Commission.

Isaac Harter, chairman of the board, Babcock & Wilcox Tube Co.; and member of the Industrial Advisory Group, United States Atomic Energy Commission.

Dr. Lee A. DuBridge, president of California Institute of Technology; and member of the General Advisory Committee, United States Atomic Energy Commission.

Dr. Enrico Fermi, Institute for Nuclear Studies, University of Chicago; and member of the General Advisory Committee, United States Atomic Energy Commission.

The CHAIRMAN. The committee will come to order.

Senator KNOWLAND. Mr. Chairman, I would like to put into the record at this time a letter, which was in answer to an inquiry I raised at the hearing on June 29. It is a letter that was addressed to the chairman and signed for Carroll L. Wilson—I cannot make out the signature; I think it is the signature of Mr. Shugg—dated July 7. It is as follows:

DEAR SENATOR MCMAHON: This will transmit to you the summary salary data requested by Senator Knowland in the hearings on June 29, 1949. This request appears at page 1697 of the stenographic transcript. For the convenience of the committee we have also included a summary of the data previously submitted on employees receiving $14,000 per year or more.

In connection with the preparation of this information, it was discovered that a change is necessary in the table recently submitted showing contractor personnel receiving salaries of $14,000 or more per year. Under General Electric Co. at Hanford on that table, W. R. McKenna and R. C. Stanton are shown as receiving basic salaries of $11,520 plus bonuses of $3,440 each. These two employees have recently received salary changes due to a reduction in working hours and now receive basic salaries of $9,600 instead of $11,520 as previously reported. For this reason, they have been included in the attached table and it is requested that they be removed from the table that was submitted June 24, 1949.

Sincerely yours—

and it lists a summary of employees of the Atomic Energy Commission and its contractors receiving payment of $10,000 but less than $14,000 per year.

It shows in a break-down of contractor employees receiving $10,000 but less than $11,000, 73 of them; $11,000 but less than $12,000, 24; $12,000 but less than $13,000, 36; and $13,000 but less than $14,000, 17; or a total of 150 employees receiving between $10,000 and $14,000.

On the AEC employees it shows those receiving $10,000 but less than $11,000, 87; $11,000 but less than $12,000, 10; $12,000 but less than $13,000, 5; and $13,000 but less than $14,000, 2; or a total of 104.

Then, the break-down on the summary of employees of AEC and its contractors receiving payments of $14,000 and above per year, that is as follows: $14,000 but less than $15,000, 9; $15,000 but less than $16,000, 13; $16,000 but less than $17,000, 5; $17,000 but less than $18,000, none; $18,000 but less than $20,000, 3; and $20,000 and above, 3; for a total of 33.

Of the AEC employees, the previous list I just read was contractor employees, AEC employees, those receiving $14,000 but less than $15,000, 9; $15,000 but less than $16,000, 5; $16,000 but less than $17,000, none; $17,000 but less than $18,000, 1; and $18,000, 3; for a total of 18.

The total number of employees receiving $10,000 or over, contractor employees, 183; AEC employees, 122.

I ask that that be made a part of the record.

(The data referred to above are marked "Exhibit 31" and will be found in the appendix.)

Senator HICKENLOOPER. Mr. Chairman, before we proceed, if you would indulge me for just a moment, with respect to the discussion about the clearances for the Eniwetok test of last year, and the references to it, I asked for the records again this morning, and I find that in the record of emergency clearances for the month of April 1948 there is a specific notation that—

Clearances under the interim security measures for the armed forces issued May 23, 1947, or for project 19—

which is the Eniwetok test—

are not included; so that the totals of over 4,000 emergency clearances would have to have added to that the Army emergency clearances and the Eniwetok test clearances,

and they were not included in the original figures.

Mr. VOLPE. Mr. Chairman, actually there were two groups of clearances: One, emergency clearances for contractor employees connected with the Commission's phase of this operation, and then there was another group of interim clearances for the armed forces.

I am quite certain that the footnote Senator Hickenlooper makes reference to has to do with the interim clearances or approvals given by the armed forces and does not include the emergency clearances given by the Commission which, I believe, are included in the total figure of approximately 4,000.

Senator HICKENLOOPER. I just was reading what was put on the Commission's own report, and it says that clearances for project 19 are not included, nor are clearances for the armed forces under the orders issued May 23, 1947, under interim security measures, and that was the——

Mr. VOLPE. It is not terribly clear, I agree, Senator. I would agree that we go back and check our records and submit a statement, because it may very well be that they were not included in that.

Senator HICKENLOOPER. I notice that the interim clearances for April 1948, as reported by the Commission, total 193. I do not find them for May, but they were running on the average of over 100 per month, which would indicate that the Eniwetok clearances were not included.

I merely want that in the record at this time, Mr. Chairman.

The CHAIRMAN. Now, is the Commission ready to proceed?

STATEMENT OF DAVID E. LILIENTHAL, CHAIRMAN, ACCOMPANIED BY JOSEPH VOLPE, JR., GENERAL COUNSEL, BOTH OF THE UNITED STATES ATOMIC ENERGY COMMISSION

Mr. LILIENTHAL. Mr. Chairman and members of the committee, the witnesses this morning are four distinguished citizens of this country, as follows:

Mr. James W. Parker, who is the president and general manager of the Detroit Edison Co., of Detroit, a very well-known engineer, and the administrator of a great utility company, and the past president of the American Society of Mechanical Engineers.

The second witness is Mr. Isaac Harter, the chairman of the board of the Babcock & Wilcox Tube Co., of Beaver Falls, Pa., and who has been in charge of operations of that great company for 45 years, a company, as I recall, which is engaged in the manufacturing of power boilers for industrial, naval, maritime, and other purposes, and in making special grades of steel, steel tubes for chemical and other purposes, special refractories for different kinds of materials, in which the element of development has been a very important factor.

These two gentlemen have been, respectively, the Chairman and member of the Industrial Advisory Group to the Commission, and Mr. Harter, more recently, has become a member of the Patent Compensation Board of the Commission.

The third witness is expected to be Dr. Lee DuBridge, the president of the California Institute of Technology, a distinguished scientist, and a member of the General Advisory Committee to the Commission; and Dr. Enrico Fermi, whom it is about as necessary to describe as Magellan or Copernicus, and who is on the staff of the University of Chicago, and a member of the General Advisory Committee.

I would like to present Mr. Parker first.

The CHAIRMAN. Mr. Parker, I am glad to see you here.

Would you give your full name to the reporter, please?

STATEMENT OF JAMES W. PARKER, PRESIDENT AND GENERAL MANAGER, DETROIT EDISON CO.

Mr. PARKER. My name is James W. Parker.

Mr. Chairman, you want me to offer my observations?

The CHAIRMAN. I think that would be in point.

As we understand it, Mr. Lilienthal said you are Chairman of the Industrial Advisory Committee and, therefore, we presume you have some knowledge of the operations of the Commission.

Mr. PARKER. That is true.

Previous to my appointment to that Industry Advisory Committee I had naturally been interested in this development because of the implications in my own industry. It was about the intelligent interest that anyone in the light and power industry would take in a new development that might possibly have a profound effect.

That interest was really that, you might say, of an interested observer and amateur. My contacts with the Commission were very casual. I had talked to various scientists who had been engaged on the work, but we were, of course, not dealing in any secret information at that time.

Upon my appointment to this Industrial Advisory Committee, however——

Senator HICKENLOOPER. What date was that, Mr. Parker?

Mr. PARKER. That was in November 1947.

Senator HICKENLOOPER. Thank you.

Mr. PARKER. This group of industrialists who were drawn from quite a wide area of industry, several men from the oil-refinery industry; Mr. Harter, who has been already introduced to you, a manufacturer; others who had been engaged in various manufacturing and businesses, based largely on scientific experience and information. I suppose I was chosen as being typical, we will say, of men in the management of the light and power business.

This group of businessmen was given every facility to see how the Commission's operations were carried on. We made numerous trips—I do not think you are interested in the exact number of them—but during that first 3 months, we made at least six or seven visits to the headquarters of the Commission, to their New York office, to the Oak Ridge Laboratory, Argonne in Chicago, and the Hanford plant in Washington, spending several days at each of these major installations, and then numerous visits and discussions with the Commission and their staff later on, until in May of 1948 we had prepared or had brought our thinking to the point that we wished to discuss it with the Commission. We wanted, before we wrote our final report, to correct any errors of fact, misinterpretations of things that we had seen, because although, as I say, we had made visits to all of these plants, it would be impossible in such a huge undertaking to undertake to know all of the details from direct observation.

We were everywhere met with complete openness; we were introduced to the Commission's contractors, and they were free to tell us everything that they cared to explain, and I am sure the whole impression was that we were being very frankly dealt with, not only by the Commission and staff, but by the contractors working for the Commission.

I suppose you would be interested in the general impression, first, of what seemed to us to be the progress that was being made. It was very obvious that progress was being made, that certain operations, for instance, at Oak Ridge, were being slowed down as being uneconomical, that the more economical process was being further developed and pushed forward.

At Hanford we remarked that the operating difficulties that had been encountered—and very naturally there were operating difficulties in so new an installation in so new a field—those operating difficulties were being understood and being corrected.

All of this visiting and discussion led to the first of the conclusions which we made in our report to the effect that in general we believed that the Commission was making great progress; that they were to be commended on the methods employed, and we rather applauded their policy of placing great reliance upon industrial contractors like the General Electric Co. and the Carbide & Carbon Chemicals Co. and people and organizations of great experience in allied fields.

When I say that we applauded that policy, I must say also that coming from Detroit and having some considerable first-hand observation of the operation of the principle of the industry, the automobile industry, with respect to which feeding plants of that community had converted themselves to an entirely new group of products, and the dependence placed upon that kind of capable business industrial organization by both the Navy and the Army, had greatly impressed me, and realizing the anxiety that the public generally felt for this whole development of the atomic energy field, it was something of a relief to me, at least, and I think to the others on our committee, to find that the Commission was not throwing out the window the greatest asset, in our opinion, that the country possesses, the industrial competence and ingenuity of the American industrial system.

I will put it another way: We, believing that it was necessary that the talents of the American industry be drawn upon continually, if we were to continue to make progress, drawn upon as we are certain they were drawn upon during the period when the Manhattan District was in charge, were somewhat relieved to find that dependence was placed upon that kind of operation.

If the talents of these industrial organizations as teams—and I want to emphasize that, they worked as teams; you cannot take them apart; you cannot take the components out of them and put them into another organization and expect to get the same results—you either take them as a team or you do not use them well—you do not make use of them—it was clear to us that it was very desirable that as many men as possible of competence in the application of scientific experience and data be informed, within the limits of security and safety, of the methods and of the purposes of the Commission.

I do not think I have to emphasize, because it is so obvious that it would not be necessary to emphasize, that we realized always that a great deal of the information dealt with is secret and must be kept so.

But when it comes to matters of organization, of organizing the work so that the Commission's contractors could really exert their abilities and accomplish what they are able and have been able to accomplish, when they are informed and have a free hand, it would be very desirable that they know a good deal of the internal organization of the Commission. A great deal of the information that need not be considered secret could be put into their hands. So, we recommended a greater participation; we recommended the formation of a permanent industrial advisory group. We were not looking for jobs. We very promptly discharged ourselves or asked for our discharge when we made our report, but we did think that the Commission would benefit by the continuing advice of a rather large group of industrial men predominantly in executive positions but with training in engineering and scientific work who had come up, in other words, from that kind of a foundation.

Dr. Robert Wilson of the Standard of Indiana is a typical example of the kind of man I speak of, an eminent scientist, but, at the same time, a very competent business manager.

The CHAIRMAN. He was on your committee?

Mr. PARKER. He was on our committee. He would be the type of man who should serve, and in our opinion would have been very useful, would be useful, to the Commission.

We recommended also that from time to time when special problems arose, it would be desirable for the Commission to pick special committees that would serve temporarily and work on specific problems, and then be discharged. That was a practice that they followed from time to time, and we felt they should continue to follow it, and to the best of my knowledge they have, since the making of that report, continued to do so.

Now, there were certain matters of management within the Commission that we recognized as really not in the field of our terms of reference—I believe that is the word—and we were asked to report on the possibility of securing more industrial participation, but we asked the Commission if they would like to have comment on the type of organization that had been set up, with the idea that some changes might conduce to a better participation on the part of industry.

You can well imagine that an awkwardly organized Commission would be something that the outside contractor would find it possibly very difficult to deal with, or rather very difficult to do his best work for.

Now the fact that we had some changes to recommend implies certain criticism, but it was, I believe, the sort of criticism that a consultant might possibly make when he is called in on any engineering or industrial job to advise.

We remarked, for one thing, that the General Manager, in our opinion, had too many officers reporting to him, too many division and department heads reporting to him, and we considered that an almost intolerable burden to place on one man.

Well, it was our experience, as we discussed these matters, and we were continually discussing our observations with the Commission, that they began to make changes faster than we could recommend them. In other words, at one time it seemed almost as if our report would be almost useless because everything that we were about to recommend had already been done. That is a little bit of an exaggeration, it was not quite true; but it is true that after our discussion of our first draft of the report, which was merely our attempt to put our thinking together, and after that discussion with the Commission, we discovered that they were already making moves quite along the lines of those we were recommending, and before the report was finally turned in, the Commission had made considerable changes in their organization; among others, they had appointed—among other changes that were made—a Deputy General Manager who would take some of the burden off the General Manager.

There was a concentration on division heads of executive responsibility, which we thought should be placed there, a general clarification of responsibilities of the different employees and division heads within the Commission.

Now, these changes were not very dramatic things. You would have to watch the thing very carefully to know that any change had taken place, but nevertheless those changes have taken place.

We made our final report in December, I think—yes, December 1948—and although I have not been in as close contact with the Commission's operations since then, it appears from various appointments that have been made and various new practices that have been adopted that the Commission has been moving along the general line of recommendations of this report.

I will not want to undertake to say whether they might or might not have moved faster, but at least there have been moves, and they have been in that general direction.

I will be glad to answer any questions, if you have any.

The CHAIRMAN. Do you have any questions?

Senator HICKENLOOPER. I do not believe I have any questions of Mr. Parker. I have read your report.

Mr. PARKER. I read it again last night.

Senator HICKENLOOPER. And I am somewhat familiar with the contents.

Mr. PARKER. Yes, sir.

Senator HICKENLOOPER. But I have no questions.

Senator VANDENBERG. No questions.

Senator KNOWLAND. No questions.

The CHAIRMAN. Thank you very much.

Mr. PARKER. You are very welcome indeed.

The CHAIRMAN. Now, Mr. Harter.

STATEMENT OF ISAAC HARTER, CHAIRMAN OF THE BOARD, BABCOCK & WILCOX CO.

Mr. HARTER. My name is Isaac Harter.

The CHAIRMAN. You are a member of the Industrial Advisory Committee and you are a member of the firm of Babcock & Wilcox?

Mr. HARTER. Babcock & Wilcox.

Senator HICKENLOOPER. May I ask Mr. Parker one question?

Mr. PARKER. Yes.

Senator HICKENLOOPER. Is your company doing any work for the Commission at this time?

Mr. PARKER. The Commission has, I have just learned, in fact, placed a small research project in one of our plants.

Senator HICKENLOOPER. You are equipped, are you not, to do work for the Commission in certain fields if it were deemed advisable?

Mr. PARKER. This is a very incidental thing—I might say at no profit.

Senator HICKENLOOPER. Yes.

Mr. HARTER. Mr. Parker has given an account of the contact of our committee with the operation of the Commission, so that I need not refer to that particularly, except to say that his viewpoint coincides very much with mine about the work of the Commission and its progress in what we both think are the right directions.

I would like to speak a little about another side of this matter. Great industrial developments have been made, as a rule, things of slow growth. They have begun small, and if well-managed, have prospered and have become large, like a number of the companies now working for the Commission.

In that time they have had an opportunity by trial and error to find what works well and what does not. In the case of the Commission's work they are engaged in probably the most difficult industrial operation that there has ever been. They have entered into it under pressure of time, and they have had to take the military side of the matter and make rapid progress with that. At the same time, they have had to branch into a field which, in some respects, is perhaps more difficult than the military side because it is more complex; and they have the problem of immense size in adequately organizing the personnel, and with methods, and I think, in thinking of their operations and the progress that they are making, we should all be very careful to contrast a period of about 2½ years in which they have been engaged in their job, with the period of 25 years or 50 years that corporations have had, as for example my own, 50, to grow up, in our case to about a fifth of the size of the operation that the Commission is now having.

The CHAIRMAN. How big?

Mr. HARTER. About a fifth the size of the Commission's operations.

Judged against that background—and I think it is a very important background to have—I, as a member of our committee, and with the contact in that way that I have had with the Commission, feel very strongly that their accomplishment is remarkable.

It is not to be expected that in a rapid operation and in the short time that mistakes will not be made. They are made in all corporations, so far as I am familiar with them, even in spite of their advantage of long training, and the problem of proportion must always be carefully considered: How great are the errors compared with the general magnitude of the operation?

In the discussions that you have had here before your committee, the elements of security, the methods of estimating on operations, and methods of procedure generally, have come in for a good part of the discussion.

I think that you must be very careful in considering all those problems to recognize that too much control of them can do harm as well as good. I do not think—take, for instance, the question of estimates for work—I do not think any corporation ever finds itself where it is within its estimate on work. I do not believe that most corporations feel that it would be a healthy situation if they always were. They would feel, I think, very properly, that the men responsible for the estimates are making them sufficiently large that no trouble of that kind will happen.

In our own group, we aim as far as we possibly can to come to the most correct view of what constitutes the total amount that is most likely to turn out to be justified when the work is done, and then we add to that sometimes 10 percent, sometimes in risky work even more, to cover the possible contingencies, and if, in a complex thing made up of many elements, they all came out black, we would, I think, feel that something ought to be looked into because the estimating was not upon a correct basis.

In all those things, if too much is made of that side of the matter, there will be inevitably a wrong result instead of a good result. I think that is something that should be thought of in this whole affair, as I have been reading about it as it has gone on.

In looking at the work of the Commission, so far as I have come in contact with it and with its people, I am greatly impressed with the high sense of obligation and duty and the effort with which they are trying to carry out their work.

I do not think that any corporation that I know of has in its standards any better approach to their problems or works any harder at it, and I think, in conclusion of what I am saying, we ought to remember that this is 2½ years old, not 25 years old, and that background, I think, of its accomplishment to date is very fine.

Senator HICKENLOOPER. Just to clarify the record a little, Mr. Harter——

Mr. HARTER. Yes, sir.

Senator HICKENLOOPER. Did the Commission build Los Alamos, or did the Manhattan District build Los Alamos?

Mr. HARTER. The Manhattan District.

Senator HICKENLOOPER. Did the Commission build Oak Ridge, or did the Manhattan District build Oak Ridge?

Mr. HARTER. Up to a certain stage of completion, the Manhattan District.

Senator HICKENLOOPER. Yes, certain facilities have been torn down.

Mr. HARTER. Yes, some parts have been added, but in general it has been built by the Manhattan District.

Senator HICKENLOOPER. Did the Commission build Sandia base or did the Manhattan District build Sandia base?

Mr. HARTER. I think it was in between, if I remember correctly.

Senator HICKENLOOPER. Did the Commission build Hanford, with the exception of one new pile which is in the process of being completed now, or did the Manhattan District build Hanford?

Mr. HARTER. Manhattan District, except for——

Senator HICKENLOOPER. So that this is not an installation or a plant that has been built in the last 2½ years. You do not want to be understood as saying that, do you?

Mr. HARTER. No, but it is not alone just a question of plant; it is a question of what you do with that plant. Those plants were built for military purposes.

Senator HICKENLOOPER. Yes.

Mr. HARTER. The Commission's problems are very much wider.

Senator HICKENLOOPER. Is there any difference in the main purpose of those plants now from that which existed before? Are they still being operated in major degree for military purposes?

Mr. HARTER. I would expect that those who really know the answer to that would say yes to it.

Senator HICKENLOOPER. Yes. In other words, there was a very extensive going concern built during the war, was there not?

Mr. HARTER. Going under war conditions, and under that pressure, and operating and, therefore, successful for that purpose; but not going in the sense of a long-term industrial affair which is, after all, what it is in many of its aspects, has to do if it is to be efficient, and if it is to continue, and I think the main work of the Commission is to take the operations that were in a state of beginning, able to do what they had to do, but to improve them to the point where they should be for economy of operation and for extension of their field of work, and I think in those regards the Commission has had a tremendous task on its hands, and it is that that I speak about in the 2½-year period.

Senator HICKENLOOPER. But what operation is the Commission able to do now that was not done by the Manhattan District?

In other words, the Manhattan District built bombs; the Manhattan District produced isotopes; the Manhattan District set up health surveys and had beginnings of research in biology and things of that kind. I am just wondering what new and different operations are in effect now; some of them have been perfected to some extent.

Mr. HARTER. I think that the whole thing turns upon just that question of perfection to some extent, and there my contacts with the various operations of the Commission lead me to feel that the degree of perfecting is a very great degree. I do not mean it has all been accomplished by any means. It is still a great part which yet remains, but it is a very significant difference to me in what contacts I have had between the state of the matter at the time the Commission took over and what has happened to it in this brief time.

Senator HICKENLOOPER. Did you have any intimate connection with the Manhattan District?

Mr. HARTER. No, sir.

Senator HICKENLOOPER. So, then, you are not in any position to judge what the state of perfection was in the Manhattan District except by hearsay.

Mr. HARTER. No; I beg your pardon, sir. I have an idea of certain processes carried on in a certain manner at the time the Commission took over the work.

Senator HICKENLOOPER. Yes.

Mr. HARTER. And I have some idea of the changes in the most important particulars that have been made in those processes.

Senator HICKENLOOPER. You are aware of the fact—are you not—that after the dropping of the bomb on Hiroshima, the whole Manhattan District went into a quiescent state, awaiting the establishing of a public policy by Congress as to how the matter would be handled?

Mr. HARTER. Oh, yes.

Senator HICKENLOOPER. So it was in what one might say was a semioperating state during that period until the method of operation had been determined by Congress through law in the establishment of whatever type of control Congress would decide to establish.

Mr. HARTER. Yes; I believe a recent witness described it as being "flat on its back."

Senator HICKENLOOPER. Yes. Well, perhaps he did. I think the description was one which could be subject to argument, but the fact is that the plant was there, and it was being held in abeyance in its operations until there was a determination of what the direction of operation would be, and the only purpose of questioning was to try to probe for a moment your suggestion that this entire plant had been built in the place 2½ years ago.

Mr. HARTER. I did not mean to give that impression.

Senator HICKENLOOPER. Yes.

Mr. HARTER. But I do want to bring out that what Manhattan finished with was for a single purpose, under great duress, accomplished under those conditions in a remarkable degree, but a very different and insufficient total purpose as against that which the Commission immediately took on as its duty.

Senator HICKENLOOPER. What company do you represent, Mr. Harter?

Mr. HARTER. Babcock & Wilcox Tube Co., a subsidiary of the Babcock & Wilcox Co. For most all my time I was in the former company until 2 years ago, when I retired from that.

Senator HICKENLOOPER. Was your company engaged in the past, or are you presently engaged, in any work for the Commission?

Mr. HARTER. I beg your pardon, sir?

Senator HICKENLOOPER. Has your company engaged in the past, or are you presently engaged, in any work for the Commission?

Mr. HARTER. We are doing some work for the Commission; and, compared with our operations, I suppose, it is a matter of a percent, a half percent, or something of that sort.

Senator HICKENLOOPER. I see. I think that is all, Mr. Chairman.

Senator VANDENBERG. No questions.

Senator KNOWLAND. No questions.

The CHAIRMAN. Thank you very much.

Mr. HOLIFIELD. No questions.

The CHAIRMAN. Thank you very much, Mr. Harter.

Mr. HARTER. Thank you very much.

Mr. LILIENTHAL. Dr. DuBridge was not in the hearing room at the time I indicated that he would be one of the witnesses. He is here now and prepared to testify.

He is, as I said, the president of the California Institute of Technology.

The CHAIRMAN. Dr. DuBridge, are you ready?

STATEMENT OF DR. LEE A. DuBRIDGE, PRESIDENT, CALIFORNIA INSTITUTE OF TECHNOLOGY

Dr. DUBRIDGE. Yes, sir.

The CHAIRMAN. Doctor, it is nice to see you again.

Dr. DUBRIDGE. It is nice to see you gentlemen. Would you like to have me start with a brief statement of my views on this whole question?

The CHAIRMAN. Yes; I think that would be quite desirable.

Dr. DUBRIDGE. I assume that I have been called because I am a member of the General Advisory Committee and, in particular, because I am the chairman of the Subcommittee on Research of the General Advisory Committee. For that reason I will confine my remarks largely to the Commission's activities in the field of basic research.

I would like, before coming to the Commission's activities, however, to say just a word about the position of basic research in science in this country. In my view, it is a very precarious position. We, as a Nation, are bragging a great deal about our scientific personnel and our scientific resources; but, as a Nation, we are doing very little about them to strengthen them still further.

The reasons for this situation are a little complicated. During the war the scientists of this country were mobilized into great war laboratories; and, as you all know, they were spectacularly successful in developing new weapons of war such as radar, the proximity fuze, and, of course, the atomic bomb.

As a result, there is a widespread feeling in this country that the only purpose of science is to develop weapons of war and that, therefore, science can be kept on a wartime footing.

Now, both of these assumptions are grossly untrue. The chief goal of science is not to develop weapons of war, but to understand nature. The knowledge of science is, and always has been, primarily used to improve the happiness and welfare of men; nor can science survive or thrive on a wartime footing. Science did not thrive during the past war.

On the contrary, science, as such, was stopped during the war while the scientists devoted themselves to developing weapons of war.

The developing of weapons of war, particularly under the stress of war, is a very different thing from doing scientific research. When the practices and techniques of weapon development are extended to pure science, science is stifled rather than strengthened. And yet it is a tragic fact, which bodes ill for the strength of science in this country, that the only Federal agencies today which are supporting to any large extent the Nation's program of basic science are the agencies whose primary function is a military one, namely, the National Military Establishment and the Atomic Energy Commission.

Now, both of these agencies have done a fine job in the supporting of science; but, since their interests are largely in military weapons, the areas of science they support are those related to military applications, and the methods that they are forced to use in such support derive more largely from the traditions of military development rather than from the traditions of pure science.

Therefore, I want to make, as a fundamental thesis of my remarks, the statement that the support of pure science, with which also goes the education of new scientists, is a totally different task from that of developing weapons of war and must, therefore, be treated on a totally different basis.

Now, to be more specific: I think it is obvious to the members of this committee that a strong base of pure science in this country is essential to national security. We were strong in the last war because we were strong in science. It will be even more important, if there should be another war, to have this strength to count upon.

Science is essential to national security. Nevertheless, when we attempt to extend to pure science the principles of secrecy which go under the name of security rules, we automatically suppress the progress of science. Therefore, secrecy imposed upon basic science is actually inimical to national security. Thus, we have the paradoxial situation that for greatest national security in the field of pure science there must be a minimum of the so-called security regulations.

It is unfortunate that this word "security" and the word "secrecy" have come to be regarded as almost synonymous. In the field of basic science, secrecy and security are neither synonymous nor even compatible. Unless these things are clearly understood, we will only have confusion when we discuss the program of the Atomic Energy Commission as it relates to the field of pure science.

May I come down more definitely now to the responsibilities of the Atomic Energy Commision in the field of pure science?

These responsibilities of the Commission are set forth fully in the McMahon Atomic Energy Act of 1946. You will recall that the Atomic Energy Commission was charged with three responsibilities: (1) for the development of atomic energy as a military weapon; (2) for the development of industrial applications of atomic energy; and (3) for the encouragement and support of basic science in fields related to nuclear energy.

I am personally very glad that the Atomic Energy Act does provide that the Commission shall lend its support to the development of pure science. Nevertheless, I am also cognizant that this responsibility is a most difficult one for the Commission to fulfill, because the policies which the Commission can and must adopt in forwarding its other two tasks are very different from the ones that it must adopt in forwarding basic science.

May I review briefly the history of the Commission's activity in the support of basic science?

When the Commission first took office, as you know, the atomic energy enterprise was in a precarious position, following the year and a half of uncertainty between the end of the war and the day the Commissioners finally took office.

The tasks of the Commission at that time, as I see them in order of their priority, were very clear cut; namely, first, the restoration of the bomb-development program at Los Alamos and the placing of this program on a firm foundation.

As other witnesses have already testified to you, this objective has been accomplished with superb success.

The second task of the Commission was to place upon a sounder footing the activities relating to the production of fissionable material. This meant removing the Oak Ridge and Hanford plants from a wartime footing, where speed was the primary consideration and economy and efficiency were secondary, and placing them on a permanent peacetime basis, with due regard to economy, efficiency, and stability.

Now, I am not an expert in the field of production of fissionable materials, but it is my firm conviction, from what I do know, that in this task, too, the Commission has met with great success.

Production facilities have been increased; production has steadily risen, and economy and efficiency have been successfully achieved.

The third task of the Commission was to build up the facilities for the development of atomic energy as a peacetime tool. This means primarily the development of methods for producing atomic power.

The Commission could not give adequate attention to this task until the first two were placed on an adequate footing, but during the past year or more enormous strides have been made in connection with this objective, the strengthening of the atomic power program; and this, too, can now be regarded as on a solid foundation and progressing most satisfactorily.

Fourth, the final task of the Commission, in order of priority—and I am neglecting a number of other tasks which I will not speak about—was the development of the country's facilities for research in science, in the field of nuclear science and allied fields.

In this area, the task of the Commission was twofold: (1) the development of adequate research programs in the Commission's own laboratories and (2) the development of many centers of research in universities and industry throughout the country.

Naturally, again, the Commission gave first attention to the research program in its own laboratories. I am not speaking here so much of the research at Los Alamos and Argonne and Oak Ridge, research which is incidental to the development of atomic weapons or nuclear power. Much research of this sort is, of course, necessary, and is being pursued on a large scale at those laboratories.

There are, however, two Commission laboratories which are primarily devoted to what we call basic research. These are the Radiation Laboratory of the University of California and the Brookhaven National Laboratory on Long Island. Neither of these laboratories is primarily concerned with atomic weapons or with nuclear power. Both are concerned with strengthening our basic knowledge in nuclear physics, in nuclear chemistry, in radiobiology, in metallurgy, and other fields which are related to nuclear science.

Now, both of these laboratories were actually established by the Manhattan District before the Commission took over, but during the last three years the Commission has been most successful in encouraging the growth of these laboratories so that both are now flourishing and are valuable assets to the country's scientific program.

It is unfortunate, though possibly inevitable, that certain secrecy restrictions have to be imposed on these two laboratories. At neither of them does the work, for the most part, have anything to do with the design or production or use of atomic weapons.

However, at Berkeley, there is some work on the chemistry of fissionable material, and at Brookhaven, one of the chief facilities is a nuclear reactor, whose design is still classified. Practically all the other activity at these two laboratories is unclassified and is freely published and freely discussed, as it must be if these laboratories are to make a contribution to science.

Yet, because of the small amount of classified work, secrecy restrictions must be imposed even at some cost in speed and the effectiveness of the work.

This situation, I say, although unfortunate, is at the present time inevitable. I would, however, like to pay tribute to the Commission for the wisdom it has shown in providing, as far as is possible within security requirements, for the atmosphere of freedom in both of these laboratories, which is most essential to their success.

I would like now to come to the final aspect of the Commission's responsibility in the field of basic research, namely, the stimulation of research throughout the country in fields related to atomic energy.

Science is not strong solely by having one or two large laboratories. Its strength grows from a widespread interest at many centers, by many individuals. Also, science will stay strong only if there is an extended program of training of new scientists. Consequently, the Commission early recognized as a part of its task the stimulation of university centers of research and of teaching in the field of nuclear science.

The General Advisory Committee, of which, as I have said, I am a member, has always had a very keen interest in the Commission's activity in strengthening research at universities. This is partly because many members of our committee are university scientists themselves, and it is partly because the General Advisory Committee is charged under the law with advising the Commission with respect to scientific and technical matters.

University research is an area in which we feel competent to advise. We were quite cognizant of the fact that the Commission was unable to take any strong forward steps toward the encouragement of basic science in universities during the early days when it had more urgent tasks to perform. Even so, we, on the committee, on various occasions, gently, I think, reminded the Commission that sooner or later they must direct themselves to this task. They have now made a number of most important moves in this direction. The first one was to continue and strengthen the program which was initially established by the Manhattan District relating to the distribution of radioactive isotopes manufactured in the reactor at Oak Ridge.

It happens that I was asked by General Groves back in 1945 to serve as chairman of what he called the Interim Advisory Committee on Isotope Distribution, at the time when the program was being established, shortly after the end of the war.

General Groves felt, very wisely I believe, that the Manhattan District could make an important contribution to the development of science in this country by providing recognized scientific laboratories with radioactive isotopes which they needed in their research and which could be supplied from the Oak Ridge Laboratory.

Our Interim Advisory Committee set up a suggested program and a set of suggested policies to be followed in allocating these isotopes, and this program and these policies were adopted by the Manhattan District.

The Interim Committee recognized that in the initial stages the program would need to be a restricted one with only a few isotopes available, and the distribution policies would need to be on an experimental basis. But, as time went on, and as the needs for the isotopes increased and the ability of Oak Ridge to produce them increased, we proposed that the distribution program be gradually expanded, as, of course, it was.

When the Atomic Energy Commission took over, this Interim Advisory Committee was continued for a time, and in line with its recommendations the isotope distribution program was gradually enlarged. Eventually, after the Commission got fully organized, it appointed a permanent committee to advise on this matter, and, because of my own membership on the General Advisory Committee, I withdrew from the isotope advisory group.

As a member of the General Advisory Committee, however, I have followed the isotope distribution program with some interest up to the present time.

As you know, our committee has been asked to advise the Commission on this isotope distribution program, and the position of the General Advisory Committee on this subject has been outlined to you in considerable detail by Dr. Oppenheimer, our chairman. I wish only to add to Dr. Oppenheimer's testimony, that I agree fully with what he has said, and that I believe the isotope distribution program has been an extremely valuable one and has been, on the whole, very wisely administered, and that it has made a most important contribution to the progress of science.

I believe, also, that the distribution of isotopes abroad was a wise move under the conditions under which the foreign distribution was set up. The knowledge of science knows no national boundaries, and the developments of science in Europe will have just as great a value to us as to any other country; indeed, probably a greater value because we have greater technological facilities for making use of new knowledge that opens up in the field of science.

The distribution of radioactive and, later, of stable isotopes to research laboratories in this country and abroad, then, was the first step which the Commission took toward the strengthening of basic science.

A second step of great importance was taken when the Commission entered into a cooperative agreement with the Office of Naval Research for the joint support of projects in nuclear physics and in biology and medicine.

The Office of Naval Research, as you know, has taken a keen interest in the development of basic science in this country since the war. In recognition of the important role which science played during the war in the development of our military strength and the important role which it will play in any future conflict, the Office of Naval Research has taken that keen interest.

The demands upon the Office of Naval Research, however, were much greater than its budget would allow it to fulfill, and the contribution of the Atomic Energy Commission to this program was of far-reaching value.

A very large share—and this is not often realized—of the basic research in nuclear physics which is now being carried on in the universities of this country is supported by the joint Office of Naval Research-Atomic Energy Commission program.

A third step taken by the Atomic Energy Commission in support of basic science was the direct support, through contracts of its own rather than the Office of Naval Research, of university research projects.

I personally believe that the Atomic Energy Commission would have been wise to have initiated this program of direct support at an earlier date than it actually did. However, I also understand the reasons why this was impractical in view of more urgent tasks.

Fortunately, the cooperative program with ONR enabled the Atomic Energy Commission to get its feet wet in this field while it was setting up for itself a suitable administrative organization to handle the problem more directly.

I believe that the Atomic Energy Commission's direct support of research projects in nuclear physics, in nuclear chemistry, radiobiology, and other fields is of very great interest to this country for the following reasons: (1) These activities, these research activities, greatly need more financial support than the universities themselves are able to give. The university budgets are hard pressed because of rising costs in every area, and research in many of these fields requires expensive facilities which the universities themselves cannot afford; (2) a strong program in these fields is important to national welfare, and it is appropriate that an agency of the Federal Government should take responsibility for encouraging progress in these areas; (3) the atomic energy program itself, because it depends heavily on science and technology in many areas, greatly needed the support of and the contacts with basic science. In the long run, progress in the atomic energy field will depend very critically on the basic research program of the country and the new knowledge which this program will uncover; (4) it is wrong for the sole Federal support of basic science to come from a military agency, even one such as the Office of Naval Research, which has shown exceptional wisdom in administering its program.

The CHAIRMAN. Who is the director of that?

Dr. DUBRIDGE. The Office of Naval Research is now headed by Admiral Solberg, and the scientific director is Dr. Alan T. Waterman, and they have quite a capable scientific staff in various fields to assist them.

Universities and scientists feel more comfortable in having also a civilian agency with which to work and which can lend support, such as the Atomic Energy Commission.

Finally, the Atomic Energy Commission is specifically charged with the encouragement of basic science in the Atomic Energy Act of 1946. I firmly believe that one of the best investments the Federal Government could make would be to allow in the Atomic Energy Commission budget a sum of not less than $25,000,000 a year for the direct support of university programs in basic science in fields related to the Commission's responsibilities.

A final step taken by the Commission in fulfilling its responsibilities for the support of science was in the establishment of the National Research Council fellowship program. With this program, of course, you are all familiar.

I wonder, however, if you are familiar with the long history of the National Research Council's fellowships. As you know, these were first established through a grant by the Rockefeller Foundation back in the early 1920's, and at that time the National Research Council picked the most promising of the young Ph. D.'s in science each year and provided them with stipends in research funds which they needed to continue their studies at a research center in this country or in Europe.

A very large share of the leading active scientists of today got their start through National Research Council fellowships. For example, Dr. Oppenheimer was a National Research fellow in 1927 and 1928. Dr. Ernest Lawrence of the University of California was a National Research Council fellow from 1925 to 1927. Dr. H. D. Smyth, now a member of the Atomic Energy Commission, was a National Research Council fellow from 1921 to 1924, and I am glad to admit that I am prejudiced in this matter, since I, also, was a National Research Council fellow from 1926 to 1928.

Mr. HOLIFIELD. Dr. DuBridge, may I interrupt you there?

Dr. DUBRIDGE. Surely.

Mr. HOLIFIELD. We have had, as you know, quite a sensational situation develop among these fellows in regard to the granting of a fellowship by the National Research Council to one Hans Freistadt.

Dr. DUBRIDGE. Yes, sir.

Mr. HOLIFIELD. Who was an open and avowed Communist.

We have had under consideration, of course, the wisdom of extending this service which the Atomic Energy Commission has been able to extend through this National Research Council to these boys, giving them this opportunity, and the wisdom of continuing this has been quite sharply questioned in view of the fact that we are, in effect, in the case of Freistadt, in his case, for instance, expending taxpayer's money to people who are not in accord with our form of government and are in sharp discord with it, you might say.

The question I wish to address to you is this: Do you believe that it is possible for the Atomic Energy Commission to continue the fellowships in the field of nonsecret research, basic research, without the onus that will come upon the Commission's work as a whole in cases that develop such as the Freistadt case?

Dr. DUBRIDGE. I think the National Research Council fellowship program is a most important part of the Commission's activities. I think it would be most unfortunate to the Commission and to the country if this fellowship program should be abandoned.

Mr. HOLIFIELD. You are speaking of the field of nonsecret research?

Dr. DUBRIDGE. Exactly.

Mr. HOLIFIELD. Of course, in the secret field now we require the FBI clearances.

Dr. DUBRIDGE. That is right.

Mr. HOLIFIELD. Now, about the FBI clearances in the nonsecret fields.

Dr. DUBRIDGE. I will restrict my remarks to the education of scientists in fields which are not secret.

Mr. HOLIFIELD. Yes.

Dr. DUBRIDGE. To place restrictions on the choice of fellows in those fields, restrictions which would adversely affect the research-fellowship program I think would be a very bad thing for the country and a very bad thing for science.

To answer your question specifically, I think that the initiation of an FBI investigation for all of these youngsters, students, who are being considered for fellowships would be a very bad thing for the country. To extend secret investigations by the FBI to students, undergraduate and graduate, throughout the country, inquiring among their young friends and relatives about their political beliefs, associations, and affiliations would be a very disrupting influence.

It would bring the basic ideas of a police state into American youth. I think this would be a very unfortunate thing, not only to the fellowship program itself, but for the country as a whole.

Mr. HOLIFIELD. You think that the calculated risk that we would be taking in educating an individual who might eventually be disloyal to the country would be justified in relation to the amount of good that would be accomplished by the hundreds of young men who could enter the field of basic research and receive assistance, that the good which would be accomplished would far outweigh the small percentage of bad that would occur in isolated cases such as the Freistadt case?

Dr. DUBRIDGE. I firmly believe that. If it is Government money you are worried about, it would cost thousands of times as much to investigate everybody as to pay a few hundreds to a few Communists, even if they did get in. But it is not the matter of money so much, I think, as the principle of the thing; and to extend political investigations to young students working in nonsecret fields where there is no question of national security involved at all I think is contrary to American principles of democracy, and we should not enter into it. We should take this small calculated risk.

Mr. HOLIFIELD. You have no objection to the loyalty oaths that are required, do you?

Dr. DUBRIDGE. I have no objection to it, except insofar as it might be a first step toward going further. I think the loyalty oath is a piece of paper which has very little meaning. It will eliminate an occasional naive youngster who is quite willing to admit he is a Communist and still thinks he can be loyal to this country.

It will not eliminate the really dangerous, subversive Communists, who are quite willing to perjure themselves if they think it to their advantage to do so.

Therefore, we will soon find the loyalty oath is not eliminating the possibility, at least, of having subversive Communists apply and possibly receive these fellowships. So it will be reasonable to say: Shall we not go a step further? And a step further will be made and that, in turn, will be found to be inadequate, and pretty soon we will have the whole FBI machinery investigating these youngsters again.

So what I am afraid of—while I oppose communism and do not like to see Communists in the fellowship program, I am still more afraid of the methods which would have to be adopted to prevent this. There will only be occasional ones, and I think the methods which would have to be adopted in order to prevent this are far more dangerous than the small risk of having an occasional Communist on the fellowship rolls.

Mr. HOLIFIELD. You know that the public is somewhat confused as to the differentiation between the nonsecret and the really vital secret work, and it is hard, I think, to get to the people the real differentiation between those two programs of study. Therefore, it seems to me that this field of nonsecret research, while I am heartily in favor of it and I believe it could be carried on personally in the manner in which it has been carried on, but it seems like because of the explosive public opinion, which is attached to anything having to do with the atomic energy program, it might be necessary to disassociate that field of research from the Atomic Energy Commission and place it, for instance, in a National Science Foundation, which we hope to establish.

Strictly from the standpoint of yielding with the gale of misunderstanding, which is abroad in the land, and the hysteria which is abroad in the land, not from really a logical standpoint, that is.

Dr. DUBRIDGE. I certainly hope that the National Science Foundation will be promptly established. When there is such a foundation to provide fellowships and to provide support for the basic research in all fields of science, that will relieve some of our problems. However, I think for us to retreat in the face of a public misunderstanding from a most valuable program, which is most appropriate and indeed very important for the Atomic Energy Commission to pursue, I think to retreat from that program in the face of pubic misunderstanding would be unwise. I would rather try to correct the public misunderstanding and make it clear to the public, if we can, that 99 percent of the so-called field of atomic science is just as nonsecret as biology or medicine or agriculture or metallurgy or seismology or what have you, and there are no more reasons for extending into this vast nonsecret area of atomic physics secrecy and security regulations than there is to extend them into the field of biology, medicine, agriculture, and these other fields.

I think it is worth while to make an effort to make the public understand that and to bring this point out sharply in our discussions, so that when the Commission is operating in these nonsecret fields, it has the same policies that are always adopted in the encouragement of science in nonsecret fields. When it is operating in secret fields, it adopts the policies appropriate to secret work.

Mr. HOLIFIELD. Notwithstanding the technical approval which the Commission exercises and must exercise in the approving of these fellows, it is true that the real responsibility lies among the Board of the National Research Council, and it is true that they are following practices and procedures which they have followed for years in selecting these brilliant young men for special training.

Dr. DUBRIDGE. That is right. And that set of policies and procedures which the National Research Council has followed for nearly 30 years now has proven its value by its results. As I have said, a large share of our scientific strength at this moment in this country has been built up through these National Research Council fellowships. I think it is wise to continue and expand them because we need them even more today than we did in 1925.

Mr. HOLIFIELD. It is perfectly possible that if some of these brilliant men that have been educated in these fellowships, if their political and economic views should have been questioned in the days when they were immature, struggling young scholars, that they may have been eliminated by a rigid loyalty questionnaire program.

Dr. DUBRIDGE. It is perfectly possible, and it is very fortunate that such inquiries were not made at that time. You never can tell where brains will arise. They may arise in association with very curious political ideas, but brains are a national asset, and we should encourage them and support them wherever they are found.

I do not like also, as I think a previous witness indicated, the idea that we are doing a favor to these fellowship candidates by giving them a fellowship. We are doing a favor to the country by developing their skills and their brains in the field of science. The country needs those brains and the country is getting a good bargain in spending money to train these men who will be important in the future leadership of science.

Mr. HOLIFIELD. One relatively small scientific discovery by one of these young men in actual monetary value would far outweigh the cost of the program?

Dr. DUBRIDGE. Precisely.

Senator MILLIKIN. I would like to suggest to the doctor that as to whether or not the investment is well made depends on how the young men turns out and how he turns out may have some relationship to his viewpoint.

I would like to suggest also that there is no right in any citizen of the United States to have a fellowship. I wish to take sharp issue with you on that. There is no right in anyone to have a fellowship.

The United States, which spends the money, has the right to set the standards by which those men will be chosen. The people of the

United States may be very wrong and they may be misinformed, as has been suggested, but they have the notion, for which considerable support can be developed, that the United States should not be spending the taxpayers' money to educate anyone who joins a conspiracy against the United States. Now, that is a sort of grass-roots notion, it may not appeal to straight logicians, it may have some defects under some sophisticated philosophy, but the average fellow in the United States has the notion that the taxpayers' money should not be spent to educate people who are in a conspiracy against the United States.

Now, then, in spending that money—and since that is the basic feeling, and I share that feeling—since that is the feeling, we are entitled to take those steps which are necessary to eliminate the youthful, the middle-aged, or the aged conspirators. It is just that simple.

Now, maybe the Communist oath will not do it. I am inclined to agree with you that if a man is a Communist, a real Communist, he does not pay any attention to the oath; but certain people are finding that the crime of perjury has certain perils to it, and it may act as a deterrent, which is a useful thing when you are trying to keep bad people out of any service. It builds up some of the odds against the ease with which people can join these services for conspiracy purposes.

Now, I am curious about the FBI business. I have no opinion on whether there should be an FBI investigation, but let me ask you bluntly: What is wrong with an FBI investigation so far as this particular purpose is concerned? That is, of determining who we want to have in the fellowships.

And in that connection, Doctor, I remind you we are not engaged in a shotgun educational process; we are giving these fellowships to men who work in nonsecret fields preparatory to the secret field. We are not just educating scientists on a shotgun basis. We are educating these fellows to prepare them for secret work.

Of course, we all hope by the time they are educated we will no longer have the menace of war and that there will be no occasion for secrecy, but until we get rid of that, we have to govern ourselves accordingly.

What do you have to say about that?

Dr. DuBridge. You brought up two or three points.

Senator Millikin. Take them one at a time.

Dr. DuBridge. You say that the purpose of this program is to educate scientists for secret work. That was not my understanding of the purpose of the program.

Senator Millikin. I suggest to you, Doctor, that it follows just from a statement of the matter that the Atomic Energy Commission has no authority to engage in general educational campaigns for the aid of science.

Dr. DuBridge. But it is charged with the encouragement and support of basic science, and with the stimulation of training of scientists in fields related to the field of atomic energy.

Now, as I have just said——

Senator Millikin. If I may interrupt, I would suggest that is a pretty big tent. I suggest any part of the general field of science has some relation to the field of atomic energy. The business of the Atomic Energy Commission is to concern itself with atomic energy.

We cannot sophisticate that off into thirty-second-cousin activities. The purpose is to educate men who will be useful in the field of atomic energy, not other fields, not too distantly related fields.

Keeping that in mind, the purpose obviously is to educate men in nonsecret work with the ultimate idea that if secrecy is then necessary, that they will be available for secret work.

What is the use, then, if that be true, of being careless about the kind of fellows that you bring into nonsecret work?

Dr. DuBridge. I think the basic purpose of the fellowship program probably is the real question that is before us. As I said, I did not understand that the sole purpose was to educate men for secret work, but a part of the purpose was to educate men to strengthen those fields of science which have some relation to atomic energy and which are not now and may never be secret fields.

One can never predict in what field of science a result of very great importance to atomic energy may arise.

Senator Millikin. And one cannot predict, Doctor, which one of these fellows you might want to put into secret work.

Dr. DuBridge. That is right. When he goes into secret work, obviously, you must then clear him. There is no question, I think, about that.

But it seems to me that carrying out the clearance during his student days is unnecessary and undesirable.

Senator Millikin. Let me get it down to brass tacks. Why spend the money on someone who might not be cleared when the day of clearance comes?

Dr. DuBridge. Would you rather spend a hundred thousand dollars in clearing everybody than spend $1,000 in a stipend to one?

Senator Millikin. I would rather spend a hundred thousand dollars or several times a hundred thousand dollars to keep any conspirator against the United States Government out of the field of atomic energy. Put your own dollar sign on it. Write your own check on that.

Dr. DuBridge. I would agree if you are talking about the secret fields of atomic energy, that we should spend any amount of money to keep subversive influences and disloyal influences out of those fields, but I think it is very difficult to initiate a program which is guaranteed to keep them out of any field, nonsecret field, which is within the scope of the Atomic Energy Commission's activities as set forth in the law.

Senator Millikin. Now, let us take the FBI investigation. Those who object to the FBI investigation in most instances do not object to the oaths. There is a certain inconsistency there, but we will pass that.

Now, you tell me what is wrong with the FBI investigation. I would like to have someone make an intelligent comment on it. You said awhile ago that it introduces the police state into the life of the young men. Doctor, it might be better to introduce a police state into the life of some of these young men than to have a police state introduced to the whole United States.

Dr. DuBridge. The FBI investigation, as you know, involves a secret inquiry among friends, relatives, associates, about an individual's political beliefs, his political activities, all of this must be done on a secret basis. The men and women who make statements about the candidate remain anonymous. They can make statements without being under oath, without being known to the candidate, and while all of this may be necessary in clearing people for secret work, I just do not think that this is a part of the American democracy in nonsecret fields in education or in any other activities that have nothing to do with national security as such.

Senator MILLIKIN. If the secret fields were not connected with the nonsecret fields, I would gladly and quickly agree with you.

Dr. DUBRIDGE. Then the question boils down to how you are going to separate the nonsecret fields from the secret fields. I judge what you mean, therefore, is that the areas which the Commission is charged under the law with supporting must be connected with the secret field. But there is an enormous amount of work in areas related to biology and medicine and nuclear physics, to chemistry, and so on, which the Commission is charged with supporting under the law, which has either immediate or remote connection to a secret area.

Furthermore, there are other areas of science whose connection to atomic energy we may not even know about. As soon as you start getting outside the secret fields at all and say that because there is a connection, we must extend the FBI clearance, pretty soon you have the whole field of science and education under it.

Senator MILLIKIN. Let us assume that the student is not preparing himself for a secret field. Let us assume we could tell in advance that this particular fellow will not be in a secret field. I still suggest to you that the American people might not want to give a fellowship to a fellow who joins a conspiracy against his country to work in a nonsecret field. They might not want him to have a fellowship.

As long as they are spending their own money, they have the choice of the kind of fellows they want to educate.

Dr. DUBRIDGE. I realize there is this feeling. I think it is an unfortunate feeling, not because I do not share in a sense the distaste for giving money to a man who is a member of the Communist Party, but I think that the methods that must be adopted to be sure we prevent that are far more dangerous and more distasteful than having an occasional Communist receive a Government stipend.

Do you know how many Communists receive Government stipends through the GI scholarship program? I do not, and we did not inquire. Mr. Freistadt did receive a GI scholarship. As far as I know, nobody complained at that time or even complains now about that fact.

Senator HICKENLOOPER. That is a different philosophy entirely.

Dr. DUBRIDGE. That is giving Government money to a Communist, which is what we are talking about.

Senator HICKENLOOPER. The GI educational bill is based on the theory of an earned stipend. It is the payment for something that has been earned prior to that time.

Dr. DUBRIDGE. I would think a national research fellowship is also an earned stipend, based upon the fact that the man has brains and ability of value to this country and it is to this country's interest to educate him. He has earned this education by his ability, as proven in his previous work, and he is doing a service to the country by training himself.

Senator MILLIKIN. There, Doctor, we have a clean-cut issue.

Dr. DUBRIDGE. I think that is where the issue arises.

Senator MILLIKIN. He has not earned it until he has earned it, and it depends on what kind of a bird this fledgling becomes after he gets over the pinfeather stage and develops his wings and starts to fly. Then we can say he has earned it. We cannot say it before, I suggest.

Dr. DuBridge. It is a question of the definition of "earning." When we find bright young fellows in the country and educate them for the national welfare, it seems they are on the same basis as the GI scholarship.

Senator Millikin. I think Senator Hickenlooper has demonstrated the fallacy of that distinction. But, in addition to that, there is still another fallacy, and that is the inescapable part of this discussion—that we are dealing in the field of atomic energy and that we were not giving GI scholarships to deal necessarily in the field of atomic energy.

Now, what is wrong, what is this harmful thing resulting from the FBI investigation, which becomes all right when the man starts to enter secret work but is not all right when he is in nonsecret work preparing possibly for secret work?

Dr. DuBridge. Simply that the secret areas of science are very small, a tiny fraction of the whole area of science; and if the blanket of clearances and security regulations and secrecy, which need to be imposed on the secret areas, are extended to the whole area of science, you are going to have a very big blanket, indeed.

Senator Millikin. The whole area of science will not be covered by those who get fellowships.

Dr. DuBridge. You have already suggested that the National Science Foundation fellowships, for example, would be giving Government money to Communists unless there is an FBI investigation.

Senator Millikin. I did not suggest that.

Dr. DuBridge. It was suggested in a previous discussion. As soon as you say that even in nonsecret fields FBI clearance must be essential if it is a Government fellowship, then you find that Public Health scholarships, National Science Foundation scholarships, Agriculture Department scholarships, would have to come under the same regulation, and I do not like to see that blanket extended beyond the secret field.

Senator Millikin. I do not like to see it, either. I do not like to see it in this field. I hope the day will come when we do not need secrecy at all; whereupon we will all be more happy. But in this field of atomic energy, where we are training men for nonsecret work to start with and possibly secret work thereafter or in ramified related subjects, I would like to have your reason why there should not be an FBI investigation in terms of the damage that such an investigation does, if you please, to science, or, if you please, to the young man.

Dr. DuBridge. The damage which it does is the damage not only to the individual, but to the country in extending FBI secret investigations to a large area of American life and, particularly, to American youth.

Senator Millikin. How large would that area be?

Dr. DuBridge. There are now 500 National Research Council fellows, I think, in actual residence at universities.

Senator Millikin. Do you call that a large segment of American life?

Dr. DuBridge. There have been hundreds of others who have applied.

Senator MILLIKIN. Would it be a large segment of American life?

Dr. DuBRIDGE. Yes; a very large segment.

Senator MILLIKIN. What is the figure? You are a mathematician, and I want to get your idea of mathematics. Put your top figure on the number that would be involved.

Dr. DuBRIDGE. You are speaking now of only those who would be involved in the Atomic Energy Commission activities?

Senator MILLIKIN. That is right.

Dr. DuBRIDGE. I assume that there would be possibly a thousand a year.

Senator MILLIKIN. Call it a thousand a year. We have almost 150,000,000 people in the United States. Do you call that a large segment of American life?

Dr. DuBRIDGE. It is a fairly large segment, since it includes many universities throughout the country, in all parts of the country; it includes not only the applicants, but their friends and their associates who will be interviewed by the FBI.

Senator MILLIKIN. Multiply it, Doctor, by five and you still would not have a large segment of American life. There is a considerable segment of American life that is not involved in scientific matters.

Dr. DuBRIDGE. That is true.

Senator MILLIKIN. And they are the producers who produce the money that enables us to carry on this scientific program. They are interested in this business. You had better give some attention to them.

Dr. DuBRIDGE. I have given very careful attention, and I think the investigation and the interviewing of thousands of American students at universities throughout the country—I think it is a large enough segment of the youth of this country to give us cause for worry.

I would not like to see secret investigations extended so widely when it is dealing with nonsecret work, because that opens the door to extending it still more widely.

Senator MILLIKIN. Doctor, you have extended it argumentatively. I have not extended it. I am talking about atomic energy.

Dr. DuBRIDGE. That is true, but the same arguments you give would then later be used for further extension, and I am trying to dig a trench right here.

Senator MILLIKIN. Let me suggest, Doctor, you let us worry about that when the first extension develops. We are talking here, this inquiry concerns itself with atomic energy. I think all of us are aware of the implications of secret investigations. We do not want any more of it than is considered to be necessary.

I am trying to develop from you: How is this young man harmed by an investigation that will determine whether or not he has joined up with something that represents a conspiracy against this country?

Dr. DuBRIDGE. The harm comes from the very considerable number of perfectly honest and loyal men who will be disqualified on evidence which is quite inconclusive and possibly even wrong.

Now, during the war I saw many people, honest and loyal men, disqualified for employment in war programs on misunderstandings, on incomplete information, on misunderstood information, on all sorts and kinds of information, some of which might be true and some of which the truth could not be verified. There will be a large number of perfectly loyal and able young Americans who will be disqualified. That will be a very serious matter to them.

Senator MILLIKIN. This inquiry indicates that the Commission is not harsh in judging these FBI files. The Commission will evaluate the FBI files. Therefore, the responsibility will be in the Commission's hands, and one of the criticisms—and I am not passing on it at all—in this hearing is that the Commission has not been harsh, that it has been excessively liberal in this clearance.

So when you have considered that fact, together with the very small number of those who might be subjected to suspicion, you are dealing with a very small segment of American life. That does not mean that that small segment should be persecuted, that it should be denied any rights it has. I am quite a crank on that subject. But it is a small problem in relation to an enormously important subject.

Dr. DUBRIDGE. But all big things have small beginnings. I am afraid of the results.

Senator MILLIKIN. Let Congress worry about the ramifications.

Dr. DUBRIDGE. I hope they will.

Senator MILLIKIN. I suggest we keep our minds on the purpose of this inquiry.

Dr. DUBRIDGE. Yes. I think there is a clear difference in point of view here, and I do not know whether I can say anything more to clear it up.

Senator MILLIKIN. I hoped that you would convert me, Doctor.

Mr. HOLIFIELD. Dr. DuBridge, the part with which I am concerned, along the line of your reasoning, is that there is a great area of science which is nonsecret, in which discoveries can be made without any danger at all to the Nation in any way, but those discoveries that are made in the nonsecret field might become very valuable in application in the secret field.

Dr. DUBRIDGE. That is right.

Mr. HOLIFIELD. And if you stultify the nonsecret field, then you preclude to a certain extent the possibility of making tremendously important scientific discoveries, say, in the field of chemistry or metallurgy, which are in the nonsecret field as far as those two sciences are concerned, but the application of that discovery in the construction of machinery, in the construction of the mechanism of the bomb later on might prove of inestimable benefit in the secret field.

I think that is the part that is unclear in the minds of the people, that there is this tremendous area where important discoveries can be made for the benefit of the 150,000,000 people, but also which might have a very direct application in the science of atomic energy for weapons.

Is that not true?

Dr. DUBRIDGE. I agree with you completely. I think that is one reason why it is the Commission's responsibility to encourage the development of these nonsecret fields. You cannot tell where an important discovery will arise.

Furthermore, the Commission's own strength for the future will be undermined when these FBI investigations come in, if they do, because an individual, a bright individual, who might have an interest in nuclear physics, when he finds that as soon as he gets into that field, he is going to be investigated by the FBI, he is going to be regarded as a dangerous character, he will simply say, "Why should I bother to go into that field? There are other fields of science."

So that the field of nuclear physics might be weakened by diverting the best brains of the country to other fields which might not be so critical to national welfare. As a matter of purely self-concern for the national welfare, we ought to encourage the best brains to go into this.

Mr. HOLIFIELD. On the mathematics, the relation of the thousand students to the 150,000,000 people, I submit that is a clear misapplication of logistics. The application, it seems to me, should be the thousand young men to the number of people engaged in scientific research.

Dr. DUBRIDGE. Right.

Mr. HOLIFIELD. That is the comparison, the legitimate comparison.

Now, if the figure of the thousand young men is 10 percent or 5 percent of those engaged in basic research, then that is your comparison with which we are concerned.

Dr. DUBRIDGE. That is right.

Mr. HOLIFIELD. It might be interesting to bring up at this point that already this thing is spreading and in the House an attempt is being made now to write this thing into the National Science Foundation bill. How far it will go on the floor of the House by some hysterical Member, I do not know. He may demand a complete FBI investigation of every individual who participates in the National Science Foundation, a complete FBI clearance.

The danger of the spread, as you have pointed out, is the thing with which we are concerned.

Dr. DUBRIDGE. I think that is cause for very deep concern. This would be an opening wedge. Every disaster has started in a small way.

If you look at the early days of the Nazi regime in Germany, some of their earliest activities seemed relatively harmless at the time, but they were the opening wedge.

Mr. HOLIFIELD. They eliminated the Society of Masons in Germany and then the labor unions. They went from one thing to another and finally liquidated everyone who opposed naziism.

Dr. DUBRIDGE. That is right.

Senator HICKENLOOPER. I might suggest to Dr. DuBridge that what he has just said is extremely significant. They do start in a little way, and it is the infiltration of those who conspire against the United States who start in a small way and who are brushed off with an indifference and the statement that their belief in communism is not inimical to the general broad picture of the United States—it is that very thing of infiltration that lays the basis for the success of the conspiracy later.

Dr. DUBRIDGE. That is perfectly right, Senator Hickenlooper, and I did not suggest that the FBI should reduce in any way its activities for getting after subversive Communists wherever they are found. It should trace down Communist organizations; it should bring to the light those who are engaged in subversive activities. That is a job which the FBI should be continually pursuing.

Senator HICKENLOOPER. When they do, there is a very vocal segment in this country which begins to pooh-pooh and belittle the FBI's investigation, that begins to resist them, that begins to defend these subversives who are uncovered, and, unfortunately, we are too apathetic about it, in my judgment.

Dr. DuBridge. I do not defend that point of view.

Senator Hickenlooper. I am not suggesting that to you as an individual at all. I want to make that clear.

Dr. DuBridge. When proof is brought out by the FBI about subversive activities, I think all normal legal channels for punishment or elimination of such dangerous individuals should be found, but I am saying, to find such individuals in the student field, the field of fellowships, involves the bringing in of an FBI investigation in a sweeping way, which I think is dangerous to American democracy.

Senator Hickenlooper. I may say this, Doctor, as I have repeatedly said: I have favored the fellowship program, and I still favor the fellowship program, of the Atomic Energy Commission. It is the administration and the methods of selectivity that I oppose; and, also, I was surprised to learn that they were going into all fields of basic science, which was not my understanding of the justification for the fellowship program.

It was my early understanding that the justification for the fellowship program of the Commission was to educate likely young scientists who would form a reservoir which eventually can be dipped into from time to time as the need arose to further the vital things of atomic energy.

There I have disagreed—that is my understanding—from what apparently now is the policy. But I shall not support the elimination of the fellowship program from the Atomic Energy Commission's activities. I believe in it, and I think it should be operated. It is the selectivity and perhaps the scope that I have been somewhat confused about.

Now, I would like to ask you this: There are various types of science. We have laid great emphasis on the physical and the exact sciences here, but I am wondering if there is not a greater science.

Dr. DuBridge. If there is not what?

Senator Hickenlooper. I am wondering if there is not a greater science from the standpoint of immediate importance than all of the rest of them, and if that is not the science of government.

In other words, government can close every laboratory in the United States or in the world. It has closed the laboratories to free thought and free investigation in other places. Government can close the doors of every church and religious and moral institution in this land if it gets out of hand.

The science of government, while it may go wobbling down the road, first to the right and then to the left in various ways, nevertheless, the science of government is the thing that keeps the laboratories open and free and keeps research available for the advancement of people.

Now, in our Government we do not believe in nurturing people in the Government activities who conspire to destroy the very system that we want to keep alive. It would seem to me that in science there would be a similar resistance among the scientific people themselves to the nurturing of people whose conspiratorial attitude is to destroy the very free system which keeps their laboratories open.

Dr. DuBridge. That is right, and there is.

Senator HICKENLOOPER. I believe there is. I have said repeatedly that scientists have done perhaps as patriotic and grand a job as has ever been done by any group so far as their contribution is concerned, but I cannot defend any philosophy that opposes the greatest reasonable selectivity of people who go into science in order to keep out of that field—that is, at Government expense—people who, as Senator Millikin said, are members of a conspiracy, which will not necessarily destroy science as such, but will destroy the system that keeps science free.

It would seem to me that that is a very important thing in our attitude toward beliefs of this kind.

Dr. DUBRIDGE. I hope you do not feel that any statements which have been made by scientists or by myself on the question in regard to this FBI clearance is in any way an attempt to defend Communists or defend communism as such or defend subversive activities of any sort. None of us wish to defend those things.

We believe there are mechanisms in our Government for hunting out offenders and taking proper methods of punishment or elimination of them from this country, the elimination of such offenders, but we feel hysteria caused by a fear of Communists in this country can introduce into our own democracy some of the very things we do fear in communism, namely, the police-state methods, the review of political opinions, the purge of scientists and the purge of other people, too, on the basis of political ideas.

How many of these people who are said to be Communists or fellow travelers—and incidentally, the terms are not very clearly defined—simply have a sort of political feeling usually on the basis of youthful naivete that here is something new they wish to explore because it has some attractive features?

They will get into it and get sick of it in a couple of years and be out of it and be better and more loyal American citizens perhaps as a result of their practical introduction to communism and the Communist conspiracy. It is not as though these people are permanently tied up and are forever subversive citizens. They may not be. If they are, they should be investigated by the FBI, and they should be brought through the normal legal procedures for necessary punishment for any illegal or subversive action. But let's not extend police-state methods to a large section of American life in the hysterical fear that one or two such fellows are going to overthrow the country. I do not think they will.

Senator HICKENLOOPER. I think that minimizes the problem considerably, and probably minimizes the entire pattern of Communist infiltration.

But there is another matter that I want to mention. I think the chairman has to leave very shortly, and I want to hurry along.

There is the suggestion that the only people who will make discoveries—I do not mean to say it has been made flatly that way, but the idea that the only people who will make great discoveries in this field are those against whom some background information is bad. It seems to me that out of the 500 young men—and that is infinitely more than the Rockefeller Foundation and all of the rest of the foundations put together have been able to place in the last few years, anyway—it seems to me that in those there is a comparatively small handful of people, I would say a very, very small number, indeed, who might be questionable.

But I also suggest this to you: That every time some person with a questionable background is given a fellowship some other young American against whom there is nothing is precluded from having a fellowship.

So far as the investigations we have had on the background, let us say of the Freistadt case which has been mentioned here, we find that he was not an exceptional student. He was a brilliant man, but he was not at the top of his class. He was down somewhat. One professor rated him among the top 10 percent; another said in the top 25 percent of this group, indicating that he was not an exceptional or a unique student at all.

But it would seem to me that the occasional elimination of some person, even with the chance that he might at some later date develop an unforeseen brilliance and stumble across some magnificient new law of nature, even at that risk, we could well afford to look into his background pretty carefully.

Now, whether that would take an FBI investigation or not, I do not know. So far as I am concerned, I would have no objection to the FBI investigation, and I would think that the overwhelming number would have none if their backgrounds are clear on their general over-all political beliefs. But I do think that the science of government, which is always in danger of infiltration, the science of government has to be kept as clean as possible, as well as the liberality and the freedom of the more exact sciences.

Dr. DuBridge. I certainly believe that, and I believe one way the science of government can maintain the kind of government and the kind of life that we have is to keep its fingers as much as possible out of nonsecret areas when national security is not involved.

The purpose of our Government is to maintain a free society, and one of the important aspects of the science of government is the ways by which that free society can best be maintained.

Senator Hickenlooper. But one of the obligations, I think, is to not support a growing infiltration of people who would destroy the very free systems that keep our laboratories and other activities open.

Dr. DuBridge. I agree, and the FBI is set up for the purpose of hunting down such people and taking such action as is necessary against them when they are found, and one should not interrupt normal action of the FBI in hunting down such people and taking action against them.

I did not mean to imply that the only brilliant brains are those of Communists—far from it. There will only be an occasional Communist who is found in the fellowship program, and it is for that reason, because it is only on occasion, that to extend to everybody these FBI investigations is so dangerous. The point is that there is only an occasional brilliant mind, too. The great discoveries of science have been made by a small handful of people throughout the past few generations. We never know where those brilliant brains are going to be found.

It seems it to me it is logical to do the best we can to judge the most suitable candidates for fellowships on the basis of their intellectual capacities, intellectual promise, normal honesty and integrity, and not on the basis of their political beliefs, and then we will have the best chance of supporting the best brains and not of eliminating some of the best ones.

The CHAIRMAN. Doctor, it is true that under the act we insist on investigating all employees of the AEC, whether they are engaged in secret or nonsecret work. It is because legally these students in nonsecret research have been interpreted as not coming within that provision, because they got a stipend instead of a salary that the question arises.

Of course, a pragmatism sometimes will drive you to very great error, but pragmatically speaking, if I may, I just want to raise the thought that if we consider the students as employees of the Commission, then they would come within the operation of the act.

You see, it is a legal interpretation of the word "salary" instead of "stipend," which is pretty thin.

I would like to raise that, because it would seem to me that it would provide a powerful argument against extending this in the National Science Foundation.

Also I think it provides a good argument for getting nonsecret research out of the Atomic Energy Commission just as fast as we can and getting it into the National Science Foundation.

Dr. DUBRIDGE. On that first point, I would agree, that any barrier which we can erect which would prevent the extension of these so-called security regulations into the Science Foundation we should erect.

The CHAIRMAN. If that is the eventual determination of the Congress, that a full FBI investigation shall accompany the oath, I think the scientists ought to take cognizance of the fact that the students are being placed in the category of employees of the Commission, bearing the same burdens that the stenographer or janitor would who is working in nonsecret work.

I personally am desperately concerned that the scientists of the country do not get the idea that we are marking them out for special loyalty treatment. I think that would be very unfortunate. However, if that is the determination of the Congress, if they would look at the fact that we do require, even of the janitor or stenographer who is an employee of the Commission, full investigation, then at least they can take some solace and comfort in the fact that they become employees of the Commission and are not being treated any differently from the other people employed by the Commission in nonsecret work.

Dr. DUBRIDGE. As I tried to bring out in my statement, it is perfectly true the AEC will have to adopt very different policies for its own employees working in its own establishments in contact with secret work than it adopts in supporting any work outside of those secret establishments.

Now, the confusion, of course, is just this: That up until the fellowship program and some of these university contracts started the activities of the AEC were pretty largely confined to laboratories, production centers, and so on, in which secret work was going on and in which everyone from the director to the janitor had to be cleared.

The act, however, authorizes the Commission to extend its activities into these fields of basic science. If it is going to extend its activities into the fields of basic science, into the universities, then it must, I believe, set up different policies for treating either employees or fellows or anyone else, including those on contract, than it does for employees or contractors within its own laboratories where secret work is involved.

It is just that confusion in the minds of the public about these two areas in which the AEC is authorized and charged to carry on activities: One, the nonsecret university and industrial field and, second, the secret activities of its own installations.

I think it might clarify the situation if the AEC was told it was to carry on nonsecret work, but this would be very damaging to the country and to the AEC because, as has already been pointed out, a lot of these nonsecret fields are of very great importance or potential importance to our activities in nuclear science and atomic energy itself, and it is quite important, I think, that the AEC for its own future good be in contact with those nonsecret areas being looked into by the scientists of the country. As a scientific body it must have an interest in and the support of science. It must have the friendship of scientists in nonsecret fields, for if another emergency were to come along, the AEC would suddenly have to recruit a large additional group of scientists. If it has contact with them, knows them, has their friendship, this task will be enormously eased.

I think it would be unfortunate to say that we must eliminate from AEC activities all nonsecret work, but if we do allow the AEC to continue with its nonsecret work, which I hope we do, then we must also, I believe, allow them to adopt different policies in hiring people, in awarding contracts, and in extending its regulations into those areas.

The CHAIRMAN. I thought you were going to remind me that the employees of the contractors who are not engaged in secret work and do not have access to restricted data under the law do not have to be investigated by the FBI. That is an inconsistency, there is no question about it.

In other words, General Electric at Hanford, assuming there is a man who does not have access to restricted data, although he is working in the reservation—that is, in the town there—does not under the law have to be investigated by the FBI.

Dr. DUBRIDGE. As a matter of fact, this question of being an employee of the Commission is a little difficult to define also because, except for the Commission's direct employees in the Washington office and in their branch offices, nearly all of the men who work on Commission enterprises are not employees of the Commission directly, but of contractors.

The CHAIRMAN. You are a contractor?

Dr. DUBRIDGE. Yes.

The CHAIRMAN. Of a university——

Dr. DUBRIDGE. You mean my institution?

The CHAIRMAN. Yes.

Dr. DUBRIDGE. I believe we do not have as an institution any Atomic Energy Commission contracts, although we have some Office of Naval Research contracts into which some AEC money comes in.

The CHAIRMAN. In the nonsecret work connected with those contracts there are no FBI investigations.

Dr. DuBridge. None; that is right. In fact, as an educational institution we avoid having any secret contracts on our campus whatsoever. Therefore, none of our students——

The Chairman. You have no secret work?

Dr. DuBridge. We keep any secret work off the campus.

The Chairman. You are not faced with that problem. G. E. would be and Carbide & Carbon would be.

Dr. DuBridge. Yes.

The Chairman. Any other questions?

Dr. DuBridge. May I add just one word to a question which came up earlier about the scope of the areas of science in which fellowships have been awarded? I believe this is partly a matter for legal interpretation of the act, but I believe, Senator McMahon, in formulating the act, you and your colleagues purposely made it a fairly broad authorization, recognizing that there were many fields related to nuclear science and whose strength was important to the strength of nuclear science.

The General Advisory Committee has been asked from time to time by the Atomic Energy Commission to advise it on these areas of science, and it has been our policy to interpret the act broadly because broad areas of science need support, and AEC needs the support of broad areas of science.

Therefore, we have recommended rather strongly that activities in the field of biology and medicine and metallurgy and so on be supported and that fellowships be given in those fields. Those are fields of critical shortages of people, and the AEC is always looking for metallurgists, chemists, biologists, radiophysicists, et cetera.

The Chairman. All those things are made of atoms, are they not?

Dr. DuBridge. They are made of atoms. We felt it was wise for the Commission to extend its activities on a broad basis. We also recognize that when and if a science foundation is created, the activities of the AEC could then possibly be somewhat narrowed because there would be another agency which would take care of these other fields. But there is not any science foundation and for 4 years there has not been any, and we have always said when it is created, things will be different, but it is not created yet and, therefore, offices like the Office of Naval Research and like the Atomic Energy Commission have, I think, been very wise to extend a broad base of support to science.

I think even with a science foundation, a broad interpretation of the act in the fields of science which the Atomic Energy Commission takes an interest in would still be wise.

Senator Hickenlooper. Have you finished?

Dr. DuBridge. Yes.

Senator Hickenlooper. I just want to make a suggestion here with reference to the field of isotopes and their distribution, beginning with the program of the Manhattan District.

Distribution of isotopes, as I understand it, was not only discussed but authorized in the Manhattan District before we had as many or so great a capacity for production as we have now.

Dr. DuBridge. Yes.

Senator Hickenlooper. And that distribution was within the United States.

Dr. DuBridge. Yes, sir.

Senator HICKENLOOPER. That is, at that time. There has been some discussion, which I will not go into at this time, I do not care to anyway, about the international distribution of isotopes.

Dr. DUBRIDGE. I am familiar with some of that discussion.

Senator HICKENLOOPER. I merely suggest to you, Doctor, that since the program of distribution of isotopes was begun in the Manhattan District some time ago, a statute has been passed which has some bearing on the legality of the distribution of isotopes, that the McMahon Act was passed after the program of isotope distribution had been set up and that it does have something to say about the matter of distribution of information and things of that kind.

So that the statute operates now where only Executive order controlled in 1945 and most of 1946.

Dr. DUBRIDGE. That is perfectly true. In fact, I think General Groves was very doubtful as to whether he really had authority to distribute these isotopes. He was very concerned about it. That is one reason he called in this rather large committee of scientists to advise him.

When the Atomic Energy Act was passed, however, that seemed to give the Commission a broader field of operation than the Manhattan District had, and it seemed to make it quite clearly legal for the Commission to undertake activities such as the distribution of isotopes that the Manhattan District only——

Senator HICKENLOOPER. Within the United States.

Dr. DUBRIDGE. Does the Atomic Energy Act forbid the distribution of isotopes abroad?

Senator HICKENLOOPER. That is a legal argument about which we could talk for a long time, but it is my opinion that the Atomic Energy Act does not give any authority for the distribution of isotopes outside of the jurisdictional limits of the United States.

Dr. DUBRIDGE. That is a legal question upon which I could have no opinion. I think it would be very unfortunate, however, if that were the interpretation of the act.

Senator HICKENLOOPER. I am not discussing the merits of the distribution of isotopes to universities any place in the world—that is, from a moral standpoint for humanitarian purposes—but from a purely legal standpoint I think there is a very important legal question growing out of the language of the McMahon Act which will merit some examination.

Dr. DUBRIDGE. I hope this is examined, and I hope the result is that the act is clarified so that the foreign distribution of isotopes is specifically provided for, because I think this is an advantage to this country to strengthen science all over the world.

Senator HICKENLOOPER. The act always could be clarified by a simple amendment to the act making no question about the matter, if it is considered to be highly desirable.

Dr. DUBRIDGE. I imagine you and I would differ on the wording of that amendment.

Senator HICKENLOOPER. No; I think not necessarily; if we were in agreement that the humanitarian distribution of isotopes was justified in various places of the world, I do not think we would have any difficulty in writing the language.

Dr. DUBRIDGE. Fine.

Senator HICKENLOOPER. My difficulty is with the present language contained in the act, and I am quite strongly of the opinion that we and our public institutions should operate within the law and not outside the law.

Dr. DUBRIDGE. I take it there has been a difference of legal opinion on the wording of the law, as to whether this is or is not authorized, and I assume the AEC got legal advice before they entered into this matter and felt they were on sound legal grounds, but on this, of course, I have no expert opinion.

The CHAIRMAN. Doctor, this has indeed not been a boring session, and I want to thank you very much.

Dr. Fermi, we will reserve you for a matinee. I am going to see if we cannot have a meeting, if it is agreeable, at 3 o'clock this afternoon. I think we ought to try to hear you today because I know you are anxious to get back to your work.

So, if that is agreeable, we will meet at 3 o'clock.

(Whereupon, at 12:50 p. m., the joint committee adjourned, to reconvene at 3:00 p. m. of the same day.)

AFTERNOON SESSION

The CHAIRMAN. The meeting will come to order.

We have with us this afternoon Dr. Enrico Fermi, who is no stranger to this committee.

I remember with a good deal of pleasure, Doctor, your appearance back in the early days and the help that you were to us. I am glad that you could come back today.

Now, Doctor, you can proceed in your own way to make such observations which you think are pertinent to our inquiry.

STATEMENT OF DR. ENRICO FERMI, INSTITUTE FOR NUCLEAR STUDIES, UNIVERSITY OF CHICAGO

Dr. FERMI. I have had a long association with the atomic activities in this country, first with the Manhattan project, later on with the Atomic Energy Commission, as a member of the General Advisory Committee.

Concerning that last phase, I believe it is pertinent to state that when the Commission took over at the beginning of 1947 the situation was not very bright. By that, no criticism whatsoever is implied of the policies of the Manhattan District which were very fine and, in fact, extremely courageous in wartime.

The whole enterprise suffered the natural drop to be expected when the war ended—when the reconversion from a wartime enterprise to a peacetime enterprise had to be accomplished. It suffered from the considerable uncertainty as to what would be the national policy in atomic matters. So that when the Commission took over, they were confronted with a staggering task.

I would like to stress that it was not clear at that time which of the two basic objectives of atomic energy, the war aspect, or the peacetime aspect, would for the next few years be the most important. The emphasis was shifting while the policies were being worked out.

The problem that faced the Commission when they took over their job was to set the work going in a vigorous way. Weapons had been designed during the wartime. There had been some rather vague and informal ideas for improvement of weapons but there is nothing that could even approximately be called an improved design.

The laboratory responsible for carrying through this aspect of the work, the Los Alamos Laboratory, at that time was suffering somewhat from the general paralysis that was pervading the whole enterprise. We can consider it one of the great achievements of the Commission to have started the Los Alamos program on a vigorous basis. You know that the new weapons that have been produced are satisfactory. This is, perhaps, the best and most material proof that in this line progress has been made.

Since I am mentioning the Los Alamos Laboratory, I would like to state that the place is now in full swing and activity.

A problem that cannot be separated from the problem of weapons is that of the production of fissionable materials. There, too, at the beginning of 1947 the situation was somewhat confused. The situation now is much better. Materials production is rapidly improving. I would not be entirely truthful if I did not mention that there are very serious problems with which this committee doubtlessly is familiar, with which the Commission is struggling at present. They are problems of recovery, problems which will have to be solved.

I believe that the steps are being taken and have been taken that will lead to such a solution. I believe, in other words, that although the situation now is better, much better than it was at the beginning of 1947, it is steadily improving, and I expect still further progress.

Also, the problem of raw materials has been tackled with extreme energy by the Commission. Subject to the limitations of nature, very nice progress is being made, and I do not see any reason for immediate concern in this field.

These three are the angles that most directly concern the activities of the Commission in the military line. There are, then, the peacetime activities and of those the one that has received the greatest attention is the problem of reactors for power production.

At the end of 1946 one thing was clear, and it is clear now, that energy could be produced—after all energy had been produced. It was not clear to anybody how energy could be produced in an economical way except for the fact that it was the general consensus of opinion that the problems would be solvable.

The problems are to a large extent of a technical nature. One needs materials that can stand very high temperatures and still operate satisfactorily in a nuclear reactor.

I have the impression that the general opinion at that time was somewhat underestimating the difficulties. These difficulties are not of a theoretical nature. But in any major industrial development, like the atomic development is, problems which are not theoretical but are practical are of paramount importance.

There also had been a certain overemphasis built up in public opinion as to the immediateness of this program, through statements of people who thought they were informed and, perhaps, were not extremely well-informed.

The reactor problems indeed were more difficult than had been estimated and, unfortunately, complete solutions are not yet available. In spite of that, I would want to go on record with the statement that very substantial progress has been made, in ironing out that great mass of detail which, in a technical problem of this magnitude, constitutes the core of the development.

At present, work is going on which, I hope, will lead to some results. I would not want by any means to be misinterpreted. I do not expect extremely startling industrial results for at least very, very many years to come, but I am reasonably confident that progress will come and that there will be in the not too distant future something more concrete to point to than general technical progress.

Among the peaceful applications of atomic energy, is the production and use of isotopes. I can only applaud the policy of the Commission in this line. I do not know at all what are the legal aspects of the question since in this field I have an extremely limited competence, but I believe that the generous distribution of isotopes, both within the United States and to foreign countries is exceedingly right, and has done much good to this country.

As I say, I do not want thereby to enter into a dispute of what is the exact wording of the law on which I feel myself somewhat out of my depth.

Finally, I would like to mention one more extremely important aspect of the activities of the Commission that has been stressed by Dr. DuBridge this morning: the promotion of science.

If I read correctly the law, promotion of science is one of the duties of the Atomic Energy Commission and, I believe, that the Commission has recognized this duty and has acted quite courageously and effectively in this direction.

I share the view of the previous witness that promotion of science should be taken in a not too strictly utilitarian meaning. If we think of the recent history it appears very clearly that results of science have such unexpected and unforeseeable connections with important human events and important industrial achievement, that to attempt to foresee and to catalog what is the science that will be "useful" and what is the science that will not be "useful" would be a task that would require much more knowledge of the future than any of us can expect to have.

For this reason, I have been very much in favor of the actions of the Commission in supporting general science in connection and in collaboration with the Office of Naval Research, in supporting a considerable amount of basic science in the laboratories of the Commission; and finally in supporting education in the field of science.

In this respect I am afraid that I shall have to repeat some of the arguments of Dr. DuBridge as to the present controversy on clearances of applicants for fellowships.

It has been alleged that a person who is loyal should not be opposed or distressed if such loyalty is checked. This indeed is probably true from a somewhat theoretical standpoint, but not from a practical point of view. I have seen very many cases of loyalty investigations. It is my duty to state that such investigations are usually carried out in a very considerate manner. I have seen very few cases of hardships arising from such investigations that could reasonably have been avoided.

The questions that are asked are fair. FBI agents come to see me every once in a while to ask me, "Do you know anything about Mr.

So and So?" There is never, in my experience at least, any attempt to cause me to make any damaging admissions.

But I know a great number of students and young men in science and I notice a general preoccupation. After all, science is a matter of investigation into mysteries, and scientists are people who have a natural curiosity, who think that way professionally. They are considered good scientists if they are very prone not to take anything for granted.

Senator HICKENLOOPER. Well, Doctor, may I interrupt?

Dr. FERMI. Absolutely.

Senator HICKENLOOPER. Is there any criticism, then, on those who have the responsibility for Government to not take anything for granted and to be very sure in investigating the mysteries of people's subversive beliefs?

Dr. FERMI. That is a very good question. I am afraid I have no answer. [Laughter.]

Well, the point is this: Think of a young man—a man say of 20—he has seen very little of life; he has a certain natural curiosity. Supposing he says "They tell me the Communists are so bad. All right, let's see what they are; let's take the Daily Worker"—or whatever is their official publication—"and I shall just see what they say for themselves."

An attitude of this kind is something that I would view with some sympathy. After all, why not? Why should not a young man get enough information to be disgusted by himself as to what he may read?

Now, the landlady sees the Daily Worker lying around; comes the FBI agents; the landlady says, "Well, yes; he is a nice chap, but" and there the man goes on record as a very dangerous character who had better be kept out of the ranks of the loyal American scientists.

I understand the philosophy of the inquiry is not to spot an offender but to detect a risk—well, to be considered a poor risk is no irrelevant matter for a young man who has not had a chance to be established. A young man who is trying to acquire that competence that may eventually lead him into establishing himself may properly object to the danger of being so branded. I believe that the percentage of those who would be properly weeded out by a loyalty investigation is extremely small, but I believe that a widespread investigation of students not engaged in secret work would have a very depressing influence.

There are also false rumors as to how much police methods are adopted in such inquiries, but after all people react to things for what they believe them to be and not necessarily for what they are.

The impression is abroad that on the slightest hint of the janitor or the landlady or whoever may have the occasion to look into your wastepaper basket you may be branded, and you may find it very difficult, and, at least, very unpleasant to clear yourself.

Now, that makes for a very unhealthy feeling. I sense that sometimes young people in the schools are not quite frank. They do not talk with that complete carelessness which I believe would be a privilege of their age.

For this reason I want to endorse most strongly the views that were mentioned this morning by Dr. DuBridge, that loyalty investigations should be looked upon as necessary evils wherever they are necessary. To expand them into a field in which they are not clearly necessary is, in my opinion, a grave mistake. It would save a ridiculously small amount of money that might go to an undeserving person but make all the fellowship program less effective and less generous and less appreciated. I believe the price is just too high.

This is all that I would want to say in the way of general comments.

The CHAIRMAN. Senator Hickenlooper.

Senator HICKENLOOPER. I think it is very fine of you to come down here, Dr. Fermi. I want to take this occasion to publicly say—well, I am not sure whether I want to say that for your great accomplishments in nuclear physics, whether we owe you a debt of gratitude, because I am not certain that I am happy that we ever invented the atomic bomb.

Dr. FERMI. It is certainly a questionable point.

Senator HICKENLOOPER. But for your invaluable contribution to this science, as a scientific contribution to the world of science, you have a debt of gratitude, I think, of people everywhere, that cannot be repaid.

Dr. FERMI. Thank you, Senator.

Senator HICKENLOOPER. I believe that with respect to your contribution, it was some of your bold and rather revolutionary predictions that enabled people to have confidence in building the first pile under the stadium in Chicago and you did not know whether it would blow up or not.

Dr. FERMI. It did not. [Laughter.]

Senator HICKENLOOPER. For which we can either be grateful or perhaps take some other attitude, but I do want to have you know that so far as I am concerned, the appreciation of your unique contributions to science—your contributions are appreciated, and I know that your contributions now in the future will be equally as far-sighted and as startling.

Now, I may find myself in some little disagreement on philosophy. I could not discuss science with you, and certainly I am willing to bow to your judgment, of course, in any matters scientific.

I have just one question that I would like to put to you: Do you believe that economical power development, that is, in any kind of a competitive way with fuels that we have now, economic power development is anywhere in the reasonably foreseeable future out of this thing, or would it be experimental, the establishment of new laws and other things?

Dr. FERMI. It is a difficult question. I may try to answer it to the best of my ability.

Senator HICKENLOOPER. Well, the reason I ask that is that I noticed in the papers yesterday or this morning statements that power was just around the corner. I mean that was the understanding apparently taken from the testimony yesterday. That is not my understanding of the situation, and while we produce power or heat in these piles now, yet I am talking about economic, competitive power that could be used in industry.

Dr. FERMI. Well, I certainly agree with you. The thing is not around the corner. Some limited experimental applications may be possibly not far in the future. Perhaps some naval applications may come forth in the not too distant future, but if by "competitive" power, you mean something that could be comparable to coal or oil, I believe that production of such huge amounts of power, if they ever will be produced are certainly very, very far in the future.

On the other hand, perhaps, one should not take necessarily a too pessimistic view about this situation either. There are basic possibilities; I find it really extremely difficult to strike the right note between optimism and pessimism.

You see, we talk of a matter certainly of 15 or 20 years. Now, who is the prophet who can see things at that distance? Atomic power may ultimately develop not into a competition but, rather, in supplementation of conventional fuels.

I believe that it would be a great disservice to engender unjustifiable hopes—I believe that it is very desirable that the public should stop thinking that atomic power is around the corner, because if they do so they are in for a disillusionment, and the public has a right to know and certainly should get a reasonable perspective of the program.

If atomic power will develop at all into a very important industrial fact, it will do so only in a very many years. That is very clear to me.

There might be some interesting spotty applications to this or that field to which the special features of this form of power are particularly suited. But before atomic power becomes a really large-scale affair it will take a long time.

Senator HICKENLOOPER. Well, the only purpose of my question was that periodically things appear in the public print, statements of people, and maybe some know what they are talking about, and are misinterpreted, and others may not know what they are talking about, but statements appear periodically which give recurrent hope to people that we are just on the verge of substituting atomic power for other methods of the production of power, and it is only in the hope that it can be put into its proper perspective, and that delusions are not engaged in, that I bring this up.

I, for one, if we could have atomic power tomorrow, would be very happy, and I think a great many people would. It would cause us some great readjustments, but I think I would be glad to see it arrive as a progressive scientific development at any time that it could.

But there are many people who write to me and say, "I saw in the paper that maybe next year we are going to be running engines on locomotives with atomic power." Or they say, "When are we going to have experimental atomic engines in our automobiles?" Or they write about things of that kind. I write back to them and tell them in my judgment it would be a very, very long time before we even approach that, but I also qualify by saying that I am not qualified to give a scientific opinion on it.

Dr. FERMI. I do not know whether I am qualified, but certainly I agree with your opinion.

Senator HICKENLOOPER. If you are not, I do not know who is, because if there is anybody who is qualified, I think you would be in that class.

Dr. FERMI. And I believe it is certainly a public service to try to present the chances into a good perspective because, as you say, occasionally misinformed statements are interpreted correctly, or informed statements are misinterpreted and a great confusion arises in the public opinion.

Senator HICKENLOOPER. Well, thank you, Doctor. It is very nice of you to take your time to come down here. Good luck to you.

Dr. FERMI. Thank you.

Senator HICKENLOOPER. I have no further questions.

The CHAIRMAN. Doctor, of course, if we had been successful in our efforts to get an international control agreement, would you say that that would have speeded up the accomplishment of the peacetime achievements in atomic energy?

Dr. FERMI. I think very probably yes, and for the following reasons: I believe that the atomic development suffers under the necessity of a tight secrecy policy. Unfortunately, the peacetime applications are all wrapped up in the same package with the wartime applications.

As long as the scare of the destructive potentialities is there, there is no alternative but to keep secret all that can lead in the direction of the military applications.

But this secrecy acts as a tremendous brake on progress. If I may give you an example. I am teaching a course in nuclear physics at the University of Chicago, and I would have liked to give my students a certain background to the work in atomic energy.

I have a fair notion of what is classified and what is not classified, but still the feeling that I would have had to weigh my words very carefully—I could have been asked embarrassing questions, and I would have been faced with the choice of either telling a student in the open classroom, "I am sorry, my boy, but this is something that I am not allowed to answer." And just this uneasiness drove me to stay off the subject.

Now, I do not think my lectures would have been extremely effective, but there you have some 50 boys or so who have lost that chance to acquire a training in atomic energy problems.

Also at present in many foreign countries, so far as I know, people just do not even think along the direction of atomic energy problems since they say, "There is this American monopoly, and they keep everything wrapped up in secrecy."

Perhaps the belief is that in basic science much more is kept under wraps than actually is. But just the feeling of this blank wall—the fact that nobody knows exactly where the wall begins, how far one can go without overstepping the limits—acts as an extremely serious psychological block against what would be a very natural and very appropriate field for free investigation.

For this reason, I believe that, if there were any conceivable way to overcome the international difficulties, an extremely valuable speeding up of progress would result. It might be that something would be found; perhaps, not power and not bombs, but just something else; who knows.

The CHAIRMAN. Well, I think it is important—just as Senator Hickenlooper does—that we do not get any misapprehensions about it being right around the corner, but, as I say, it is very difficult to prophesy for the next 15 to 20 years.

You know, Doctor, 20 years, 15 years, seem to be a long time, but really it is not very long, is it? It is 3½ years ago now that we began to talk about it in Congress, and it seems to me as though it were yesterday.

Dr. FERMI. It is very true that 15 years pass—perhaps, one should make the following remark: That unless a vigorous program is kept up, the 15 years will become 30. I would not want my words to be interpreted as discouraging for the reactor program. The way is long, but a long way cannot be traveled unless one starts to move along it.

Senator HICKENLOOPER. I think the Chinese say that the journey of a thousand miles begins with the first step.

Dr. FERMI. That is very true.

The CHAIRMAN. I think Henry Ford began the manufacture of his car in quantity around about 1906 or 1907. Of course, he made individual cars before that, and in that period of about 40 years, we have had a total transformation in American industrial life and the whole economy due to the mass production of automobiles.

I reflect on the fact that I was born in 1903, and it seems——

Senator HICKENLOOPER. Just a kid. [Laughter.]

The CHAIRMAN. Yes; just a kid. It seems like a very short time ago.

While I think it is true that we must not lead people to believe it is rather around the corner, we still have to remind people when we are thinking about something that may change the whole pattern of life, that may do so many things, through this atomic energy; we must also remind them that 15 years is not a century or two.

Dr. FERMI. I think I cannot agree more with what you say. I believe that is what should be done, and it is perhaps just difficult to do it right. I believe it would be irresponsible to make rashly optimistic statements.

On the other hand, I am convinced that it would be a wrong policy to say, "Let us drop it and save the money."

The CHAIRMAN. Doctor, it is now 2½ years since the Commission took over, almost; where are they now, in your opinion with respect to where you expected them to be after 2½ years?

Dr. FERMI. I believe, as I said before, that the progress has been very considerable. I do not want thereby to give the impression that the progress has been just the very maximum possible. Naturally there have been things that, after the fact, could have been started in a better way but I believe that it is fair to say that the progress has been greater than what I would have expected.

I was at that time really somewhat discouraged. I saw things drifting so hopelessly that if you asked me the specific question of what I thought at that time, I do not think I would have overestimated what the achievements could have been in that period.

The CHAIRMAN. Well, thank you very much indeed, Doctor. It is good to see you again. I hope we will have a chance to see you again in the time to come.

Dr. FERMI. I hope so. Thank you.

The CHAIRMAN. Now, I understand from the Commission that they have two, possibly three, more witnesses, and I also believe this will conclude the Commission's presentation?

Mr. VOLPE. Yes, sir.

The CHAIRMAN. So, we will meet then—plan to meet—on Monday at 10:30.

Mr. VOLPE. Mr. Chairman, to conclude Monday morning, which is our aim, and not to burden the committee with many witnesses, we have endeavored to prepare some statements on various aspects of the program, more important aspects of the program, which we would ask permission to insert in the record. This might be done Monday or perhaps even later.

(The data referred to above are marked "Exhibit 32" and will be found in the appendix.)

The CHAIRMAN. All right.

We will recess then until Monday at 10:30.

(Whereupon, at 3:40 p. m., the joint committee adjourned to reconvene at 10:30 a. m., Monday, July 11, 1949.)

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84th Congress }
2d Session }

JOINT COMMITTEE PRINT

PEACEFUL USES OF ATOMIC ENERGY

REPORT

OF THE

PANEL ON THE IMPACT OF THE PEACEFUL USES OF ATOMIC ENERGY

TO THE

JOINT COMMITTEE ON ATOMIC ENERGY

VOLUME I

JANUARY 1956

Printed for the use of the Joint Committee on Atomic Energy

Sam Schurr
Resources for the Future
1145 19th St NW
Washington 6, DC

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LETTER OF TRANSMITTAL

JANUARY 30, 1956.

Hon. CLINTON P. ANDERSON,
Chairman, Joint Committee on Atomic Energy,
The Capitol, Washington, D. C.

DEAR MR. CHAIRMAN: On March 26, 1955, your committee established the Panel on the Impact of the Peaceful Uses of Atomic Energy and instructed us as follows:

I. To appraise the present and future impact of all aspects of the development of atomic energy on our way of life, our economy, our industry, our natural resources, and including the effect upon employment. While this appraisal will be concerned principally with the peaceful applications of atomic energy, it obviously must take into consideration its military applications as they affect or concern peaceful uses.

II. To consider also the effects of the application of atomic energy upon economies and industries abroad. While the study will be concentrated upon United States industry and economy, it must take into account the interlocking effects that such development and application abroad might have on our own economy and industries.

III. To study the activities of the Atomic Energy Commission as they affect the foregoing both in the Commission programs aimed at developing peaceful uses in atomic energy and in the Commission role as the regulatory agency of the new field.

IV. To recommend to the Joint Committee any legislative or policy actions needed to speed the proper development under both Government and private auspices of peaceful uses of atomic energy.

We were instructed further to prepare and submit by January 31, 1956, a report on our activities and findings.

We take pleasure in reporting to you herewith the results of our study, together with our conclusions and our recommendations. In preparing this report, we have borne in mind your charge concerning the many problems and objectives which must be weighed and balanced. In accordance with your instructions, we have sought, without diluting the effectiveness of the report, to merge our individual views into a single set of findings to balance these problems and objectives in a single report representing the joint judgment of the panel.

Our chairman has been instructed by the panel to submit the previously unpublished background material, collected in the course of our work. This material, contained in volume 2, is submitted separately, though not endorsed by the panel, as a collation of valuable information concerning the peaceful uses of atomic energy and their impact.

In our work, we have been ably supported by a conscientious and hard-working staff on assignment to us from your own organization and from other sources. The many individuals, firms, organizations, and departments and agencies of Government upon whom we called for assistance invariably gave generously of their time and thought. Without them, we could not have completed our task.

We are grateful to the Joint Committee on Atomic Energy for the rewarding opportunity afforded us to explore a broad new subject which will in the future demand more thought and effort.

Respectfully.

ROBERT MCKINNEY, *Chairman*.
ERNEST R. BREECH.
GEORGE R. BROWN.
SUTHERLAND C. DOWS.
JOHN R. DUNNING.
FRANK M. FOLSOM.
T. KEITH GLENNAN.
SAMUEL B. MORRIS.
WALTER P. REUTHER.

CONTENTS

FOREWORD

Description of Method

Performance of an assignment of the scope and within the time limits imposed by the Joint Committee's terms of reference to the panel has severe problems—particularly since no survey of this nature has previously been attempted in this new field.

At the outset it was apparent that, unless self-imposed restrictions on the range of inquiry were adhered to, our efforts would be diluted to the point of ineffectiveness. Our first step, therefore, was to survey the areas into which we could profitably inquire and in which we could expect to draw useful conclusions. This survey developed six principal peaceful uses of atomic energy which seemed to warrant review: power, medicine, agriculture, food preservation, propulsion, and general industrial uses.

In addition, international aspects of the peaceful uses of atomic energy seemed to be of great significance to our study.

Further, it was clear that the role of the Federal Government in this field could strongly influence, if not control, the rate of future development. Therefore, much of our effort was devoted to the organization of the Atomic Energy Commission; control of information; research and development; manpower; education; hazards, protection and insurance; ownership of materials; licensing and regulation; financial environment; patents; and Government organization in general.

Having established a method of approach which essentially defined the table of contents of our report, mechanisms were needed to collect and digest the great volume of material which must inevitably be required. An essential characteristic of this mechanism was that any possible unwarranted preconceptions had to be distilled out continuously and natural differences or bias in opinion brought to light. To accomplish these objectives, we divided the six areas of technological impact for assignment to qualified individuals, organizations and study groups, each operating autonomously and submitting their independent findings of fact and their conclusions to seminar discussion groups.

These seminars were composed of individuals who, by background and experience, could be expected to provide the panel with objective views in their specific fields. The seminars acted autonomously under their own chairmen, but pursuant to terms of references provided by the panel.

Fifteen seminar or discussion groups were convened and approximately 50 special studies were prepared. All in all, 327 people, all authorities in their field, took part in this work.

In order that the seminars could have the full benefit of frankness and openness of discussion, neither verbatim notes nor attributions of statements were taken. Summaries of the points of view expressed and the general areas of agreement were prepared under direction of the seminar chairmen for submission to the panel.

At the same time, questionnaires were sent out by the panel staff and collaborating organizations on a wide variety of subjects. Replies from individuals, universities, and industry served to check the validity of background papers and seminar reports. Two hundred and twelve organizations helped in this phase of the project.

Concurrently, the panel undertook to acquaint itself with the scientific and technical activities, the administrative work, and organization of the Atomic Energy Commission. Discussions took place with the Commissioners, General Manager, key personnel, and representatives of Commission contractors.

In the interest of minimizing any possible disruptive effects of our study on the Commission's activities, collection of background information on Commission policies and activities was carried on as much as possible by exchange of correspondence on specific matters.

The statements of fact, opinion and conclusions expressed in the seminar reports and background papers were studied, digested, and correlated by the panel staff; then considered at length by the panel.

The weighing and balancing of the data and opinions thus made available, and outlining of each the related report sections occupied a great proportion of the panel's time. The final step in the process was the detailed review of the report and agreement on it in the form in which it now appears.

Of our many findings, perhaps the one of which we can be most certain is that the data on which such a report as this must be based are so complex and ever changing that only by periodic review and updating can they retain continuing value.

REPORT

of the

PANEL ON THE IMPACT OF THE PEACEFUL USES OF ATOMIC ENERGY

CONCLUSIONS AND RECOMMENDATIONS

Inevitably the many peaceful uses of atomic energy will be explored, fully developed, and put to man's best use. They will have strong impact on the American society and economy. For the Nation as a whole, and for most people, impact should be beneficial. Dislocations which may be in store will not be different from those normal in a rapidly expanding industrial economy.

For the many peaceful applications to enter into everyday life on a scale sufficient to cause impact, much remains to be done. Atomic power must first become economically competitive. Later it may be cheap but not free. Other atomic applications can add to the production capabilities of our factories and farms. New avenues to better health are in prospect.

More than money and promises are needed, however. It takes time and trained people to stake out the resources of this new technology. Widespread understanding of the difficulties to be overcome—potential hazards, and necessity for realistic international working arrangements—is an essential element in the realization of these benefits. Not only are these benefits our objective for ourselves; they must also be our objective for the whole free world. With our ability and leadership, their realization need not be far off.

Atomic Power

Atomic power gives promise of becoming an important new resource for the generation of electricity. For the expanding economy of the United States and for less highly developed countries seeking ways to raise their levels of industrialization, atomic power provides reason for optimism.

The bright promise of the future must not hide the fact that large sums of money and years of effort must be spent to bring atomic power to a point where it can be used effectively and widely on a competitive basis. Unless and until research and development demonstrate that atomic power can be economically feasible, there can be no substantial impact.

Private enterprise should carry a substantial part of this research and development program, including especially the construction of full-scale "demonstration" plants. But in the event that industry does not take on the full risks and burdens, such a program should be supported by the Commission, even to the construction with public funds of one full-scale "demonstration" plant of each major reactor size and type.

The present development program is deficient to the extent that appropriate "demonstrations" of the small and medium-size types are not now underway. The urgency associated with accepting the challenge to United States world leadership, together with the need for establishing atomic energy as a power resource available to assist in maintaining maximum expansion rates of the American economy, require that effective development and "demonstration" of all major reactor sizes and types be carried forward at high priority. If progress is not expeditious and efficient, it is clear that the Federal Government has a fundamental obligation to carry it out. Although private participation in this program is desirable, it should not be obtained at the cost of delay.

The rate of growth of atomic power will depend to a large degree on the rate of expansion of our total economy. By 1975 atomic power could amount to 20 to 40 percent of presently installed electric generating capability in the United States. If this occurs, however, it will be in the context of a total generating capability of 3 to 4 times present levels.

The net domestic impact of atomic power should be beneficial to individual consumers and to industry. Disruptive influences, even on specific industries most directly affected, are likely to come—if at all—over periods of time long enough to permit orderly adjustment. In specific industries popularly assumed to be most vulnerable to atomic inroads—coal, for example—such dislocation as appears possible would come from a welter of forces more complex and more overriding than atomic energy alone.

If atomic power is exploited as a source of electric power at a rate consistent with sound technological, economic and public policy considerations, the impact will be totally beneficial at home and abroad.

We recommend:

1. that the Congress, the American people, and the people of the world recognize that large sums of money and years of effort must be spent to bring atomic power to a point where it can be used effectively and widely on a competitive basis; unless and until research and development demonstrate that atomic power can be economically feasible, there can be no substantial impact;

2. that, in the event that industry does not take on the full risks and burdens, the Commission should support a program to bring atomic power to a point where it can be used effectively and widely on a competitive basis, even to the construction with public funds of one full-scale "demonstration" plant of each major reactor size and type;

3. that the urgency associated with this program requires that the technological resource of atomic power be fully explored with high priority; and

4. that atomic power be exploited as a source of electric power at a rate consistent with sound technological, economic and public policy considerations.

Controlled Thermonuclear Power and Direct Conversion of Radiation Energy

Controlled thermonuclear power and direct conversion of radiation energy are subjects which stimulate men's imaginations. We have come to the conclusion that we can contribute nothing in the way of sound estimates of future impact in the absence of better data and on the basis of the speculations available to us. Exploration of these areas offers a great challenge to the best scientific minds in the world today.

There are military implications, however, which would come with the availability of special nuclear material as a byproduct of controlled thermonuclear power. Within the limitations of national security considerations which these impose, we believe that this entire area of scientific and engineering development warrants the maximum interplay of ideas. We note the recent decision by the Commission to make available information about its controlled thermonuclear program to United States citizens holding permits for access to secret restricted data. As private citizens, we would hope that the day will come when world conditions will permit all those able to contribute to thermonuclear power to learn all there is to know about it. Of greater present importance is the development of procedures by which more people can contribute freely to it.

This is a truly frontier research project. It concerns a basic energy resource which could have impact on the economics of the entire world. The Government has a clear obligation to give it full support as well as to stimulate scientific contributions from every quarter. At the same time there is also an obligation to the public and to those being encouraged by the Federal Government to invest in nuclear fission power to see to it that they are allowed to have sufficient information about the feasibility of nuclear fusion power to have an adequate foundation upon which to base a determination for themselves of the propriety of their investments and actions.

We recommend:

1. that the Commission, within the limitations which national security considerations impose, permit the maximum interplay of scientific and engineering ideas, and develop procedures by which more people can contribute to the controlled thermonuclear program in the United States; and
2. that the Commission, in encouraging investment in nuclear fission power, see to it that investors have sufficient information about the feasibility of nuclear fusion power upon which to base determinations for themselves as to the propriety of their investments and actions.

Medicine and Public Health

We feel that a high priority must be set on means for bringing higher health standards to our people and the peoples of the world through the beneficial use of atomic energy in medicine and public health. As individuals learn to recognize these beneficial aspects, they will begin to lose their fears of atomic energy arising from the fact that hitherto their attention has been focused on its military applications.

In setting forth the recommendations below, we have purposely refrained from suggesting specific methods of financing. It is our strong feeling, however, that medical institutions and research centers should not assume a passive role and expect the Government, and more especially the Commission, to assume all or even a major portion of the responsibility for providing research facilities, equipment, and materials. Government monopoly of atomic energy for weapons was wise and necessary, but this monopoly must not be allowed to extend itself into the medical field, with all the concomitant dangers of secrecy, concentration of research, and control over facilities and personnel. Any Government assistance afforded the medical and public health professions should flow from all the various governmental agencies concerned with health, education, and research, and should carry with it no implication of Federal control over medical practice or research.

If maximum benefit is to be gained from the advances in medicine and public health made possible by atomic energy, it is necessary to:

1. Provide all medical schools with adequate facilities for training in atomic medicine techniques;
2. Create additional research centers with all appropriate equipment, including reactors;
3. Design low-cost atomic medical equipment suitable to the needs of the 6,100 hospitals and medical clinics without atomic facilities and provide at least minimal facilities to this group as rapidly as possible;
4. Make available at reasonable prices the now-expensive radioactively labeled organic compounds essential for research and therapy;
5. Assure prompt availability of current atomic developments in the field of medicine and medical research, with opportunity for full interchange of latest data and without interference of the independence of medical research investigators; and
6. Inaugurate a nationwide educational program on the more judicious use of radiation and the need for better recordkeeping of the exposure of individuals to radiation from all sources.

Agriculture

Peaceful uses of atomic energy in the field of agriculture are significant additions to the many other modern methods of improving farm technology.

Man can already produce the food he needs if he takes advantage of the modern techniques available today. Atomic contributions will extend this ability to a still higher level, thus accentuating farm surplus problems in the United States. The extent of this impact will depend upon the rate of speed of development and the breadth of application. Efforts to speed the contribution of atomic energy to agriculture will inevitably increase the urgency of meeting the challenge to the Nation posed by farm surpluses.

Benefits of atomic applications to farmers can be as real and as immediate as each individual wishes to make them. The cumulative impact will be an increase in the farmers' ability to specialize, diversify, and better deal with their traditional worst foes—weather, pests, and diseases.

Peaceful uses of atomic energy in agriculture can help the undernourished peoples of the world have more to eat, if technological assistance is provided. There can be no miracles; research, education, and work are needed.

We recommend:

1. that the humanitarian benefits which can result from the application of atomic developments to agriculture require that this technological resource be fully explored with high priority;

2. that those charged with meeting the farm surplus problem take into consideration the fact that such atomic developments—as other major new farm techniques—will contribute materially to farm output; and

3. that the Agencies and Departments concerned with assistance to foreign countries develop a coordinated and vigorous program of high priority with technical assistance from the Commission, to focus atomic research where it can be useful soonest in undernourished countries. Only in this way can the United States bring to bear atomic contributions to agriculture, so as to demonstrate our historic sense of international humanitarian leadership.

Radiation Preservation of Food

Radiation preservation of food does not appear likely to replace other methods of food preservation to any substantial extent in the foreseeable future. When economically feasible, it would be a supplement to other methods.

It appears that nothing but benefits can come from success in this field for both the consumer and for the economy as a whole. Higher proportions of skilled workers would probably be needed in the food industry, but the levels of skill should not be difficult to meet by retraining.

As radiation preservation is adopted commercially, more of the food produced in the Nation would reach consumers in usable condition. This would have the effect of adding to food supplies without relationship to any increases in food production. Radiation deinfestation of grain, a technique now available, could lead to greater surpluses.

Radiation preservation techniques appear to be new tools of an advanced and mature technological and industrial society, and are not likely to be readily applied to industrially underdeveloped areas of the world.

We see no need to change the present rate at which development of radiation preservation techniques is going forward, except insofar as military needs may require.

Therefore we recommend:

1. That the present program for development of radiation preservation techniques for foods and other perishables be supported at present and projected levels; and

2. That those charged with meeting the farm surplus problem take into account the fact that radiation deinfestation of grains, a technique now available, could lead to greater surpluses.

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Atomic Propulsion

Propulsion of Commercial Ships

Atomic propulsion of commercial ships is technically feasible. However, economically competitive atomic ships are not generally yet in prospect. A limited number of applications, such as ocean-going tankers, may have economic advantage. The possible need to replace a large portion of the United States merchant fleet in the 1960–65 period makes it desirable for the Atomic Energy Commission, the Maritime Administration, and the shipping and shipbuilding industries to work out a program for exploring the economic feasibility of atomic-powered ships. Only in this way can adequate engineering and operating data be obtained in time to permit determination of the advisability of construction of any substantial number of atomic-powered commercial ships a decade hence. Advantages of such ships during any future war, as well as maintenance of United States maritime prestige, give a degree of urgency to this line of development.

Propulsion of Commercial Aircraft

Though technical prospects for military aircraft with atomic propulsion are considered good, prospects for economically competitive commercial applications seem unlikely until some experience with military prototypes has been acquired. If commercial types ever come into use, they will probably be byproducts of the military program. Foreseeable impact, even so, is not substantial since only very long-range cargo aircraft appear likely to be able to make profitable use of atomic power. The prospect of nuclear crashes in populated areas and resultant radiation hazards could serve as additional deterrents to extensive use. There appear to be no advantages inherent in commercial atomic aircraft worth additional efforts now, over and above those being expended on achievement of military objectives.

Propulsion of Locomotives

Atomic locomotives could in all probability be built and operated successfully, but appear to offer no economic advantages until substantial improvements in reactor technology are made. There is no real industrial development program directed at atomic locomotives today and no directly comparable military atomic power projects are underway, but the technical and engineering data being developed will undoubtedly improve the outlook for economically competitive atomic locomotives in the years ahead. There appears to be no incentive or necessity for Federal support of an atomic locomotive development program, but the Commission should cooperate within the limits of national security with any industrial efforts.

Propulsion of Motor Vehicles

Atomic-powered civilian automobiles, and commercial trucks and buses are not technically feasible today and apparently will not be in the foreseeable future.

Recommendations

We recommend:

1. that the Atomic Energy Commission, the Maritime Administration, and the shipping and shipbuilding industries work out a program for exploring the economic feasibility of atomic-powered ships; and

2. that the Commission cooperate within the limits of national security with any industrial efforts to develop atomic locomotives.

General Industrial Uses

Radioisotopes and radiation are already being used by industry for process control and inspection and for research. Savings in the form of reduced scrap, reductions in additional work performed on faulty products in process, and in better knowledge of what is happening in complex processes undoubtedly will be large in the years ahead. These have become natural tools of industry.

Atomic heat for industrial processes could be of significance in the future. No active research and development program on this problem is in progress. In view of the nature of the potential industrial applications of process heat, it would appear that private industry must bear the primary responsibility for the development of specific applications. However, at the present time, only the Commission has the facilities required to conduct the metallurgical research essential to the development of high-temperature reactors.

Atomic radiation may be very important as a new form of energy for the chemical and other industries. Present Commission support could profitably be stepped up in these areas of fundamental exploration. However, here again it appears that the development of specific applications will be most successful if they are carried out by the actual industries which are prepared to exploit them.

Atomic space heating, while theoretically feasible, appears unlikely to prove economically competitive on any substantial scale. Nevertheless, since space-heating requirements are a large fraction of total national energy demand, any efforts on the part of private industry to explore promising ideas should be encouraged by the Commission.

We recommend:

1. that the Commission step up fundamental research in areas relating to the use of atomic radiation as a new form of energy for material processing; and
2. that the Commission encourage any efforts by private industry to explore promising ideas relating to atomic space and process heating.

Impact on the United States of Peaceful Atomic Developments Abroad

The humanitarian applications of atomic energy can make significant contributions to the health and prosperity of peoples throughout the world. These techniques offer the United States an opportunity to establish specific research goals, the accomplishment of which could demonstrate the benefits of our concepts of freedom and the importance of the individual in society. There are many ways in which United States leadership in application of humanitarian uses must be pressed forward with imagination and vigor.

Atomic power may be the most tangible symbol of America's will to peace through the peaceful atom. Our domestic needs cannot be our only motivation. Otherwise, we leave without effective rebuttal the argument that America is so rich, so prosperous, that a revolutionary new energy resource can emerge without any urgent need on our part to put it to man's use. This must seem a strange position indeed to peoples possessing neither conventional fuels nor technical capabilities to put the atom to work.

If we fail to act to bring atomic power to the free world, other countries will do so ahead of us, or progress will proceed at a slower pace.

Peaceful uses of atomic energy will inevitably be developed throughout the world. The United States must lead.

Therefore, we recommend:

1. that the executive branch establish specific research and development goals to meet the needs of friendly nations; and that attainment of these goals be assured by provision of technical services, including the conduct of projects at home and abroad aimed at developing crops and farming methods, medical practices, and education and training in basic science and in applied atomic techniques adapted to the problems of specific friendly nations;

2. that the Commission center its responsibilities with respect to international development of peaceful uses of atomic energy in one alert, forward-looking organizational unit;

3. that adequate research and educational equipment and facilities be provided to friendly countries, accompanying research reactors sponsored by the United States, so that atomic scientific, agricultural, and medical benefits can be brought to bear promptly where most needed;

4. that the United States encourage other nations to decide for themselves the rate at which they wish to apply atomic power and other industrial uses of atomic energy to their own economies, to which end, we further recommend:

I. that the United States promptly convene a series of regional conferences of our bilateral partners for the immediate establishment of realistic goals for the installation of atomic electric generating plants in specific countries;

II. that the United States, in issuing invitations to such conferences, announce that it is prepared to furnish nuclear fuels, provide necessary technological assistance and permit contracts for the installation of at least 1 million kilowatts of atomic generating capacity outside the United States as soon as possible—we hope by 1960. The attention of the world should be called to the fact that such a program would parallel and possibly exceed the capacity installed during the same period at home;

III. that financial assistance, when required and where justified for this program, be made available through normal governmental and private channels, not through the Commission; and

IV. that atomic powerplants constructed under these programs be subject to interim control plans involving appropriate inspection to be agreed upon by each participating bilateral partner, and requiring reprocessing of spent fuel and recovery of plutonium or uranium 233 in the United States; materials thus recovered to be earmarked for further expansion of peaceful uses.

Public and Private Attitudes as They Affect Development of the Peaceful Uses

Until there is a better informed public opinion—until there is more balance in programing what lies ahead—and until there is integrated policy to guide both our domestic development and our participation in international development of peaceful uses of atomic energy compatible with international atomic control, attitudes and climate alike are apt to shift from day to day and week to week. Stabilizing these in the framework of sound public policy is a task which requires the concerted, responsible attention of all those seriously interested in the future of America in the atomic age.

With the opening up of applications of peaceful uses of atomic energy to private enterprise, however, the Congress clearly needs the full benefit of a well-informed and vocal public opinion. This is necessary to provide a balance to special-interest pressures. In the normal course of the democratic process there are pressures concerning public and private power, concerning guaranteed ore and byproduct purchasing programs, concerning Federal encouragement of developments which, it is feared, may cause dislocation of workers or obsolescence of capital investment. These and other pressures can best be kept in balance by an informed and critical public, and an intelligent, freely functioning press. It therefore follows that the inherent requirement for less secrecy and freer flow of significant information concerning the peaceful uses of atomic energy is greater than the encouragements to this end contained in the 1954 act.

Control of Information

National security requires that some information related to atomic energy be controlled. Important though the peaceful uses of atomic energy may be, military uses are vital to our defense. As long as world tensions continue, some classification system will be required both to reduce the knowledge of potential enemies about our defenses and to avoid making it easier for potential enemies to build military strength to be used against us.

The existence of a dual system of information control, one for "atomic" information and one for "defense" information, has less validity now that other countries have developed capabilities of their own in military and peaceful uses of atomic energy. We would think it appropriate for both the Congress and the executive branch to explore the possibility of reinstituting a single information control system with uniformly applicable penal provisions for violations. The concept that information is "born" classified is not compatible with the expeditious action required to make information available for the full development of peaceful uses. This concept should be limited to nuclear weapons.

As long as any atomic information remains under control, those interested in its development and applications will suffer serious handicaps. No administrative agency can ever give a guaranty that a private citizen has all the information needed for decisions and actions.

The Commission can take steps beyond those now contemplated, however, to improve the situation. The collation of all information pertinent to peaceful uses on some rapid and continuing basis is an important technique. Collections can and should be divided into classified and unclassified categories so that they can be made available to the maximum number of people. Without action of this sort, important data seem doomed to pile up in obscure documents, and never reach those competent to use them. Such data may not even come to bear fully on Commission work. If any significant quantity of information essential to development of peaceful uses is to remain classified, it would seem that a substantial number of people will have to become engaged, directly or by contract, in the tasks of digesting, collating, reviewing, and distributing it for those entitled to use it.

Therefore we recommend:

1. that the Commission remove all reactor technology from the restricted data category, including such areas as fuel element fabrication and processing techniques, leaving specific military applications of such technology to be protected, insofar as national security is involved, by the defense classification system;
2. that the Joint Committee reexamine the concept that atomic information in all fields is "born" classified; we believe that this concept is not compatible with the expeditious action required to permit rapid development of peaceful uses of atomic energy; and that therefore this concept should be limited to the design, manufacture, or utilization of atomic weapons; and
3. that the Joint Committee require the Commission to undertake the compilation of both classified and unclassified information relating to peaceful uses of atomic energy on a continuing and current basis so that it can be available in ready reference form for those entitled to use it.

Research and Development

During the present transition from all-Government to Government and private responsibility for the conduct of applied research and development relating to the peaceful uses of atomic energy, a more equitable sharing of the burden should be the constant objective of the Commission and of industry. The research resources of the Commission should continue to be directed to exploration at the frontier and at the same time be available to insure that no promising area is left unexplored or receives insufficient effort to meet the national interest.

For industry to bear its responsibility, it must have facilities, personnel, current and full information, and detailed knowledge of Commission programs as they relate to peaceful uses. Normal competitive incentives must be available. To hasten progress a two-way flow of information between the Commission and industry is essential.

Continued expansion of basic research is, of course, essential to future progress. Such research should continue to be supported vigorously by the Commission in the university centers where, historically, the dual function of advancing fundamental knowledge and education has flourished.

In order to achieve these objectives, we recommend:

1. that basic research in universities be given generous support, both in funds and facilities, through all normal channels to insure

continued expansion of fundamental knowledge in the fields related to the peaceful uses of atomic energy;

2. that the Commission be encouraged to place research and development contracts with universities and other private research centers—even in advance of actual construction of such facilities—in order to expand total research efforts and to aid in the prompt establishment of such private research capabilities; should additional contract authority be necessary, appropriate amendment of the 1954 act should be made promptly;

3. that the Commission be encouraged, and, if necessary, required to state its research and development objectives and programs in detail on a current basis so that industry can have a firm base in knowledge on which to make its decisions; and

4. that the present Commission laboratories continue to be supported as vital national assets for assuring the expeditious exploration of atomic energy. For exploration of our peaceful atomic resource, these laboratories, however, must be used to encourage non-Commission research capabilities as they develop. Their objective must continue to be research at the frontiers so that they can make the maximum contribution to peaceful and military applications of atomic energy.

Manpower; Education of the Public and the Individual

Whatever limitations are imposed by present secrecy rules on other aspects of the development of the peaceful uses of atomic energy, there can be no doubt that sufficient information now exists in unclassified form to serve as texts for the most advanced college courses in nuclear science and engineering.

Having noted the need for more nuclear scientists and engineers, and having noted that present college programs are not adequate to supply them, the consideration of various alternate solutions is in order.

An all too normal tendency is to "view with alarm," to consider every problem in every field a crisis, and to call for crash program solutions.

America's multitudinous forums of public opinion are now at work on the important task of searching for an answer to the problems of higher education in a free society. We believe the Nation will find the answer in a variety of ways, not in any single master plan.

We feel that nuclear scientists and engineers will be important to the Nation in the years ahead. It will also be important to train scientists and engineers in many other specialties as well. Further, scientists and engineers are an important element, but only one of the elements of a free society. Our social sciences and cultural arts need equal emphasis to aid us in adapting to conditions and tensions of the atomic age—both military and peaceful.

The balanced society is the society which serves all its members best and uses all their talents.

Our recommendation here, as on other subjects, is balance. Specifically we recommend:

1. the encouragement of orderly and determined efforts on the part of all concerned to increase the output and improve the quality of scientists and engineers capable of contributing to the development of peacetime atomic uses;

2. that the Commission continue support of university research and graduate study; we urge that private enterprise likewise give them support;

3. that the facilities of the national nuclear laboratories be made more widely available to support college training programs; and

4. that recognition be given to the need for additional research reactors and other facilities. In addition to facilities required for use on college campuses, we would consider it wise to design, locate, and operate future research facilities, and especially reactors, in such way that they can be of the greatest use to the greatest number of college and graduate students.

Hazards, Protection, and Insurance

The possible hazards from peaceful uses of atomic energy range from minor to catastrophic. Hundreds of applications in the fields of medicine, agriculture, and industry can apparently go forward under present regulations and standards with no serious risks.

There is urgent need for better data, however, and every effort to expedite its development should be made by the Commission and all other responsible public and private groups involved in development of peaceful uses. Every argument for changes in standards should be explored fully in competent forums to insure that no lead is left unexplored and that real doubts are resolved for maximum public safety.

Federal, State, and local authorities must continue to cooperate closely in the establishment and enforcement of the best uniform radiation health standards which can be developed. There must be balance between the conceivable and the actual hazards, however, and for some years to come the Federal Government will certainly have the responsibility of establishing this balance. This is not the sole responsibility of the Commission, but a joint responsibility of all Federal agencies involved or affected.

We are not satisfied that the time has yet arrived to reconsider the need for a Federal atomic insurance program covering peaceful uses. We have noted with interest recent plans of private insurance companies to deal with these problems. Such efforts should be encouraged. At least 2 and possibly 3 years remain in which to conduct research and accumulate knowledge and experience before any substantial private activity can be delayed or stopped because of inability to obtain adequate insurance. In fact, implications that the Government is prepared now to take on the insurance burden might stifle vigorous private efforts to meet the problem. We look on a Federal atomic-insurance program as a threat to private atomic enterprise, not a benefit. It is a last resort not yet called for and one which may not be needed.

Therefore, we recommend:

1. that the Commission be encouraged to step up its program of research into the causes, effects, and control of atomic hazards; the 2 or 3 years remaining before any full-scale "demonstration" atomic powerplant comes into operation must be used to obtain the maximum amount of information in order that both those concerned with protection against harmful levels of radiation and those concerned with providing insurance to cover such damage

as may occur can have the most advanced knowledge possible at the earliest time; and

2. that the Joint Committee and the Commission continue to encourage the insurance industry to develop ways of meeting atomic-insurance problems entirely within the concepts of private enterprise.

Ownership of Special Nuclear Materials, Licensing and Regulation

Ownership of all special nuclear materials by the Federal Government is now desirable and useful, but at some future time the factors motivating such Federal ownership may change. We would expect that continuing review of this statutory finding would result in its abandonment at some future date.

We have noted that while it is desirable to construct a sound licensing system as rapidly as possible, contracts for private possession and use of Government-owned special nuclear materials could provide, in addition to financial terms, all of the conditions necessary for protection of public safety and national security. The emphasis in the 1954 act on licensing is sound as a means of establishing equality of treatment of private participants, only if it is recognized that licensing rather than Federal ownership is to be the future course.

Despite recognition of the fact that there is no evidence of anyone now being injured by the licensing provisions of sections 103 and 104, the principles involved in these sections, in our opinion, conflict with the principles of private enterprise which the 1954 act has been represented as advancing.

As the peaceful uses of atomic energy expand, public safety requires establishment of minimum Federal standards on radiation dosage and equipment design. Enforcement on a uniform basis should be shared with State and local authorities as rapidly as possible. (Assignment of responsibility for various aspects of standards and enforcement is discussed in chs. 14 and 18.)

Delays in clarifying for American businessmen what they can do or what they can discuss with potential foreign customers with respect to peaceful atomic applications further impair incentive for development of industrial manufacturing potential at home, and the leadership of the United States in these fields abroad.

We therefore recommend:

1. that the Joint Committee on Atomic Energy create statutory devices to insure a continuing review of the present policy of Federal ownership of all special nuclear materials in anticipation of the establishment of private ownership;

2. that the 1954 act be amended to permit initiation of proceedings for the determination of "practical value," as required in section 102, by private citizens as well as by the Commission, limiting the definition of "practical value" to technical considerations;

3. that the Commission, and other appropriate Federal departments and agencies, work with State and local authorities to establish uniform safety and health regulations and enforcement relating to peaceful uses of atomic energy; and

4. that the Joint Committee on Atomic Energy revaluate now the propriety of the controls on the activities of American business in foreign countries imposed by section 57a (3) of the 1954 act, over and above those controls established by other provisions of the act relating to control of information.

Financial Environment

The selection by the Commission of research and development projects is significant in affecting the financial environment surrounding development of peaceful uses of atomic energy. Research performed by the Commission and access granted to the results can take the place of work which otherwise would have to be performed by private investors.

Guidance related to research conducted in Commission laboratories for itself and for others should be given by the Congress on three points: the priority to be accorded civilian versus military research tasks; the desirability of creating additional Commission facilities to conduct peaceful research as an alternative to other devices, such as direct Government financial aid to private industry to develop such research facilities; and priorities as between potential private applicants for research in Commission facilities.

Without such guidance, the Commission is placed in a position to exercise influence over the economics of private ventures which may lead to charges of favoritism, partiality, and mismanagement of Government resources. This is an excessive responsibility to place on the Commission. It is almost certain to lead to an overly cautious attitude on the part of Commission personnel.

The establishment of priorities for making available Commission facilities for processing, fabricating, separating, or refining source, byproduct, and special nuclear materials should follow the standards of urgency applied to peaceful uses requiring these services. Conflicts between Commission and private requirements for such services should also be considered in the context of the organizational problems discussed in chapter 18.

With respect to Commission support of research and development in licensed facilities, we have concluded that only in this way can the Commission assure that exploration of the frontiers of peaceful atomic uses will move forward with sufficient impetus. Investment of Commission research and development money in both small and large private "demonstration" atomic powerplants seems to us to be sound national policy.

The Commission can seek to meet its own requirements for products and services of a military nature by contracting with industry. There may be some question, however, as to how useful this form of financial encouragement can be to peaceful uses development, except for the value resulting from the training of skilled personnel.

Waiver by the Commission of charges for fuel inventories and consumption could be of substantial financial assistance in the development, construction, and operation of experimental, medical, research, and "demonstration" facilities. This device now has limited effect because the Commission is considering the exercise of its discretionary authority only in relation to fuel consumption.

Military requirements for uranium are the present reason for ore-price guaranties. A free market should be the objective for the era of expanded peaceful uses without guaranties.

As an alternative to price guaranties in accomplishing the transition to a free market, tonnage guaranties based upon military requirements should be considered. Any guaranties should be reviewed annually and extended on a 5-year moving basis only if justified by military requirements.

Commission authority to establish guaranteed prices for production of special nuclear materials in licensed facilities is a powerful financial device which has a material bearing on the economics of atomic power. The Commission has exercised its pricing authority in a conservative manner so as not to lay the foundations for a long-term subsidy to the atomic-power industry. The wisdom of this cannot be examined publicly unless the entire supply and demand picture can be declassified. We are not critical of the Commission's prices, but we think it undesirable for a financial device of such far-reaching significance to be hidden from public examination.

The authority of the Commission granted by section 81 of the 1954 act to distribute radioisotopes and fission products with or without charge has been exercised with beneficial effects in the sale of radioisotopes at 20 percent of cost for medical research. We can think of no better way to increase the rate of development of many peaceful uses of atomic energy in the years immediately ahead than by extending this same policy to all research in the fields of general science, agriculture, and industry, as well as to diagnostic and clinical uses in the field of medicine. This may be an ideal way for Government to speed exploration of potential new resources and to aid humanity at modest cost.

Other financial devices, direct and indirect, controlled both by the Commission and by other Government agencies, can be used as necessary to improve the financial environment and speed development of peaceful uses of atomic energy.

We recommend that:

1. the Joint Committee review the 1954 act, in light of the priorities for development of various peaceful uses set forth in our report, with a view to providing clear guidance to the Commission on the relative priorities of military and peaceful uses and between various peaceful uses;

2. the Commission provide financial assistance under section 31 of the 1954 act for the conduct of research involved in one "demonstration" of each major type of utilization facility insofar as such assistance proves essential to private participation in such projects;

3. the Joint Committee, in considering future Commission requests for long-term contract authority for the procurement of materials and services from industry as an alternate to building additional Government facilities, bear in mind that in some cases it may be unsound to encourage private enterprise to focus its attention on Commission military needs not compatible with the ultimate direction of peaceful uses;

4. the Commission waive all charges for fuel used in experimental, medical, research, and "demonstration" facilities where

such facilities are owned by nonprofit institutions and used substantially for educational or medical purposes;

5. the Commission recognize that military requirements for uranium are the present reason for ore-price guaranties and that a free market should be the objective for the era of expanded peaceful uses without guaranties; that the Commission, as an alternative to price guaranties in accomplishing the transition to a free market, consider tonnage guaranties based upon military requirements; any guaranties should be reviewed annually and extended on a 5-year moving basis only if justified by military requirements;

6. the guaranteed price schedules for the production of special nuclear materials be declassified to make possible public examination of this important financial device;

7. the Commission sell radioisotopes at 20 percent of cost for use in all research in the fields of general science, agriculture, and industry, as well as in diagnosis and clinical use in the field of medicine; and

8. the study prepared by the Department of the Treasury be examined as a valuable exposition of important and often-misunderstood financial techniques. (See vol. 2, ch. 16.)

PATENTS

Patents can stimulate private investment in the development of peaceful uses of atomic energy. The absence of clear patent policies or ambiguity in administration can seriously retard. The 1954 act for the most part accomplishes the same objectives as the normal patents system and at the same time protects the public against unwarranted abuse or monopoly. Return of patents on peaceful atomic applications to the normal system must be the objective. In the meantime, prompt and definitive statements of Commission patent policy are currently more essential than revision of the patent provisions of the 1954 act.

We recommend:

1. that the Commission announce its complete interpretation of patent provisions relating to private development of peaceful uses promptly, not on a piecemeal or case-by-case basis;

2. that the Commission notify inventors promptly as to the intentions of the Government with regard to the filing of applications for patent rights in foreign countries on inventions to which title in the United States rests with the Commission and authorize the inventors to file applications for patent rights in foreign countries where the Commission chooses not to do so; and

3. that the complete review of the patent provisions of the 1954 act by the Joint Committee be set aside until the expiration date relating to the reserve power compulsory licensing provisions in section 153 (h)—September 1, 1959—is closer at hand. There are many other important policy issues which require more prompt attention.

Government Organization

The peaceful uses of atomic energy affect the functions of almost every department and agency of the executive branch and all of the corresponding committees of the Congress. Organization of both branches of our Government must be directed toward acceptance of the fact that the era of atomic centralization in the Government in general and the Commission in particular ended with the decision to press forward with peaceful uses.

There is no actual focal point in the Commission for the integration of policies and programs related to peaceful uses comparable to the focus and impetus provided for military applications. Yet the urgency for exploration of both is rapidly approaching equality as a matter of national policy.

In the transition from primarily military orientation to dual emphasis, the speed with which the Congress recognizes problems and adjusts legislative policy will be of great importance in determining the rate and continuity of progress. The need for a mutuality of understanding between the Joint Committee on Atomic Energy and the Atomic Energy Commission and for leadership on the part of both to a common end is of greater importance today than ever before.

We therefore recommend:

1. that the Commission provide a real focal point within its organization at which are concentrated authority and responsibility for defining the integrated objectives for research and development of the peaceful uses of atomic energy, both at home and abroad, for establishing definite requirements with time scales for accomplishment of these objectives, and for assuring expeditious execution of the necessary programs and projects;
2. that other departments and agencies of the executive branch be encouraged to develop their own organizations for dealing with their functional interests in peaceful uses of atomic energy, drawing upon the Commission for advice and services rather than leaning on the Commission or delegating their functions to it;
3. that the Joint Committee on Atomic Energy continue to serve the Congress as a mechanism for balancing the interests of the Nation in both peaceful and military atomic pursuits and for providing the Congress and the Nation, through hearings, reports, and by other means, with a constantly expanding but realistic understanding of the import of peaceful uses of atomic energy to the American way of life, economy, industry, employment and natural resources, and to our international leadership; and,
4. that the Joint Committee on Atomic Energy recognize deficiencies in law, act expeditiously to make appropriate adjustments and clarification in law, and provide the Commission and other agencies and departments of the executive branch concerned with peaceful uses of atomic energy with opportunity for sympathetic consultation, as well as conducting continuous critical but constructive evaluations.

CHAPTER 1—CURRENT FRAMEWORK FOR THE DEVELOPMENT OF PEACEFUL USES OF ATOMIC ENERGY

1.1. HISTORY, 1939–56

The inherent possibilities of releasing atomic energy have been suspected for many years. But only since 1939 have the real prospects for using atomic energy begun to unfold. The atomic age began in 1939 with the discovering of nuclear fission, an event which coincided with the outbreak of World War II.

From a start in research in 1939, motivated in the scientific community primarily by the great peaceful potential, atomic activity became almost exclusively military during the period between 1941 and 1945. Though achievements were made relating to the metallurgy of uranium, plutonium, and other new materials, and to the application of many beneficial effects of radiation to people and materials, most of the $2 billion spent during World War II on atomic energy was initially directed toward development and production of weapons essential to our survival as a free nation. Many wartime laboratories and plants were built for purely military objectives and had a short useful life. Other facilities adaptable to peacetime uses had the characteristics and efficiency required for permanent use.

World War II ended with the world in a state of physical and emotional exhaustion. Nowhere was this more clear than in that part of the American scientific community devoted to development and production of the first atomic bomb. Scientists, engineers, and those with newly acquired atomic production know-how, were deeply affected by the magnitude of what they had done. The result of isolation, secrecy, fatigue, repugnance, and accomplishment of the wartime goal was a general feeling of letdown. Hundreds of key wartime employees left United States atomic technological centers with a sense of relief and escape.

Behind, they left a vacuum. There was no national policy, no direction of national atomic effort. Those who remained had their hands full just keeping a semblance of a program together. National and international attention was focused in 1946 on the American proposal to put atomic energy under international control. Soviet rejection of the proposal caused the concentration by the United States on military uses of atomic energy. This reorientation toward military uses was not fully appreciated by some American people for months, by the rest for years.

During World War II, in moments of relaxation, many scientists had explored ideas of peaceful uses of atomic energy. They tended to minimize, however, the complexities of converting these ideas into properly engineered accomplishments. The task proved larger than expected, and there was no concerted program in the immediate postwar period to put intense efforts into development of nonweapon uses. These uses included low-cost electricity from the atom, and propulsion of aircraft and true submarines. Meanwhile, the American people were barraged with fabulous stories. Expectations ran high.

But during the years from 1946 to 1949, the public saw none of the much-publicized peaceful uses come into general use. Predictions failed to materialize rapidly. By 1949, men in the street throughout the world assumed that atomic energy meant only weapons, weapons more terrible than ever known. Atomic energy was a mysterious something not to be understood by everyday folks. It became a symbol—especially abroad—of sheer military might. This attitude in large part was due to the intense veil of secrecy which in 1946 was drawn around the nuclear field by the first comprehensive law governing atomic energy.

The Atomic Energy Act of 1946 reflected all the high hopes of that time for peaceful uses and for international control. At the same time the 1946 law made all atomic development an absolute Government monopoly; it placed complete authority in the hands of a five-man civilian Commission. Strong emphasis was placed on making atomic weapons our paramount national defense. Only 1 responsible public body was entitled by law to have all the facts: the new 18-man Joint Congressional Committee on Atomic Energy. As administered during the 1946–49 period, the 1946 act effectively barred creation of a public opinion informed on atomic energy. Frequent reassuring statements by public officials encouraged the public to have confidence that the American atomic-energy program was sufficiently vigorous and productive. Such statements tended to confirm the popular view that an informed public opinion was not necessary to sound national atomic policy for peace or war.

During the 1945–49 period—while Russia was energetically building up an atomic military capability—advocates of increased atomic-weapon research and production in the United States, meanwhile, met stiff resistance. Even top military policymakers did not think in terms of large stockpiles of nuclear weapons.

With the announcement in September 1949 of the first Soviet atomic-weapon test, the Western World—especially America—was shocked to discover that Russia meant business. The American reaction took two turns: the one, feverish stimulation of atomic weapon research and production; the other, a wave of fear of Communist infiltration. Charges of espionage and subversion became commonplace. Many scientists and engineers who had been of a liberal turn of mind during the depression years of the thirties believed themselves open to public attack. It became a significant depressing force in the research and development community. This climate of suspicion was enhanced by the uncovering of the actual Soviet spy achievements of Dr. Klaus Fuchs and others who had worked on the United States wartime atomic project.

On the other hand, an attitude toward national defense approaching that of wartime began to take shape around the beginning of 1950 and was emphasized by the outbreak of hostilities in Korea later in that year. Larger expenditures for national defense were again acceptable to the American people. Uranium 235 and plutonium production facilities were expanded full speed. The military were urged to expand their procurement of atomic weapons. Research on thermonuclear weapons, revived from the doldrums, was given top national priority. At the same time, the program for atomic submarines and aircraft finally began to get support of the kind needed to get results. Thus, for the first time, major effort began to be devoted to atomic military developments which could also have peaceful uses.

With the prospect of achievement of usable atomic propulsion systems for the Navy and Air Force, and of atomic electric-power-generating units for remote military bases, American industry began in 1950 to move onto the atomic scene in force. Several companies had operated production plants and carried on research activities under Government contract. Undoubtedly, part of their compensation for this effort lay in the hope that someday this background knowledge would give them a substantial background for the development of peaceful commercial uses of atomic energy.

From 1949 on more and more companies began to interest themselves in the peacetime atom. Manufacturers saw a prospect of producing substantial numbers of atomic power and propulsion plants for the military, and saw also the later prospect of civilian customers of comparable devices.

By the end of 1953 it was clear that American private enterprise was interested in carrying forward some portion, as yet undefined, of the burden of developing some applications of atomic energy requiring large research and development investments.

In partial response to requests of private industry, but before this private interest came into clear focus, however, the Congress revised the law, adopting the Atomic Energy Act of 1954. This sweeping revision replaced a relatively simple Government monopoly with a complex structure for regulation of private activities. At the same time, it gave wide discretionary authority to the Commission to stimulate and aid private development. The new law called for an extensive shift in attitude from the previous exclusive emphasis on military uses by the Commission. Many new provisions required Commission interpretation and action before industry could tell what it could or could not do. The task of carrying out the new peaceful responsibilities competed for the time of the Commission organization; it competed with the continued conduct of the vast operating responsibilities of research, development, and production in connection with the military program of which the Commission had in no way been relieved.

To some extent, the 1954 act anticipated a state of atomic technology not yet actually achieved even now, 18 months after its passage. On the other hand, it was barely completed soon enough to give the United States the flexibility needed to maintain leadership in the international scene. The enthusiastic worldwide reception

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accorded to the United States proposal in December 1953 for peaceful international atomic development indicated that the people of the world were weary of living on substandard scales in the constant shadow of another global war. Some other nations appeared determined to get on with peaceful uses of atomic energy without awaiting accomplishment of broad international controls. However, some byproducts of such peaceful uses, particularly of atomic powerplants can, nevertheless, be diverted to the manufacture of atomic weapons. It remains to be seen whether the desire to get on with realization of the benefits of peaceful uses of atomic energy will force establishment of an international control mechanism as the United States has been urging and must continue to seek, or whether, instead, the world will add this military potential to other military risks already in existence.

1.2. INTERNATIONAL VERSUS DOMESTIC PRESSURES AND ATTITUDES

The pressures in the United States for development of peaceful uses of atomic energy differ somewhat from those in other countries. The United States has most of the elements of a prosperous economy. Supplies of fuel and food, efficient productive capacities, and efficient distribution of goods, for example, are basic national strengths. There is no current urgent need for new sources of fuel for the production of electric energy.

However, our present relative abundance of other energy sources has not lessened interest in realizing the potentialities of this new source of energy. Intelligent and consistent effort to develop this new source of power will assure that the growing energy demands of a dynamic and expanding economy will be fully met without the need of resorting to future crash-development programs.

The Federal Government spends freely for research and development, however, primarily only in relation to national defense. The scientific community has grown accustomed to this pattern in less than two decades. Many scientific and engineering achievements useful for peacetime purposes have been byproducts of military efforts.

In many foreign nations the pressures are quite different. England needs atomic power now, for it is running low in the production of coal and has no domestic oil supply. Many underdeveloped nations lack either adequate conventional fuel resources or the industrial complex needed to exploit them. Most parts of the world are not yet at the point of possessing adequate food supplies. To some countries, atomic energy offers the means of maintaining standards of living which might otherwise fall in the next decade. To others, atomic energy offers a possible shortcut on the difficult road to industrialization and higher living standards.

But in some areas of peaceful atomic application having humanitarian aims, all people have common interests. These are the areas where the least emphasis has been placed on secrecy. Steady, although relatively unpublicized progress has been made in basic scientific fields—especially medicine, public health, agriculture and animal husbandry. Small investments are already yielding significant returns. In industrialized nations, such as Sweden, England, and the United States, progress has also been steady in general industrial applications of atomic energy. Radioisotopes and radiation devices are already adding substantially to industrial efficiency in scores of goods-producing activities.

1.3. PRESENT GOVERNMENT POLICIES

American development of peaceful uses of atomic energy exists in the context of complex pressures, all of which must be understood if the whole pattern now and in the future is to be appraised realistically. Important among these is public attitude. Secrecy and atomic matters were long associated in the public mind. From 1954 onward, this situation began to correct itself. By passage of the 1954 act, the Congress in a sense invited expression of public and private attitudes, problems, and pressures. Public hearings before the Joint Committee in February and March 1955 demonstrated the caution and hesitancy of private citizens in expressing their opinions of actions of the executive and legislative branches of Government in dealing with the development of the peaceful uses of atomic energy.

The principal burden for the shift from atomic monopoly and concentration on military applications to normal patterns was placed on the Commission. This one agency has the task of transforming itself from an orientation strictly military to an orientation at once military and peaceful.

The rate of development of peaceful uses of atomic energy in the United States, for employment both at home and abroad, is controlled by nontechnical factors as much as by technical developments. There are important nontechnical areas in which Government policies play a controlling role.

1.3.1. Ownership of Material

The 1954 act, as did its predecessor, the 1946 act, gives title to all special nuclear materials to the Federal Government. The charges made for possessing or using such materials and prices paid for the production of new special nuclear materials—even the prospects for availability of such materials—are determined by the Commission. Private investors can own plants but not the special nuclear material needed to run them.

The 1954 act precludes the growth of a free market in special nuclear material, hence forces private industry to depend on the Commission for its economic future. The duration and character of the assurances of availability of materials and charges and prices for materials are controlled exclusively by the Commission.

1.3.2 Licensing and Regulation

In another manner the Commission can also influence the rate of development; namely, through discharge of its licensing and regulatory functions. The Atomic Energy Commission is not sufficiently advanced in its development of licensing procedures and in the promulgation and enforcement of regulations, however, to permit evaluation of how licensing and regulatory authority will be exercised. Nor is industry yet at the point where Commission administration of its licensing and regulatory authority is being tested. Nevertheless, these are clearly potential mechanisms for exercise of Government influence on the rate of development of peaceful uses of atomic energy.

1.3.3. PATENTS

The American patent system is designed to serve as a stimulus to private initiative and invention. In the field of atomic energy, however, private patents derived from any relationship with the Commission can be obtained only if the Commission waives its claims to the inventions. Until September 1959, the Commission or other interested parties can take action to force the private patentholder to make his patent available to other potential users. These are departures from the normal patent system. To this extent the incentives of the patent system for exercise of private initiative in the development of peaceful uses of atomic energy differ from those on the normal industrial scene.

The Commission has authority, however, to prescribe in advance the conditions under which it will exercise its rights to new atomic inventions. A mechanism has, thus, been provided for almost complete restoration of patent normalcy. The Commission has waived its claims to private inventions arising out of licenses, purchases of radioisotopes, and access to confidential restricted data. Such patent-policy decisions by the Commission can affect the rate of development of peaceful uses by private inventors.

1.3.4. RESEARCH AND DEVELOPMENT

Though patent policy can influence the rate of private development in some degree, Federal policies on the conduct of research and development for peaceful uses of atomic energy may well be more nearly controlling.

These policies may be applied in two ways:

The Commission has statutory authority and responsibility to conduct such development either in its own facilities or by arrangement with others, including industrial organizations, universities, and private individuals. The results of all such research and development are public property. Access to these results is restricted only insofar as national security requirements intervene.

In contrast with private industry, the Commission has in existence large modern research facilities completely staffed. The Commission has authority to conduct research and development in these laboratories for private industry where such contracts will advance technology of interest to the Commission.

The Commission can take on such work in response to requests, make charges below cost and give private patent rights to private individuals financing such work. Military research projects and other projects of interest to the Commission can, however, completely absorb the Government laboratory capacity. Striking a balance between these two extremes is entirely within the discretionary authority of the Commission.

1.3.5. HAZARDS AND INSURANCE

The Atomic Energy Act of 1954 requires licensees to assume full liability for any damage resulting from licensed private activities. The Commission has no discretionary authority in this area. As peaceful uses of atomic energy reach a stage of technological development sufficient to permit commercial applications, the economics of such applications will come to depend in some measure upon the actions required to insure against potential hazards to safety and public health. Adequate knowledge of these hazards has not yet been fully developed, especially with regard to long-term effects of radiation, and radioactive contamination of humans, animals, and croplands.

The risks entailed in peaceful uses of atomic energy are thought by some prospective private licensees and insurance companies to be greater than can be covered by normal insurance. Exploration of ways of guarding against extremes of public liability and of means of assuming the full extent of such risks is in progress.

1.3.6. SECRECY AND CONTROL OF INFORMATION

One of the complicating factors in prompt development and application of peaceful uses of atomic energy is the interrelationship of much of the technology required for peaceful uses with the technology required for military uses. Information of military significance affects national security and is therefore controlled. Although the Commission is encouraged by the 1954 act to disseminate atomic technology as widely as possible, the Commission nevertheless has absolute responsibility for controlling atomic information, called "restricted data," in such way as to safeguard national security.

A complex information control system is in effect to assure that sensitive information is available only to those who need it in order to accomplish specific national security objectives. Inevitably, there must be included within this category any information which might either disclose American military progress and intentions or aid any potential enemy in accomplishing comparable ends with more speed and less work. Social, political, and national security pressures tend to discourage risk taking in dissemination of such information.

At the same time, potential private investors, denied or given only limited access to such information, fear that technical data of significance to the propriety of their own investments may be concealed from them by classification, and, thus, that much research effort and expense be needlessly incurred. Pressures, therefore, exist both for and against wider dissemination of technical atomic know-how. In balancing these pressures, the Commission and the Defense Department have within their complete control a powerful tool for varying the rate of speed of development and application of peaceful uses of atomic energy.

1.3.7. FINANCIAL ENVIRONMENT

Few peaceful uses of atomic energy have as yet any demonstrated profitability. The investment required in research and development frequently appears to be large, and the time necessary for profitable completion lengthy. The growth of a private atomic industry can therefore be influenced through direct and indirect financial inducements offered by the Federal Government. Among these are certain tax advantages, Federal Government financing of vital research and development, waivers of charges for special nuclear materials, placing of Government orders for atomic products and services with commercial organizations instead of filling them in Government-owned facilities, and assurances of firm future prices for atomic fuels and for production of special nuclear materials in licensed plants.

1.3.8. Manpower and Education

Regardless of how the Federal Government and its departments and agencies resolve all the factors for and against rapid development described thus far, one factor—which is not properly identified in atomic laws or national policy—may very well determine the overall rate of peaceful atomic development. That factor is the availability of enough men and women with the proper skills and training. Business and Government, military and peaceful uses are now in vigorous competition for scientists, engineers, administrators, and workers with special skills and training in the atomic field as well as in all fields of science and engineering. No exhaustive study of supply and demand for such people in peaceful and military atomic pursuits has been made. The Federal Government—through its actions and policies with relation to the support of education and by reason of demands it generates for such people—has vast influence in determining whether the realization of peaceful uses of atomic energy can be speeded. The substantive chapters of our report, which follow, should be examined in the light of this underlying factor of manpower supply and demand.

1.4. CURRENT FRAMEWORK FOR INTERNATIONAL DEVELOPMENT

The 1954 act authorizes the Federal Government to enter into specially negotiated agreements with individual foreign governments. These agreements, called bilateral agreements for cooperation, can provide for United States assistance in all peaceful uses of atomic energy including atomic-power reactors. There is also separate statutory provision for international military atomic arrangements with groups of foreign countries. The extent to which classified information can be given to foreign governments is balanced against the adequacy of the safeguards which these foreign governments can provide.

Thus all United States international activity in peaceful uses is on a government-to-government basis. American manufacturers on their own initiative cannot tell foreign officials or businessmen any classified information. Only in cases where an agreement between the United States and a foreign government exists can such classified conversations take place. And even then, the information must be limited to that covered by the agreement and must be exchanged only after Commission approval of the United States individuals or firms involved, and after designation by the foreign government of its authorized representatives or agents. Twenty-seven bilateral agreements exist, of which only three provide for exchange of atomic power information. Some countries are not yet in a position to do more than send students to the United States for training in colleges, universities, and the special schools set up by the Commission at its laboratories for this purpose. Others are ready to start building research reactors, roughly 50 percent of the cost of which the United States has pledged itself to finance.

There is nothing, however, to prevent United States citizens from discussing unclassified atomic information with any foreigner. There is nothing to prevent any foreigner from placing orders with United States manufacturers for atomic facilities or equipment conditional on approval of their respective governments under the provisions of present or future bilateral agreements. The availability to foreign countries of nuclear fuels, fuel fabrication, and fuel reprocessing from the United States is discussed in chapter 9. Nuclear fuel has been earmarked by the United States for foreign research reactors, and the Commission has indicated it expects to be able to furnish fuel for foreign powerplants (see vol. 2, ch. 2).

United States participation in any international agency for the development of peaceful uses of atomic energy requires further congressional action in the form of approval of treaties or passage of laws confirming executive agreements.

1.5. CONCLUSIONS

Government dominance of almost all uses of atomic energy—arising from the defense needs of the Nation—has been modified by the 1954 act. Now we are in a state of transition looking toward both Government and non-Government activities in development and application of peaceful uses. The framework for the transition, as contained in the 1954 act, needs continuous study and revision so that the statutory modifications required for future development of peaceful uses will be achieved smoothly rather than by drastic or abrupt action.

Suggestions for ways in which to modify the 1954 act and its administration are examined in this report, first from the standpoint of the various peaceful uses themselves, and then from the standpoint of the role of the Government. The net result is an indication of how the transitional framework should be changed, together with some suggestions as to the order in which the changes should be made for orderly transition.

CHAPTER 2—ATOMIC POWER

2.1. INTRODUCTION AND SUMMARY

The growth of electric power expresses in one simple index the American miracle of productivity and living standards. Our electric-generating capability has more than doubled since the close of World War II, and now stands close to 115 million kilowatts. If this rate of growth continues over the next 25 years, the atomic-power capability of the United States in 1980 could be larger than our entire electric-generating capacity now.

Yet so huge, so complex, so adaptive, so ever changing is the American economy that the coming of economic electric power from nuclear fission would probably have many beneficial and few, if any, disruptive impacts. Special impact of atomic power may be hard to isolate, 25 years from now, from the sum of the forces which will have come to bear on the power economy of the world's greatest energy user.

Within 25 years our total electrical output may have gone up 3 to 5 times. If so, the national investment in generating, transmission and distribution facilities will have risen from around $40 billion to between $125 and $210 billion.

Using forecasts favorable to a high rate of atomic-power growth, atomic reactors would, in 1980, still be generating less than a fourth of our power. Using forecasts pessimistic to the use of fossil fuels, steam powerplants then will still be burning more than 60 percent more coal than they do today.

Changes in the pattern of coal-mining employment are taking place now. There may be further dislocations by 1980, but, if so, they will result primarily from the mining of more tons of coal by fewer men—not from inroads of atomic electric power.

The oil industry could lose its entire electric-power-generation market, yet find this loss could be offset by 6 months' normal increase in total United States petroleum demand.

The economics of natural gas will probably make that industry happy to hand over its central electric station market to coal or atomic power. Fourteen percent of present United States natural-gas output, which can be upgraded to domestic and other more remunerative uses, is now burned by utilities at low prices. The gas-distribution industry may even turn to atomic reactors for manufacture of artificial gas by gasification of coal, in order to meet demands for gas at economic prices.

For the railroad industry, pithead electric-power generation and alternate means of coal transportation are more probable causes of dislocation than the capture by atomic power of a moderate share of a rapidly expanding power market.

Dislocations due to fluctuating demands may occur in the uranium-mining industry, but, if so, they can come only from changing military demands, rather than from the failure of peacetime atomic power to emerge as a substantial customer.

Cheap atomic power will never be free. Even with zero fuel costs, power users must still pay capital carrying charges, operating, maintenance, and transmission expenses. And to these taxes, must be added for private power producers.

Plant location is generally determined by labor supply, water supply, nearness to markets or raw materials. Low-cost electric power may, however, be the key to further mechanization, or to radically new processes in chemistry and metallurgy, thus leading to new industrial patterns not now foreseeable.

For all these many possible events to come to pass, the safety record of atomic reactors will have to be good. Thus, by 1980 atomic powerplants should already have blended unobtrusively into the metropolitan scene. The "insurance problem," stemming from potential hazards, then should have receded into proper perspective.

Atomic power may develop more or less rapidly than we suggest. If it grows more slowly, certainly it would have less impact.

Various forces in the domestic economy may require atomic power to grow more rapidly. We may need to press its growth to forestall disruption from quite unrelated—and unforeseeable—causes.

For example, the lower of the two power forecasts used in this report requires a 50-percent higher rate of coal production than the coal industry has ever achieved. Should problems of production facilities, manpower, or increased costs prevent coal from meeting the rising demand at competitive prices, nuclear power would come more rapidly.

It is not surprising that the prospect of generating electric power from nuclear fission has been greeted both with overoptimism and overpessimism. To some, atomic power seems to promise to remove all limits to our ability to produce and consume. To others, it raises the fear of obsolescence of capital investment and disruption of employment. Reflection upon the nature of our highly developed industrial economy and its adaptability to change makes it clear that there are no facts to support either of these extreme views.

If one thing is clear, it is that much still be done before atomic power becomes widely commercially competitive. Even then, atomic powerplants will have to be constructed in substantial numbers before they will have any significant influence on the American economy.

In the long run, such technological advances as nuclear power add impetus to the dynamic elements of economic expansion. From the crucible of change comes abundance. Sudden changes in established economic and social patterns seldom flow from any single technological advance.

No single forecast, no range of forecasts, can be devised at this stage of atomic-power development which will be conclusive—except to forecast that the manner in which the Nation approaches such developments will control the speed with which the benefits will come and the degree to which impact is felt. A generation from now we will probably be concerned with newer forces now just beginning to stir, as today we are concerned with power from nuclear fission. Among these forces may—or may not—be power from thermonuclear fusion, which is discussed in the next chapter.

2.2. TECHNOLOGICAL STATUS

We do not need here to inquire into whether electrical energy can be generated from nuclear fission. Technical feasibility has been established, both in the United States and abroad.

As of January 1, 1956, plans were well along for the construction in this country of three nuclear fueled "demonstration" plants totaling 400,000 kilowatts of electric-generating capacity; proposals were actively under negotiation for construction of four more such plants totaling 400,000 kilowatts.

The first "demonstration" plant should be completed in 1957. Others should be finished and in operation before or during 1960. Experience from their operation should tell how to make nuclear power commercially feasible—competitive with conventionally fueled plants. For the purposes of the panel's study of impact, we have assumed, and we believe, that atomic power will be demonstrated to be commercially feasible, and that a subsequent generation of atomic plants will be economically competitive.

That atomic reactors can be substituted for boilers burning conventional fuels was recognized as soon as it became clear that self-sustaining chain reactions could be brought about in proper assemblies of fissionable uranium. How to do it competitively has been receiving increasing attention in recent years and still taxes the ingenuity of those engaged in the research and development programs. The various experiments involved in the multiple approaches must follow one upon another in an orderly sequence. They are time consuming, complex, and frequently involve expensive special experimental facilities which must also first be designed and built.

The first large power-producing installations in the United States were for military propulsion systems for the submarines *Nautilus* and *Seawolf*. Cost of power was not a principal factor in these designs. These and other military reactor projects have contributed substantially to engineering and technical knowledge, but represent a course different from those which must be followed for civilian applications. The experimental efforts carried forward by the Commission for civilian power have benefited nevertheless from the knowledge developed in the military projects. By 1953, these efforts had advanced sufficiently to warrant the construction of the first large central civilian atomic-power station which would "demonstrate" the engineering, manufacturing, and operating problems involved in civilian nuclear plants. This is the pressurized water reactor plant being built at Shippingport, Pa., as a joint Commission-industry venture. It is due for completion in 1957.

Some of the early reactor experiments have been completed and have been supplanted by more advanced experiments. Proposals for construction and operation of "demonstration" plants, submitted by industry in response to a Commission invitation, are primarily based upon results of the research and development programs being carried forward by the Commission. Brief desciiptions of the various experiments and "demonstrations," both proposed and in process, are given in table I. The additional projects which may result from proposals to develop and construct small civilian atomic powerplants, having 5,000 to 40,000 kilowatts of electric-generating capability, invited by the AEC in the fall of 1955, are not yet available.

TABLE I.—*Civilian use reactor experiments and nuclear power demonstration plants actual or proposed as of the end of 1955*

Type	Sponsor	Power level kilowatts	Estimated cost[1] (millions of dollars)				
			Research and development		Fabrication and construction		Total
			AEC	Private	AEC	Private	
REACTOR EXPERIMENTS							
(a) Sodium reactor experiment.	AEC-North American Aviation, Inc.	[2] 20,000	[3] 8.4		[3] 5.0		13.4
(b) Experimental boiling water reactor.	AEC (Argonne National Laboratory).	[2] 20,000	16.1	------	3.6	--------	19.7
(c) Homogeneous reactor experiment No. 2.	AEC (Oak Ridge National Laboratory).	[2] 5,000	37.0	------	1.8	--------	38.8
(d) Experimental breeder reactor No. 2.	-----do-----	[2] 62,500	24.3	------	15.3	--------	39.6
(e) Organic moderated reactor experiment.	-----do-----	----------	2.0	------	------	--------	------
(f) Liquid metal fueled reactor experiment.	AEC (Brookhaven National Laboratory).	----------	------	------	------	--------	------
"DEMONSTRATION" PLANTS							
(a) Pressurized water reactor (in operation 1957).	AEC-Duquesne Light & Power; Westinghouse Electric Co.	[4] 60-100,000	59.6	------	32.25	15.5	107.35
(b) Boiling water reactor (in operation 1960).	Commonwealth Edison et al.	[4] 180,000	------	------	0	[5] 45.0	45.0
(c) Fast Breeder Reactor (in operation 1959).	Detroit Edison et al.-AEC.	[4] 100,000	3.45	------	0	[5] 55.0	------
(d) Pressurized water reactor (in operation 1959).	Consolidated Edison	[4] 140,000	------	------	0	[5] 55.0	55.0
(e) Aqueous homogeneous reactor (in operation 1962).	Pennsylvania Power & Light et al.-AEC.	[4] 150,000	(6)	(6)	(6)	(6)	(6)
(f) Sodium graphite reactor (in operation 1959).	Consumer's Public Power District of Nebraska et al.-AEC.	[4] 75,000	10.48	------	0	[5] 16.72	27.2
(g) Pressurized water reactor (in operation 1958).	Yankee Atomic Electric Co. et al.-AEC.	[4] 134,000	7.5	------	0	[5] 33.0	40.5

[1] Cost estimate covers start as of July 1953. Earlier costs for civilian application reactor experiments total $21.3 millions.
[2] Thermal.
[3] Allocation not given. AEC participation in total, $10.55 millions; NAA participation, $2.85 millions.
[4] Electrical.
[5] Represents total private participation, portion allocated to research and development not given.
[6] Estimate not available.

The competitive status of electricity generated from atomic energy cannot be appraised until actual construction and operating experience is in hand. All we have now are calculations based upon plans. Taken together with known reactor technology and assumptions as to fuel costs, these calculations indicate that atomic power could be competitive wherever conventionally generated power costs are high. Long-term Commission policies relating to such matters as fuel costs and plant design are additional factors which will affect the general competitive status of nuclear power. These considerations are discussed in more detail in chapter 16.

Despite the fact that hundreds of millions of dollars have already been spent on bringing atomic power to its present state of development, it is clear that we are still at the beginning of this new art. Those most deeply involved in developing this new technology have called attention to the speed with which developments are coming and have cautioned that reactor types which appear most promising today will undoubtedly be improved and possibly superseded by experiments already underway.

2.3. ELECTRIC GENERATING CAPABILITY IN THE UNITED STATES

The usefulness of forecasts of the growth of the atomic-power industry in the United States depends upon the accuracy with which the growth of the total economy can be estimated. Particularly, they depend upon the accuracy of forecasting growth in those segments of the economy concerned with electric power.

Forecasts concerning a subject so vast and complex as the present study must be constructed of many assumptions. That these assumptions will have a high content of fallibility is obvious. Thus, there is little chance that any forecast can do more than give a fix or bearing.

We have examined many forecasts of the rate of growth of the electric-generating capability of the United States. We find uniformity mainly in their variability. Some underlying assumptions in every case are subject to question. Hence, we feel that it would be unsound to use any forecasts as more than indications of range and direction of the trend of the future electric-generating capability of the United States.

There is no assurance that the upward movement of our economy will continue, regardless of the environment prevailing. The net trend of the past 25 years has been upward. Since World War II our economy seems to have entered a dynamic phase sufficiently strong to provide momentum for continued growth. All forecasts of electric-power generating capability in the United States reflect with more or less optimism this confidence in growth.

We feel that the actual growth of electric-generating capability in the United States may fall within the range of existing forecasts. We do not assert that the lower limit will in fact be reached, nor that the upper limit will not be exceeded. We only say that a good measure of what seems reasonable lies within these limits. The guidelines provided by these forecasts outline the area within which nuclear power will have an opportunity to grow.

The two forecasts of growth of United States electric-generating capability which we have selected as indications of the lower and upper growth prospects are as follows:

Lower forecast

Estimated future power requirements of the United States (exclusive of industrial and railway generating capability) 1954–80, Federal Power Commission, October 1955. The peak loads in this forecast have been increased by 15 percent for reserves to arrive at figures for installed capability, and growth is predicated on an average annual increase of 4.9 percent.

Upper forecast

Forecast published in the issue of the magazine Electrical World, dated September 19, 1955. This forecast is for the period 1954–70 and is predicated on an average annual increase of 7.3 percent. It has been extrapolated at 6½ percent annual increase to 1980. This forecast is in terms of installed capability (exclusive of industrial and railway generating capability) and includes 22 percent reserves over peak demand from 1958 onward.

A summary of the two forecasts is given in table II and in figure 1, following. Fuller details are given in volume 2, chapter 2.

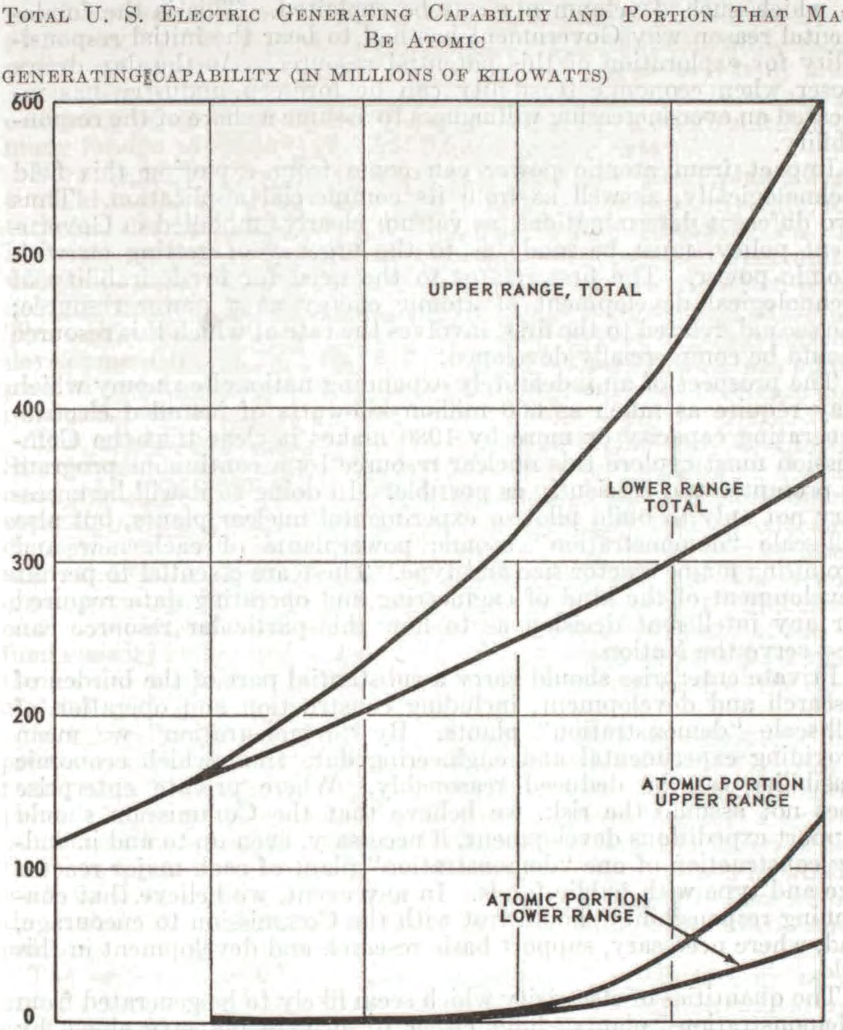
TABLE II.—*United States total electric-generating capability*

[In millions of kilowatts]

	Annual additions		Total installed capability	
	Lower range	Upper range	Lower range	Upper range
1954	11.3	11.3	103.7	103.7
1960	7.5	12.8	160.3	166.9
1965	9.5	14.8	203.6	232.0
1970	9.9	19.9	249.4	320.0
1975	11.2	25.8	301.2	438.4
1980	12.3	36.7	358.5	600.7

FIGURE 1

TOTAL U. S. ELECTRIC GENERATING CAPABILITY AND PORTION THAT MAY BE ATOMIC



2.4. GROWTH PATTERN OF ATOMIC POWER GENERATION IN THE UNITED STATES

For the growth of any nuclear power generating capability to occur in the United States, it must be firmly based on technological knowledge, and in engineering and operating experience. The required technological, engineering, and operating data can come only from research, development, and construction of plants of experimental, pilot and full-scale size. This takes time. New accomplishments in fuel fabrication and reprocessing, as well as in the broad fields of chemistry, metallurgy and physics are required. Experience of the past 5 years makes it clear that such developments can only be accomplished in an orderly way. Frequently they hold little immediate promise for private profitability, since there are as yet no markets in which such developments can be exploited. This is the fundamental reason why Government has had to bear the initial responsibility for exploration of this potential resource. As the day draws closer when economic feasibility can be foreseen, industry has indicated an ever-increasing willingness to assume a share of the responsibility.

Impact from atomic power can come from exploring this field technologically, as well as from its commercial application. Thus two different determinations, as yet not clearly embodied in Government policy, must be made as to the urgency of getting on with atomic power. The first relates to the need for or desirability of technological development of atomic energy as a power resource; the second, related to the first, involves the rate at which this resource should be commercially developed.

The prospect of an indefinitely expanding national economy which may require as much as 600 million kilowatts of installed electric-generating capacity or more by 1980 makes it clear that the Commission must explore this nuclear resource by a continuous program as promptly and efficiently as possible. In doing so it will be necessary not only to build pilot or experimental nuclear plants, but also full-scale "demonstration" atomic powerplants of each new and promising major reactor size and type. These are essential to permit development of the kind of engineering and operating data required for any intelligent decision as to how this particular resource can best serve the Nation.

Private enterprise should carry a substantial part of the burden of research and development, including construction and operation of full-scale "demonstration" plants. By "demonstration" we mean providing experimental and engineering data from which economic feasibility can be deduced reasonably. Where private enterprise does not assume the risk, we believe that the Commission should support expeditious development, if necessary, even up to and including construction of one "demonstration" plant of each major reactor size and type with public funds. In any event, we believe that continuing responsibility should rest with the Commission to encourage, and, where necessary, support basic research and development in this field.

The quantities of electricity which seem likely to be generated from "demonstration" plants—built either by private industry alone, by Commission-private combines, or by the Commission alone—are unlikely to amount to any significant proportion of the Nation's total generating capability. Present proposals for "demonstration" plants include every promising major reactor type on which sufficient experimental data exists to permit decision as to the advisability of full-scale plant construction. Yet total generating capacity from these plants will not reach 1 million kilowatts by 1960. This will, in fact, be only a fraction of 1 percent of our total generating capacity at that time.

The "demonstration" plants now underway are exclusively large—over 60,000 kilowatts—plants. Taken together, they constitute an orderly and sound exploration of atomic energy as a power resource for large integrated electric utility systems in mature industrial economies.

An invitation has been extended by the Commission for proposals for small to medium-sized atomic-power "demonstration" plants. Such plants, on becoming economically competitive, could constitute especially suitable power sources in the United States for small, nonintegrated or rural utility systems, and for single or remote industrial or mining power uses. As a type, they would be far more suitable in many foreign markets than large-sized nuclear plants.

We recognize that small and medium-sized atomic powerplants were thought less likely to be economically competitive at an early date, for technical reasons. The importance of such plants, however, on the international scene—as well as on the domestic—and the opportunity which they afford for a bold demonstration of United States technological leadership give their development a high sense of urgency. This subject is discussed in more detail in chapter 9. The present development program is therefore deficient to the extent that appropriate "demonstrations" of the small and medium-sized types are not now underway.

The urgency associated with accepting the challenge to United States world leadership, together with the need for establishing atomic energy as a power resource available to assist in maintaining maximum expansion rates of the American economy, require that an effective development and "demonstration" program of all major reactor sizes and types be carried forward at high priority. If progress is not expeditious and efficient, with private enterprise bearing its full share of the responsibility, it is clear that the Federal Government has a fundamental obligation to carry it out. Although private participation in this program is desirable, it should not be obtained at the cost of delay.

In this connection it must be pointed out that the prospects for profitable return on investment, at this stage of research and development, are admittedly not high. There are many risks uncommon to private industry which exist under the rules governing this stage of atomic-power development as set forth in law and as administered by the Commission. We discuss in subsequent chapters ways in which we believe a better balance might be struck in bringing to bear all of the managerial and technological talents of both Government and industry.

The urgency for commercial exploitation of atomic energy as a major power resource in our domestic economy will be determined by economic factors which are different from those significant in the urgency determination for technological exploration.

We have noted that electricity must be available for economic expansion. Availability of electricity at attractive prices may be conducive to even broader economic expansion. The presence of atomic energy as a competitive alternate power resource may have great influence on prices of conventional fuels, and in providing the Nation with a foundation for economic expansion soundly based on abundant energy supplies. Although the United States has conventional fuel resources, it can, of course, not now be clear whether these will continue to be available in sufficient quantities, and at costs favoring the maximum rate of economic expansion.

Around 1960 we should have adequate technological information at hand on which to base judgment of the economic possibilities of atomic energy as a power resource. After this date we should be in position

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to continue development and exploit atomic energy—at whatever rate the economy might require—as a source of electricity, and in competition with electricity from conventional fuels. Decisions made on the basis of data which should be available around 1960 could result in economically competitive atomic powerplants coming into operation 3 to 5 years later, or around 1965.

Thus 1965 marks, approximately, the earliest time at which widely competitive atomic-power generation is likely to begin in the United States.

The rate of growth of atomic-power-generating capability can be forecast by two principal methods: one is to assume that the atomic-power industry will follow the normal growth pattern of new technologies as they become economically competitive. Alternatively, an attempt can be made to analyze the various estimates which are available concerning the movement of the cost components of atomic power and the comparable cost components of conventional power, thus indicating when atomic power will become competitive under various postulated circumstances.

Here again the methods of forecasting are subject to considerable uncertainties. The first method depends solely upon judgment of the forecaster and the optimism with which he approaches the subject matter. The second depends upon tenuous assumptions of costs, future financial and political environment and market conditions. Both methods usually result in a growth rate expressed in terms of a percentage of growth of the total generating capability which, as we noted in the previous section, is in itself uncertain.

We do not believe that a study of the impact of the growth of atomic power requires the establishment of more than a reasonable range within which the actual growth of this capability may fall. For this purpose we have chosen upper and lower values as our basic range to define the area of impact, and where appropriate, have inquired into the effect of the uncertainties which are involved. This range is illustrated in figure I and is shown in table III. These values were derived from a basic study of nuclear growth rates prepared for the panel by a special study group. These data appear in volume 2, chapter 2.

TABLE III.—*United States atomic electric-generating capability*

[In millions of kilowatts]

	Annual additions		Cumulative installed capability	
	Lower range	Upper range	Lower range	Upper range
1960			Less than 1	Less than 1.
1965			Less than 3	Less than 4.
1970	1	3	5	9.
1975	5	11	20	45.
1980	8	23	52	135.

It must not be assumed that the median based upon economic factors used for the impact study is a forecast of the rate of growth of atomic-power-generating capability. Other factors may accelerate or retard the rate of growth. Among these other influences will be various Government policies, including the possibility of extensive programs for the construction of publicly subsidized or publicly owned nuclear powerplants. These and other factors of an accelerating or retarding nature are discussed in subsequent chapters dealing with the role of Government.

Nevertheless, it is interesting to note in table III that the amount of atomic power which may be in existence by 1975—only 15 years after the operation of the first generation of demonstration atomic powerplants and only 10 years after the start of an atomic-power industry—may equal 40 percent of the electric-generating capability of the United States today.

In 1975, however, the total United States electric-generating capability may stand between 3 and 4 times that of today. If the estimates of total 1975 electric-generating capability are compared with estimates of atomic power for that same year, the proportion of atomic power in 1975 may be somewhere between 5 and 15 percent of the total.

This section must end with a strong note of warning against attempts to extrapolate forecasts beyond the cutoff date used in this report. We have stated our reservations concerning the data from which the forecasts must necessarily be constructed. Our reservations increase as the forecasts advance further into the future. Twenty-five years from now totally unforeseeable factors may have come to bear upon the Nation's power economy.

2.5. THE IMPACT OF COMPETITIVE ATOMIC POWER

2.5.1. Introduction

With the advent of a new technology which makes possible exploitation of energy sources heretofore untapped, the possibility of great change in the economic environment becomes great. In a reasonably well developed environment, however, the capacity for accommodation of the new technology is usually equally great.

Before discussing the specific areas of potential impact related to the development of atomic power, several facts bear restating. An atomic-power reactor is a complex, expensive, and potentially hazardous machine. It is not a small black box in which one only has to put a lump of fissionable material. It cannot be transported in the luggage compartment of an automobile. It requires for its fabrication highly specialized techniques and materials. Its design demands a knowledge and ingenuity possessed today by relatively few people in the world. The task of bringing this source of power into reality is as great as is the challenge it offers to our society.

2.5.2. Impact on the Electric Power Equipment Industry

If total electric-generating capability in the United States increases as shown by the higher forecast in figure I, p. 35, and is all produced from conventional plants estimated to have construction costs averaging $150 per kilowatt, generating-equipment sales for the period 1960 through 1980 could reach over $65 billion.

If approximately 135 million kilowatts of the above total generating capability are atomic (see fig. I), it would result in equipment sales in the neighborhood of $27 billion. This figure includes reactors, turbines, generators, and related equipment (but not transmission and distribution), and is based on an estimated average capital cost per kilowatt for the 1960–80 period of $200.

Thus an increase in equipment sales volume of roughly $7 billion results from installation of atomic instead of conventional plants. This sum is equivalent to the sale of some 45 million kilowatts of conventional plant capacity.

Established equipment manufacturers have shown interest in this new technology. Their interest in practical exploitation is in keeping with the ready acceptance of technological change characteristic of the post-World War II period.

This ready acceptance of atomic power is in contrast with the slow acceptance of many previous important inventions. A contributing factor is customer pressure from operating utilities, based both on psychological and factual grounds. Another factor is the advantage to equipment manufacturers of staking out the competitive markets early.

This potential volume of specialized equipment sales has attracted new organizations to the field. Of these, many have had previous heavy equipment manufacturing experience; others are new, established specifically to enter the atomic-power field. To the extent that background technical information is available to industry, it would appear that the organizations just entering the field come into it with the same opportunity as established electric power equipment manufacturing firms. As a practical matter, this is not the case, however. Prime contractors to the Commission have already accumulated experience and personnel which should give them an immediate competitive advantage. However, competition between new and old and large and small companies engaged in the manufacture of atomic powerplant equipment and instrumentation is already keen. It will mount in intensity for the increasing long-term domestic civilian reactor business as it is now doing for more immediate foreign and military reactors.

Many factors enter into consideration of competitive capabilities. Government policies and legislation are important influences in this new field, which for so long has belonged exclusively to the Government and in which substantially all patents belong to the Government.

One factor which will influence the competitive capabilities of all manufacturers will be the availability of scientific, engineering, and specially skilled personnel. Because of its importance to the successful prosecution of the peaceful uses of the atom, this shortage will be given continuing mention in this report. This problem is not, however, peculiar to atomic power equipment manufacturers; hence the manpower situation is discussed as a whole in chapter 13. It is worth noting also at this point, because in some instances new entrants in the power equipment manufacturing field could gain competitive advantage solely by employment of specialists in reactor technology.

Equipment manufacturers, and those who would become manufacturers, are already experiencing a shortage of specialized manpower. At present, competition for such personnel can almost be said to exceed competition for reactor sales. The demand for specialists now employed directly by the Commission or by its prime contractors is high and disconcerting. Training of new personnel is underway but as now planned will probably not keep up with demand during the next 15 to 20 years in spite of formal education, Commission programs, programmatic retraining or on-the-job training.

2.5.3. Impact on the Electric Power Generating Industry

Atomic energy promises a whole new energy resource for the electric power generating industry. Despite the importance of this new resource, it appears that the use of atomic power will cause no major changes in the character or pattern of this industry. A kilowatt of electric energy at the consumer's light socket carries no characteristic which identifies the source of the steam used in the powerplant. Turbine and generator operation may not be substantially different as between atomic or conventional plants. If anything, present and even foreseeable atomic designs may force a return to lower temperature techniques.

The nuclear portions of civilian powerplants do introduce problems not associated with conventional plant operation. Factors controlling location of both types of plants include load centers and availability of cooling water. Atomic plants must also take into account the hazards peculiar to nuclear reactors. By drawing attention to this factor it is not intended to imply that unreasonable hazards are involved. It would appear that the extensive investigation of this problem, and the precautions being taken by the Commission in establishing safety criteria in each case make catastrophes highly improbable. Current insurance problems should become less significant with the accumulation of experience and knowledge, and therefore need not be long-term deterrents to atomic power growth. (See ch. 14.) The additional safety factor introduced by locating plants in areas where, in cases of accident, injury to personnel and damage to property will be minimal may have some minor effect on the power generating industry. Established patterns will not be greatly affected, however, as a result of consideration of safety and hazard problems. This conclusion is particularly applicable to areas where power systems are well integrated and interconnected, and therefore holds for all of the populous high-power-consumption areas of the United States.

Protective techniques to assure the safety and health of operating personnel are reasonably well developed and present no unusual burdens. Assurance that short- and long-term deleterious effects of radiation can be avoided rests on compliance with radiation dosage guides. The best opinions available indicate that the safety levels established do not materially add to the complications of plant operations. For more extended discussion of this particular subject see chapter 14.

We have already noted that it will not be possible to determine with any accuracy what the prospective costs of electricity from atomic energy are likely to be until the initial exploration phase is completed around 1960. It may well be that the adequate information will not be available until the second or third generation of such "demonstrations" are completed late in that decade. There is a possibility that these developments will lead to lower-cost electric generation. There is no prospect of free electricity: Generation, transmission, and other costs remain. We can conceive of developments which would result in prices below those now paid for electricity from any conventional plant. The stimulating effect that such low-cost power could have on the use of electricity could also be a force in continued rapid growth of the economy of the Nation.

We have examined the thesis that the possibility of low-cost atomic power might change the character of the utility industry by providing a competitive yardstick and stimulant to very rapid growth of demand and generating capability. It is our belief that the effect of low-cost atomic electricity on the utility industry will be no different than has been the effect of low-cost electricity from other energy sources, such as waterpower. While these developments have provided a starting point for new economic expansion and a stimulant to conventional generation at lower prices, we do not see any radical change in the character of the utility industry directly attributable to these developments. Such effects as are observed relate to the users of electricity more than the generating industry. (See General Impact Considerations at the end of this chapter, sec. 2.5.7.)

2.5.4. Impact on Conventional Fuel Resources

2.5.4.1. Conventional Energy Resources

As the world's largest energy user, the United States is fortunate in having some of the world's largest conventional energy resources. These are so large as to have tended to generate a national attitude of complacency about meeting future energy requirements.

Conventional fuel reserves of the United States and 1955 consumption, compared with the rest of the free world, are noted in table IV following. (For details see vol. 2, ch. 2.)

Table IV.—*Fossil fuel reserves and current consumption*

	Bituminous coal (million short tons) [1]	Oil (billion barrels) [2]	Natural gas (trillion cubic feet) [2]
	Total economically recoverable		
United States	950,000	120	725
Rest of free world	540,000	700	3,000
	Recoverable at present or near present costs	Proved reserves	Proved reserves
United States	237,000	35	212
Rest of free world	119,000	265	128
	1955 consumption		
United States	420	3.0	9.4
Rest of free world	1,200	2.2	0.7

[1] See Department of Interior Report, vol. 2, ch. 2.
[2] See Report on Petroleum Industry, vol. 2, ch. 2.

Of the total energy consumed in the United States—for electric power as well as for all other purposes—42 percent is supplied by oil, 29 percent by coal, 25 percent by natural gas, and 4 percent by falling water.

The United States economy is an energy-consuming economy; future economic growth will require higher energy output. Atomic energy may eventually be applied over much of the range to which conventional fuels are now applied, including propulsion (see ch. 7) and process and space heating (see ch. 8).

The specific impact of atomic electric power on conventional fuels is discussed in the following sections:

2.5.4.2. Impact on the Coal Industry

Central station power generation in 1955 accounted for 140 million tons of bituminous coal production or close to one-third of total United States bituminous coal consumption. It is estimated that the quantity of bituminous coal required for central station power generation will increase continuously during the next 25 years, if atomic power makes no inroads. The most serious effect on the coal industry would come about if atomic power achieved competitive status between 1965 and 1975, and rapidly captured the entire market for new generating capacity and replacement installations. It is this extreme which we now examine.

The degree of impact of such a development would, of course, depend on the size of other markets for coal at that time, as well as on other factors. To examine the significance of demand for coal for electric power generation, a forecast was prepared by the Department of the Interior for the panel. (See vol. 2, ch. 2.) This forecast indicates that during the period 1960 through 1975 coal consumption might be expected to follow the pattern indicated in Table V, following, if coal requirements for power generation are based upon the high and low values of the range shown in figure I.

TABLE V.—*Forecast of coal-consumption pattern*

[Millions of short tons]

	1955	1960		1965		1970		1975		1980	
		High	Low	High	Low	High	Low	High	Low	High	Low
Electricity	140	175	159	240	183	350	220	600	364	845	459
Coke	108	130		140		150		160		170	
Industrial uses	120	100		90		85		75		75	
Retail	52	45		35		30		25		20	
Exports	50	30		35		40		50		60	
Total	470	480	464	540	483	655	525	910	674	1,170	784

If atomic generating capacity grows as illustrated by the range forecast in figure I, the coal displaced by nuclear power and the net requirements for coal for power would be approximately as shown in table VI, following:

TABLE VI.—*Coal displaced by nuclear power and net requirements for coal for power*

[Millions of tons]

Date	Pounds coal kilowatt-hours	Coal required (see table V)		Coal displaced by nuclear		Net coal required		
		1 High	2 Low	3 High	4 Low	1–3	2–4	2–3
1960	0.95	175	159			175	159	159
1965	.90	240	183			240	183	183
1970	.85	350	220	23	13	327	207	197
1975	.80	600	364	86	38	514	326	278
1980	.75	845	459	232	90	613	369	227

It is immediately apparent that if the growth of atomic generating capacity reaches 135 million kilowatts by 1980 and if the total generating capacity approximates 600 million kilowatts by the same date, no disruption or dislocation in the coal industry can be expected. If this set of conditions prevails, a potential market for coal will be lost to the extent that atomic power displaces coal in the total generating capacity. The market for coal for generation of electricity will still be between 4 and 5 times the present power market for coal, hence this loss should not constitute a point of economic vulnerability or a focus of disruptive effects.

In order to explore the problem further, consideration should be given to the least optimistic situation from the standpoint of the coal industry. In this case, the total generating capacity of the United States follows the pattern of the lower values of the range given in figure I, and reaches 358 million kilowatts in 1980. At the same time atomic generating capacity might follow the pattern of the higher values given in figure I, reaching 135 million kilowatts in 1980. The portion of the power generation market which would be open for coal is thus seen to be 223 million kilowatts or almost twice the present total electric power generated today. In terms of coal, reference to table VI reveals that under these conditions 227 million tons will still be required for power purposes in 1980. Thus, in this case, the coal industry would have to supply over 60 percent more coal to the power industry than it is doing today.

In spite of a continued increase in bituminous production, the technological advances in the industry will in all likelihood continue to exert a strong influence on employment.

According to Department of the Interior estimates, present productivity averages 9 tons per man per day. In the most efficient mines, production reaches 20 tons per man per day for underground mines, and 40 tons per man per day for strip mines. Productivity, according to these estimates, is expected to increase at least to an average of 15 tons per man per day by 1980. The bituminous coal industry today employs about 360,000 miners. On the basis of 200 working days a year, the labor force required in United States coal mines for the period between 1955 and 1980 can be expected to decline to 320,000 people if total generating capacity rises from 115 million kilowatts in 1955 to 600 million kilowatts in 1980, of which 135 million kilowatts are atomic. On the other hand, under the least optimistic outlook for the coal industry, with 358 million kilowatts of total generating capacity in 1980, of which 135 million are atomic, employment could drop to 175,000 miners. The major part of this decline, however, would result from the normal downward trend which exists as an effect of the increased productivity per miner.

While this downward trend of employment in the coal industry is a problem undoubtedly already being considered in other quarters, it is important that the possible acceleration of this trend attributable to the potential growth of atomic power be given early recognition.

Some observers feel that there may be a plateau of bituminous coal production in the neighborhood of 550 million tons a year. On the basis of an average trend which has persisted since approximately 1940, bituminous coal production would presumably hold its absolute position at or around the 550-million-ton mark over the next decade. Coal thus may not be able to participate in meeting expanding demands for electric energy, except at the expense of other coal customers.

Furthermore, the downward employment trend in the coal industry may contain an element which presages for the United States the experience of other countries where men have become reluctant to work in the mines, thus making manpower a limiting factor in coal production. If indeed this should happen, it would appear that a total generating capacity in the neighborhood of 150 million kilowatts supplied by coal would represent close to the maximum possible based on this fuel, on the assumption that other demands for coal continue. The absence of other sources of energy would then effectively retard or prevent economic expansion unless and until coal production could be increased. Mechanization and improved methods of transportation may provide higher volumes of coal output at competitive costs. Certainly if economic growth is to continue even on a less optimistic basis than that which indicates a total power requirement in 1980 of 600 million kilowatts in installed capacity, a real challenge is posed for the coal industry.

The realization of nuclear power as a practical source of energy should be welcomed by the American people including those related specifically to conventional fuel industries. While in particular instances nuclear power may displace power generated from conventional fuels, in most cases it will provide a necessary supplement to those fuels in meeting the Nation's rapidly expanding power requirements. But even where it does displace conventional fuels, those fuels may find uses that are more profitable to those who produce them and of greater value to the Nation's economy. The gasification of coal is a good example. Using atomic energy as the heat source for that process, it may be possible to conserve our more limited and irreplaceable petroleum resources.

2.5.4.3. Impact on the Oil and Natural Gas Industries

Ultimate reserves of oil and gas in the United States, excluding the adjoining continental shelves, are presently estimated to total under 120 billion barrels and 725 trillion cubic feet, respectively. These estimates take into account significant improvements in recoverability which have been accomplished or appear to be in promise for the future. Current consumption of oil in the United States is around 3 billion barrels a year and consumption of natural gas is approaching 10 trillion cubic feet. Of this total, approximately 2 percent of the oil (including domestic and imported residual fuel oil) goes to the manufacture of electricity and 14 percent of the natural gas is used for this purpose.

Most of the natural gas that goes to the production of electricity is "off-peak" gas sold at a modest price, on an interruptible service contract. This permits pipeline operators to maintain proper working pressures and movements in the pipelines, and thus enables the lines to meet the peak-load demands of the higher paying domestic consumers. With gradual development of underground storage facilities as a means for maintaining pipeline operation, the sale of natural gas to the electric industry should show a corresponding decline. The residual fuel oil used by the electric utility companies is the end product of the distillation process, and provides a very low return to the domestic refiners.

In view of the rather small percentage of oil and natural gas used for the purpose of generating electricity and the progress being made toward reducing such low-profit use, it is unlikely that there will be any significant loss of revenue by the oil and natural gas industry due to the growth of atomic power. This conclusion is particularly true if one considers that, even should atomic power capture the entire market for new or replacement powerplant installations, existing plants requiring conventional fuels would serve out their useful lives. The more likely case that nuclear and conventional fuels will share the power generating market servcs only to strengthen the conclusion on impact just stated.

2.5.5. Effect of Nuclear Power on the Railroad Industry

Atomic energy may affect rail transportation in three ways: As a means of propulsion in locomotives; in generating electricity for railroad electrification; and through increases and changes in freight patterns as well as industrial growth which may be introduced as a consequence of a nuclear power industry. The use of atomic energy for locomotive propulsion is discussed in chapter 7.

The railroad electrification potentialities of atomic power are not significant. During the era of steam locomotives, railroad electrification did appear to present certain economic advantages. In comparison with diesel locomotives, however, electrification lost its advantage. During the 20-year period between 1955 and 1975 it is doubtful that this relationship will be changed significantly by the advent of atomic power. Even if atomic power costs do follow the most optimistic forecasts, other factors such as traffic densities and electrification costs will likely favor diesel or gas turbine operation over electrified operation.

Consideration, however, should be given to the effects on the railroad industry which may result from changes in the economy made possible by the growth of atomic power. Coal is the largest single commodity carried by railroads in the United States. It represents one-fourth of the ton-miles of traffic handled. Much of this coal hauled by railroads is used by the electric power industry. We have seen that coal will continue to be used in increasing quantities for electric power generation. Thus, if there are changes in coal haulage patterns, they will come about because of such developments as the location of coal-burning electric power stations near coal mines or along water routes, rather than from atomic power.

It is entirely possible that certain large industrial users of electricity may change their new plant location patterns because of flexibility afforded by atomic power. Such changes would be limited for the most part to those special situations in which power is a substantial contributor to the value of the product involved. Obviously, changes brought about under these conditions are more likely to affect new plants and would not normally mean abandonment of existing installations. Thus, while changes in railroad movements may occur, from the advent of atomic power, these will be overshadowed by the much greater changes resulting from the expansion of the overall economy.

2.5.6. Impact on Uranium Mining and Processing Industries

Uranium mining and milling have come of age as parts of the present extensive atomic energy complex. Government expenditures for geological studies and exploration, for proving of reserves and for building roads to serve working mines, have received impetus from military requirements. Supported by a Government ore-buying program which extends through 1962, private investment in uranium exploration, mining, and milling has grown to substantial proportions. To improve or even continue to hold the position attained, exploration for new deposits and development of reserves must go forward.

These are some of the elements which enter into a consideration of the impact of the growth of a civilian atomic power industry on uranium mining and milling. Other elements, which are discussed in greater detail in chapters 15 and 16, include competition between civilian and military requirements, the conflict between Government ownership of materials and the development of civilian atomic power in a free market and the like.

Depending upon the choice of the reactors used for atomic power, annual raw-material requirements to meet the growth forecasts in figure I, can vary within a rather wide range. Some require large inventories of fuel within the reactors, others require substantial inventories of materials in the fuel element processing or reprocessing lines. Of greater significance than the type of reactors used, however, in considering the impact on uranium mining and milling is the time scale of the growth forecast for atomic power. If it is assumed that military requirements continue at projected levels and that present sources of uranium ore operating at planned levels continue to be available, there will be adequate supplies of uranium for an atomic power industry of the size forecast by the higher values of the range shown in figure I. This conclusion can remain valid during the period of the forecast, in spite of some variation in military requirements and even if some of the power reactors in operation at any given time in the period are types requiring very high uranium inventories. The continuing validity of this conclusion arises out of the fact that any changes in demand can be foreseen for a period sufficiently long to provide more than adequate lead time for remedial action.

On the other hand, if military requirements fall off during the early part of the forecast growth of atomic power, a surplus over civilian needs may exist. Under these conditions the effectiveness of mechanisms for maintaining the stability of the uranium-producing industry will be stringently tested. As in the case of conventional fuels, the industry itself, if it is to do more than pay lipservice to the concept of free enterprise, must build toward a position in which it can survive through a period of declining demand and maintain its vigor to meet the challenge of future energy needs. The extent of the obligation of Government to concern itself with such problems of the uranium mining and processing industries—as they relate to the peaceful uses—must be considered in the context of the urgency for, and the amounts of atomic fuels required by, domestic and international atomic power programs. (See ch. 16 for discussion of Government uranium procurement policies.)

2.5.7. General Impact Considerations

The discussion above reflects the weight of available judgment to the effect that nuclear fuels: (1) Will almost certainly compete and very likely make possible lower power costs than conventional fuels in present high-cost power areas; and (2) will probably at least compete with conventional fuels for power generation in all areas except those in which fuel transportation costs are negligible. It is not entirely clear that the accomplishment of the capabilities just mentioned will occur by the 1965 date used as the starting point in the forecast of the growth of an atomic-power industry. It must therefore be remembered that if the somewhat less optimistic forecasts for capital costs per kilowatt of generating capacity or fuel costs actually apply, a growth lag can occur, possibly extending as much as 15 years beyond 1965. The problem then arises as to whether private industry will remain interested enough over such a long period of time to invest the funds required to bring about competitive status.

The trend that results from such a generalized forecast is toward the equalization of power costs at lower levels in all areas. At first glance, a wide variety of changes in industrial patterns would appear to flow from such a conclusion. The interplay of such factors as the availability of labor, raw materials, water, transportation costs, and accessibility to markets is, except in a few special industries, of greater importance than power costs. On balance, these factors often lead to industrial decentralization and even to the formation of new industrial centers, such as is now taking place. The equalizing cost trend brought about by the advent of atomic power should contribute to this movement as well as bolster economic expansion.

Thus, while there has been conjecture that in industries involving high electrical energy inputs major plant relocations could be expected with the advent of atomic power, it is unlikely that such changes due primarily to this factor will be extensive, or that existing installations will be abandoned during their useful lives. For example, with respect to the aluminum industry, it has been postulated that if atomic power becomes available, reduction of bauxite to alumina and thence to aluminum could take place at the foreign source of the raw material or at a point close to the domestic market for metallic aluminum. In this way several of the shipping charges now involved could be eliminated, with consequent cost reductions. However, there is some question whether material changes in the present pattern would be warranted, even if atomic power costs are below those presently anticipated. It is argued that the difference in tariffs and shipping costs between raw bauxite or alumina on the one hand and finished metal pigs on the other, together with the lack of assurance of stability and protection for large capital investments made in foreign areas, are also elements which contribute to the conclusion that the availability of atomic power in the context of presently foreseeable costs will not materially change the production patterns which now exist.

2.6 CONCLUSIONS AND RECOMMENDATIONS

Atomic power gives promise of becoming an important new resource for the generation of electricity. For the expanding economy of the United States and less highly developed countries seeking ways to raise their levels of industrialization, atomic power provides reason for optimism.

The bright promise of the future must not hide the fact that large sums of money and years of effort must be spent to bring atomic power to a point where it can be used effectively and widely on a competitive basis. Unless and until research and development demonstrate that atomic power can be economically feasible, there can be no substantial impact.

Private enterprise should carry a substantial part of this research and development program, including especially the construction of full-scale "demonstration" plants. Available financial incentives to encourage private enterprise in this respect are discussed in chapter 16. But in the event that industry does not take on the full risks and burdens, such a program should be supported by the Commission, even to the construction with public funds of one full-scale "demonstration" plant of each major reactor size and type.

The present development program is deficient to the extent that appropriate "demonstrations" of the small- and medium-size types are not now underway. The urgency associated with accepting the challenge to United States world leadership, together with the need for establishing atomic energy as a power resource available to assist in maintaining maximum expansion rates of the American economy, require that effective development and "demonstration" of all major reactor sizes and types be carried forward at high priority. If progress is not expeditious and efficient, it is clear that the Federal Government has a fundamental obligation to carry it out. Although private participation in this program is desirable, it should not be obtained at the cost of delay.

The rate of growth of atomic power will depend to a large degree on the rate of expansion of our total economy. By 1975 atomic power could amount to 20 to 40 percent of presently installed electric-generating capability in the United States. If this occurs, however, it will be in the context of a total generating capability of 3 to 4 times present levels.

The net domestic impact of atomic power should be beneficial to individual consumers and to industry. Disruptive influences, even on specific industries most directly affected, are likely to come—if at all—over periods of time long enough to permit orderly adjustment. In specific industries popularly assumed to be most vulnerable to atomic inroads—coal, for example—such dislocation as appears possible would come from a welter of forces more complex and more overriding than atomic energy alone.

If atomic power is exploited as a source of electric power at a rate consistent with sound technological, economic and public policy considerations, the impact will be totally beneficial at home and abroad.

We recommend:

1. that the Congress, the American people, and the people of the world recognize that large sums of money and years of effort must be spent to bring atomic power to a point where it can be used effectively and widely on a competitive basis; unless and until research and development demonstrate that atomic power can be economically feasible, there can be no substantial impact;

2. that, in the event that industry does not take on the full risks and burdens, the Commission should support a program to bring atomic power to a point where it can be used effectively and widely on a competitive basis, even to the construction with public funds of one full-scale "demonstration" plant of each major reactor size and type;

3. that the urgency associated with this program requires that the technological resources of atomic power be fully explored with high priority; and

4. that atomic power be exploited as a source of electric power at a rate consistent with sound technological, economic and public policy considerations.

CHAPTER 3—CONTROLLED THERMONUCLEAR POWER AND DIRECT CONVERSION OF RADIATION ENERGY

3.1. INTRODUCTION AND SUMMARY

We have discussed in the preceding chapter the status and promise of atomic electric power from fission. Two other possible approaches to the generation of electric power from atomic energy must also be noted. The first and presently more promising involves the harnessing under controlled conditions of energy released in reactions of light elements. This is commonly called controlled thermonuclear, or fusion, power. The second approach seeks to bring about the direct conversion of nuclear radiation to electrical energy in usable form.

The concept of power resulting from controlled thermonuclear reaction has stimulated widespread enthusiasm because it could conceivably provide an unlimited energy resource beneficial to all people. It would use as fuel the light elements—such as hydrogen isotopes—abundantly available on the earth. In addition, most thermonuclear reactions make neutrons available. If such reactions can be sustained, neutrons captured on a large scale could lead to conversion of natural uranium and thorium into fissionable materials which could be used as energy resources.

At this early stage of development of controlled thermonuclear devices there are no responsible estimates of what costs might prove to be. In fact, it is too early to make any prediction as to whether electric power can be generated commercially by controlled thermonuclear reaction. If it should be, however, it will not be free, since there will necessarily be large capital carrying charges, as well as operation and transmission expenses.

The possibility of breakthrough to unlimited energy resources warrants the establishment of high priority for these lines of development. But in our enthusiasm, it is necessary to remember that scientific accomplishment requires orderly research and development as well as maximum interchange of ideas and information.

Direct conversion of radiation into electric energy has been accomplished, but on an extremely small scale and at very low efficiencies. It is already proving useful in limited and highly technical applications. The great importance of direct conversion lies in the fact that it might eliminate the high cost and low efficiency involved in present known means of conversion of energy into electricity. It is conceivable that controlled thermonuclear devices may lend themselves to direct conversion, but the prospect of such a development cannot be explored until a controlled thermonuclear system has itself been achieved.

3.2. CONTROLLED THERMONUCLEAR POWER

(The following discussion is based upon communications from the Atomic Energy Commission, which appear in vol. 2, ch. 3:).

Through the controlled thermonuclear program being conducted by the Commission, an effort is being made to bring about the controlled release of energy from the fusion of light nuclei with the ultimate objective of providing another source of electric energy. Similar programs are being carried forward in the Soviet Union, the United Kingdom and other countries. The process of fusion involves the merging of two extremely light nuclei to form a heavier nucleus, and this process is accompanied by the release of energy. One light element nucleus which could be useful in this process is deuterium, an isotope of hydrogen. In view of the enormous amount of deuterium in sea water (even though in a concentration of only 1 part in 6,400) the achievement of the controlled release of energy from deuterium fusion would make available a source of energy virtually without limit. It is possible to think of using other lightweight elements in the fusion process.

In order to bring about the fusion of light nuclei, it is necessary to provide them with sufficient energy of motion to overcome natural forces of repulsion. The energies which are required to overcome these natural forces correspond to temperatures of several hundred million degrees.

It is clear that no container made of ordinary material can confine the reaction zone at these temperatures. Media conceivably capable of fulfilling this task are electric or magnetic fields, the appropriate use of which may serve to insulate the walls of the reaction chamber from the exceedingly high temperature at the center.

In view of the many basic problems still to be resolved before there can be any assurance of success, it is exceedingly difficult to estimate the time scale for the development of a controlled thermonuclear machine, or the probable characteristics of such a reactor once it is developed. It is reasonable to expect that some technological "breakthrough" may be required in order to achieve success. It is virtually certain that no full-scale reactor will be developed in the next year or two; it is, however, highly probable that success will be achieved eventually. Even after the development of an operating prototype of a full-scale thermonuclear machine, many more years of intensive effort would very likely be required to develop an economically competitive source of thermonuclear power. Once again, the availability of numbers of well qualified scientists and engineers will have an important bearing on this time scale.

Thermonuclear power units give promise of being extremely safe. The amount of fuel normally present within such machines would be extremely small. The possibility of a serious hazardous accident due to the failure of any component or any arbitrary mistake on the part of the operator is virtually negligible. In addition, unlike a fission reactor, there are no fission products to spread about, even in the unlikely event of an accident. It must be noted, however, that if a thermonuclear machine is developed which consumes hydrogen isotopes such as deuterium as a fuel, it could produce intense fluxes of neutrons and care would have to be taken to provide adequate shielding for this radiation.

It should be noted in addition that the intense neutron fluxes just mentioned could make possible the production of fissionable materials through the irradiation of such fuel materials as uranium or thorium. In other words, upon the achievement of the goal of controlled thermonuclear reactions, one may achieve the corollary of an economy rich in fissionable material. The parallel development of a fission power program consuming the fissionable materials produced in thermonuclear systems would thus appear to be required.

3.3. DIRECT CONVERSION OF RADIATION ENERGY

The importance of direct conversion of radiation into usable electric power can probably best be appreciated from a reconsideration of the operating characteristics of fission power reactors. The generators, heat exchangers, and other appurtenances needed to convert the energy produced in a nuclear reactor into electricity make up half or more of the total cost of any foreseeable economically competitive atomic powerplant. These are essentially the same generators, heat exchangers and turbines that are involved in conventional powerplants. Furthermore, only 25 percent of the energy available in the reactor will actually appear on the transmission line as electricity. It is the prospect of raising this 25 percent to some higher figure, as well as the reduction in plant cost, which is the basis for the importance of exploring direct conversion methods.

Various techniques for converting radiation into energy have been developed. Well known among these are thermocouples and atomic batteries. All such devices conceived thus far are capable of only extremely small energy output. These lines of endeavor do not appear likely to result in the production of massive quantities of electricity for general purposes. They do have some interesting possible applications, however, especially in the electronics industry and as control devices.

It is at least conceivable that some one of the approaches to controlled thermonuclear power may lend itself to direct conversion of the energy of radiation to electric energy. While this might add to the attractiveness of the prospects for low-cost energy from controlled thermonuclear reactions, fusion power itself, as we have noted above, is not yet sufficiently far along to permit or even warrant any serious examination of what a combination of controlled thermonuclear power and direct conversion might mean. It calls for too extreme extrapolations of technical data and tends to result in sensational observations which have no way of being checked with reality.

3.4. CONCLUSIONS AND RECOMMENDATIONS

Controlled thermonuclear power and direct conversion of radiation energy are subjects which stimulate men's imaginations. We have come to the conclusion that we can contribute nothing in the way of sound estimates of future impact in the absence of better data and on the basis of the speculations available to us. Exploration of these areas offers a great challenge to the best scientific minds in the world today.

There are military implications, however, which would come with the availability of special nuclear material as a byproduct of controlled thermonuclear power. Within the limitations of national

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security considerations which these impose, we believe that this entire area of scientific and engineering development warrants the maximum interplay of ideas. We note the recent decision by the Commission to make available information about its controlled thermonuclear program to United States citizens holding permits for access to secret restricted data. As private citizens, we would hope that the day will come when world conditions will permit all those able to contribute to thermonuclear power to learn all there is to know about it. Of greater present importance is the development of procedures by which more people can contribute freely to it.

This is a truly frontier research project. It concerns a basic energy resource which could have impact on the economics of the entire world. The Government has a clear obligation to give it full support as well as to stimulate scientific contributions from every quarter. At the same time there is also an obligation to the public and to those being encouraged by the Federal Government to invest in nuclear fission power to see to it that they are allowed to have sufficient information about the feasibility of nuclear fusion power to have an adequate foundation upon which to base a determination for themselves of the propriety of their investments and actions.

We recommend:

1. that the Commission, within the limitations which national security considerations impose, permit the maximum interplay of scientific and engineering ideas, and develop procedures by which more people can contribute to the controlled thermonuclear program in the United States; and
2. that the Commission, in encouraging investment in nuclear fission power, see to it that investors have sufficient information about the feasibility of nuclear fusion power upon which to base determinations for themselves as to the propriety of their investments and actions.

CHAPTER 4—MEDICINE AND PUBLIC HEALTH

4.1. INTRODUCTION AND SUMMARY

Atomic energy is being used today in medical research, diagnosis, and therapy. Although public attention has been focused on radiation treatment of cancer, the widespread availability of new atomic research and diagnostic tools appears to be the most significant contribution of atomic energy to medicine and public health.

The principal social impact of atomic developments in the medical field is expected to be improved health and longer life for the individual, and increased productivity and a larger proportion of aged persons for the Nation as a whole.

The increasing medical use of atomic energy emphasizes the existing problems of shortages of doctors, nurses, medical school facilities, and medical research centers. It will be necessary to provide both present and future medical personnel with opportunities to acquire knowledge and training in the atomic field, and to stimulate new means of setting up appropriate working relationships with other scientific disciplines such as biochemistry, biophysics, and radiology. To do this, construction and staffing of adequate research centers and establishment of atomic energy facilities in existing institutions will be necessary.

Atomic energy techniques have their dangerous as well as their beneficial side. As the public becomes more radiation conscious, both the medical profession and individual citizens seem likely to give increasing consideration to a more judicial use of radiation. The medical profession may profitably explore the institution of adequate recordkeeping of radiation dosages received by individuals, and some measure of control over radiation use—such as is the case with narcotics today.

The communication of atomic energy information is an important key to improving our medical knowledge and facilities. It is essential that all the latest data available in atomic medicine and health, including knowledge about the hazards of radiation, be promptly communicated to the public, the medical profession, and State and local bodies responsible for sound public health policy.

The strides made by the United States in atomic development in the medical and public health field create an obligation to utilize this new knowledge to the utmost for the benefit of our own people, and provide the Nation with an opportunity for leadership in bringing these new developments within the reach of less-developed areas of the world.

4.2. TECHNOLOGICAL STATUS

Atomic energy is being used in three ways in medicine and public health: for research; in therapy; and to provide diagnostic and clinical tools.

4.2.1. Medical Research

Radioisotopes—elements differing from normal ones only in their radioactivity—permit man, for the first time, to trace the life process while in progress: how the body grows, fights disease, and carries on its functions. In some cases, radioisotopes can be absorbed directly. In other cases, organic compounds must be synthesized or specially produced.

With these new tools, the medical profession can make many new discoveries about living organisms. As new facts are uncovered, other medical problems will come into focus and additional avenues of research will open up. We may be about to understand what life itself is.

Radioisotopes also help us study the effects of radiation on specific parts of living organisms. More massive sources of radiation, now available from atomic reactors, permit studies of various types and quantities of radiation on the human body, leading to the arrest and even cure of some ailments which have heretofore defined science.

4.2.2. Radiation Therapy

A new medical therapy reactor is being built at Brookhaven by the Commission for treating brain cancer. Joint private-Government plans exist for similar facilities at other places. Large cobalt 60 therapeutic devices are beginning to replace the more expensive and hazardous radium formerly used in hospitals.

The use of reactor radiation for therapy is still in the relatively experimental stage. More widespread use of these and standard X-ray devices is certain, although radiation is not likely to become a universal replacement for surgical treatment of cancer.

4.2.3. Radioisotopes in Diagnosis and Therapy

The use of radioisotopes for both diagnosis and therapy is becoming standard practice. An estimated 50,000 patients have already been treated with them. Two radioisotopes are already accepted pharmaceuticals. The number of individuals who appear likely to benefit from the therapeutic uses of radioisotopes will increase as new applications evolve.

Radioisotopes are being used in diagnosis throughout the country. Clinical diagnosis with radioisotopes, such as blood-volume determination, can be made more accurately and much faster, thus shortening the hospital stay and effectively increasing the number of available hospital beds. Other diagnostic use of radioactive isotopes include: exact location of some malignant tumors; and analysis and prompt diagnosis of various disorders of the heart and blood system.

Some or all of these techniques are now employed in 870 hospitals and medical clinics out of a total 6,970 in the country. The number of hospitals using the technique is growing. In the past 9 years, an estimated 500,000 patients have been given radioisotopes for diagnostic purposes.

4.3. IMPACT OF ATOMIC DEVELOPMENTS IN MEDICINE AND PUBLIC HEALTH

The impact of medical applications of atomic energy is beneficial, since it means continued medical progress, the alleviation of suffering and the prolongation of life.

For the individual, atomic developments in medicine—added to other medical discoveries—should mean fewer days of sickness, fewer days in hospitals, and a longer, more useful life. For society as a whole, the cumulative effect of atomic and other developments in the field of medicine will mean more men and women on the job every day, greater productivity, larger populations and a greater proportion of elderly people.

We must develop the ability to support a larger percentage of our population while they enjoy the years which have been added to their lives. Our past practice of regarding men and women of 65 as being at the end of their useful working lives will have to change.

Developments in the medical aspects of atomic energy offer opportunities for forthright leadership. The manner and speed with which these benefits are brought to all people may have much to do with world regard for the United States. Economic benefits should also result: more people living healthy and normal lives in other countries will not only produce more goods themselves but also provide markets for American goods. Rising standards of living in foreign countries mean better economic relationships between ourselves and other peoples.

Atomic development has its medical dangers as well as its medical benefits. Unless an accurate tally is kept of the radiation each patient receives, long-term injuries, such as more rapid deterioration, may result. Clearly, indiscriminate use of radiation—either from radioisotopes, radiation therapy devices, X-rays, or other sources—can be as harmful as indiscriminate use of narcotics, which are closely regulated. These radioactive tools and radiation techniques should be employed only when some positive good is to be accomplished. For this exercise of care and discretion, there is no substitute for adequate numbers of medical personnel properly trained.

As the public learns more about radiation, and as the medical profession becomes more cognizant of the significance of the total radiation dosage each individual receives in his lifetime, pressure may build up for better recordkeeping and control. It is unreasonable to have rigid standards for dealing with atomic energy and no control at all over the cumulative amount of radiation an individual can receive from such radiation sources as X-rays and fluoroscopy.

As the average citizen becomes more radiation conscious, the medical profession may be influenced to use X-rays and all forms of radiation more judiciously than is presently the case. The day may come when every citizen should have a personal record of radiation dosage received in the course of diagnoses and therapy. The medical profession may find that it needs this tool for proper study, control, and treatment.

4.4. FUTURE RESEARCH AND DEVELOPMENT

4.4.1. Objectives

It is very difficult to appraise what these new lines of approach and future research and development may mean in quantitative terms. We cannot estimate how many people with cancer may survive during the next 25 years who would otherwise have died. We cannot estimate how many individuals suffering from loss of blood in automobile accidents may recover because of improved blood volume determination techniques. We cannot estimate how many people will live to an older age and lead longer, more useful lives because of knowledge which will come from the laboratories.

Man now has new tools to ease suffering and prolong life in an increasing number of instances. The full exploitation of all that these make possible is the objective.

The urgency is as high as our value on men's lives. Here is an opportunity for the exercise of American leadership which could go far toward demonstrating to the entire world the ability of our free society to bring forth humanitarian benefits.

The speed with which we make medical progress in the atomic field depends on three principal factors: training of an adequate number of doctors, nurses, and technicians; construction and staffing of adequate research facilities; and provision for rapid communication of the most advanced medical knowledge.

4.4.2. Shortage of Medical Personnel

The basic need for a far larger number of doctors, nurses, and technicians is evident without relationship to atomic energy In the past 30 years, the increase in number of doctors in the United States has exceeded the population growth by only 6 percent. There is now approximately 1 doctor for every 740 people as compared with 1 for every 790 people in 1925. Increased medical knowledge, however, has resulted in increased specialization.

There is probably no single sweeping means of obtaining a rapid increase in the numbers of trained medical personnel in the country. The need is so basic, however, that it behooves all governmental bodies, industrial and civic groups to take an active part in remedying the situation. No young man or woman who has the capacity and desire to enter the medical, nursing or medical research professions—including biophysics, biochemistry, radiology, etc.—should be turned away for want of faculties, facilities or funds. (The general problem of education and manpower is dealt with in detail in ch. 14.)

4.4.3. Educational and Research Facilities and Personnel

Adequacy of facilities for education is all the more important, in view of the shortage of medical and technical personnel. Few universities or medical schools today offer formal courses in biophysics, radiobiology, or tracer chemistry. Medical students generally have little contact with these subjects. A recent survey of 80 medical schools in the United States indicated that students receive no training in the clinical use of radioisotopes in 35 schools and less than 10 hours of such training in 28 schools. Almost all medical schools agreed that tracer studies, diagnostic tests, and therapeutic uses of atomic radiation should be a part of their curricula, but few schools without such training now are planning to add it.

Even graduate students are limited in the available opportunities for learning the techniques involving radiation and radioisotopes. Twenty institutions now provide preceptorial training for postdoctoral students in the clinical use of radioisotopes. The only complete basic instruction in such techniques is a 4-weeks' course given at the Commission's Oak Ridge Institute of Nuclear Studies. Since its inception on June 28, 1948, a total of 1,534 people have attended this course, approximately half of them being in medicine or related fields. All three National Laboratories—Brookhaven, Argonne, and Oak Ridge—have facilities for training "guest" investigators, especially during the summer months. But for the most part, American medical and postdoctoral students today are going into practice without any real knowledge of the general effects of radiation or the techniques made possible by the availability of radioisotopes.

Correction of this deficiency in medical training lies partly with facilities and partly with faculties. One solution to the problem of attracting better and more alert men and women to teaching the medical sciences appears to be that of establishing more atomic energy facilities at which research, application, development, and clinical use can be pursued simultaneously. Such facilities could aid in better training of students and teachers and at the same time contribute to the retraining of doctors, nurses, and technicians already in practice.

At least three types of such training and research centers are already in existence: basic investigative centers such as the National Laboratories; regional development centers for clincial studies like Memorial Hospital in New York, Argonne Cancer Hospital in Chicago, M. D. Anderson Hospital in Houston, and Lovelace Clinic in Albuquerque; and area centers like the Veterans' Administration isotope laboratories, where the results of proved clinical applications can be put into broad use. This program seems to be in need of expansion in numbers at the present time.

Such facilities should be established and supported jointly by Government and private interests, and should not be limited in objective to medical activities. In fact, it is only by bringing together many related scientific disciplines that medical developments will be stimulated to the maximum. While the existing large Government-financed atomic research centers are making magnificent contributions to American science, some have tended to become the private preserves of those already associated with them. At any rate, the facilities now in existence are inadequate to permit large enough numbers of people to pursue these activities.

The problem of stimulating medical research using atomic energy is intertwined with the problem of training both students and faculties. Additional financial aid in the expansion and establishment of medical research centers with minimum administrative and political restrictions would appear most likely to give the greatest net benefit. The money is needed for facilities, training, and people, not for more administrative overhead. While coordination of such aid is important, it should appropriately flow from Federal, State, local, and private sources.

4.4.4. Educational and Research Equipment and Materials

The cost of equipping medical schools, hospitals, and clinics with the tools necessary to permit the use of radioisotopes and radiation varies from a few thousand dollars to very large sums. For example, the Veterans' Administration has estimated that radioisotope laboratories can be developed in hospitals at costs ranging from $2,000 to $75,000. Simple lead shields for protecting handling personnel from the hazards of low-level radioisotopes are low in cost, yet the simplest type of fully equipped scaling circuit and counter—essential for complete protection—costs $1,000. A single probe scanning scintillation counter for use in delineating tumors costs $3,600. An adequate radioisotope handling room costs $3,000 to equip. At the upper end of the scale is a complete research reactor facility: the plant and building can cost as much as $1 million and the subsequent cost of running a program is on the order of $150,000 per year.

As noted above, only 870 hospitals and clinics out of 6,970 have radiation and radioisotope handling facilities today. Roughly half the medical schools in the country have no facilities to aid in teaching these techniques to their students.

There is a real possibility that high energy particle accelerators and research reactors will be needed to an increasing extent as adjuncts of hospitals, clinical centers, and medical schools. The radiation instrument industry estimates $20 million as the total medical market for radiation and radiation detection instruments over the next 5 years, an estimate that may be too low. The total level of investment required appears to be outstripping the capacity of the present financing structure of support for all types of medical facilities.

A particular area where cost alone is limiting both research and practical use is that of so-called radioactively labeled organic compounds. While nearly 1,000 labeled compounds are now available from 25 commercial companies, the cost of many of these excludes their use in human subjects even on an experimental basis. Means must be found for stimulating cost-reduction programs so that these materials may be put to work without the artificial restrictions imposed by high cost.

A "bank" which could purchase long-lived radioisotopes in larger quantities, synthesize or contract for the preparation of radioactive compounds in larger volume, and hence get costs down is one suggestion which appears to have merit. Such a "bank" could be jointly financed by users and suppliers alike, with Government assistance, if necessary.

4.4.5. Communication of Information

The research and training now going forward in radiation and radioisotope applications is largely the result of the individual initiative of the diverse groups involved. Hospitals and clinics have undertaken a wide variety of activities in these fields essentially independently of the Commission, which has conducted, directly and by contract, a vast amount of research. As a result, overlapping occurs.

This is reasonable and scientifically sound—up to a point. As more and more organizations—State, private, and Federal—become engaged in atomic research and training there will be more overlaps, with consequent overtaxing of our limited trained manpower.

Centrally directed research is anathema to a vigorous scientific community. Nevertheless, it might prove wholesome for the medical profession to have a central clearinghouse, where any organization or individual engaged in medical research or application of radiation and radioisotopes could find out on a completely current basis just who is doing what on a particular subject. Only by interchange of technical information on radiation and radioisotopes can the items of individual significance be made meaningful for the whole scientific community.

Communication of medical information, including atomic developments, is especially essential in converting the latest knowledge about the hazards of radiation into sound public health policy. State and local codes for sound public health policy and uniform enforcement can be achieved only through rapid dissemination of all of the best data available. Failure to do this can lead either to imposition of unnecessary restrictions or to toleration of excessive risks.

An important example of the need for prompt and thorough communication of this kind of information is the pressing and growing problem of the hazards involved in the use of radioisotopes and radiation in medicine. This applies both to the patient and to the handling personnel.

The results of new developments related to the problems of hazards must be disseminated promptly, if all medical users of radiation and radioisotopes are to be able to work effectively and safely. (See ch. 14.)

4.5. CONCLUSIONS AND RECOMMENDATIONS

We feel that a high priority must be set on means for bringing higher health standards to our people and the peoples of the world through the beneficial use of atomic energy in medicine and public health. As individuals learn to recognize these beneficial aspects, they will begin to lose their fears of atomic energy arising from the fact that hitherto their attention has been focused on its military applications.

In setting forth the recommendations below, we have purposely refrained from suggesting specific methods of financing. It is our strong feeling, however, that medical institutions and research centers should not assume a passive role and expect the Government, and more especially the Commission, to assume all or even a major portion of the responsibility for providing research facilities, equipment, and materials. Government monopoly of atomic energy for weapons was wise and necessary, but this monopoly must not be allowed to extend itself into the medical field, with all the concomitant dangers of secrecy, concentration of research, and control over facilities and personnel. Any Government assistance afforded the medical and public health professions should flow from all the various governmental agencies concerned with health, education, and research, and should carry with it no implication of Federal control over medical practice or research.

If maximum benefit is to be gained from the advances in medicine and public health made possible by atomic energy, it is necessary to:

1. provide all medical schools with adequate facilities for training in atomic medicine techniques;
2. create additional research centers with all appropriate equipment, including reactors;

3. design low-cost atomic medical equipment suitable to the needs of the 6,100 hospitals and medical clinics without atomic facilities and provide at least minimal facilities to this group as rapidly as possible;

4. make available at reasonable prices the now-expensive radioactively labeled organic compounds essential for research and therapy;

5. assure prompt availability of current atomic developments in the field of medicine and medical research, with opportunity for full interchange of latest data and without interference of the independence of medical research investigators; and

6. inaugurate a nationwide educational program on the more judicious use of radiation and the need for better recordkeeping of the exposure of individuals to radiation from all sources.

CHAPTER 5—AGRICULTURE

5.1. INTRODUCTION AND SUMMARY

Peaceful uses of atomic energy in the field of agriculture are a significant addition to the many other modern methods of improving farm technology. Domestically, these technological improvements will mean increased productivity and lower costs for individual farmers. For the Nation as a whole these higher yields could, if widely achieved, intensify the already grave problem of farm surpluses.

In the international field, atomic applications, together with other American improvements to farm technology will give the United States dramatic opportunity to lead underdeveloped, undernourished nations to higher living standards.

Atomic radiation has already resulted in the breeding of useful new plant varieties. We can hope to develop many more—types adaptable to wider ranges of climate, rain and soil; more resistant to diseases and insects; tailored to mechanized cultivation and harvesting.

By using atomic tracers in research we will learn more about the life processes of plants and animals—how and when to fertilize plants, what to feed animals, how to make more efficient insecticides and medicines.

Progress in each of these lines would have continued, even without the aid of radiation and radioactive tracers. But these new atomic tools are powerful. They will add great impetus to the technological revolution in agriculture.

We may, therefore, expect higher farm output, more flexibility as to the crops and animals produced, and ultimately more varied diets at lower costs.

These are not benefits which will happen automatically as a result of technological progress. None of them will come suddenly; most cannot be achieved until food producers learn to adopt the modern techniques and products of atomic agricultural developments. The time lag between the invention and the adoption of new technologies by the farmer, however, is diminishing, and it is likely that widespread interest in atomic energy will speed the adoption process.

The entire world appears to have new opportunity in atomic energy to move forward to an age of food abundance. America's present farm surplus problem may even reflect the pattern to which atomic applications in agriculture may eventually lead, wherever men are willing to learn and apply new ideas.

In underdeveloped nations, these powerful new atomic tools will help bridge the gap between scarcity and abundance. In the United States, where we already have enough—and in some cases more than enough—they will intensify the problems of overproduction.

5.2. TECHNOLOGICAL STATUS

Peaceful atomic uses in agriculture come about primarily through (1) research in which radioactive isotopes are used to trace the life processes of plants and animals; and (2) the use of radiation to speed the evolution of new strains of these organisms.

5.2.1. Plant Breeding

A basic application of atomic energy in agriculture is in use of atomic radiation to speed the evolution process. This is only an extension of the work which has been going on for three decades using X-rays to increase genetic mutation rates. The coming of atomic energy means radiation sources of greater and more flexible use in connection with plant breeding. By exposing living plants, insects, viruses, and even animals to man-controlled atomic radiation, it is possible to induce new species and subspecies at a more rapid rate. In one case, it is estimated that 9 years of conventional plant breeding results were accomplished in 18 months. By increasing the total number of such changes, the entire process of natural selection can be speeded. The small percentage of good variations still have to be winnowed from the many bad ones before they can be put to work on the farm. For example, the following accomplishments have already been achieved through the use of radiation (see vol. 2, ch. 5):

1. *Barley.*—Dense heads, stiff straw, tall straw, higher yield of grain and straw.
2. *Oats.*—Earliness, higher yield, stem-rust resistance, short stems.
3. *Wheat.*—Stem-rust resistance, higher yield.
4. *Corn.*—Shorter or taller stalks, earlier or later ripening, resistance to lodging.
5. *Peanuts.*—Leaf-spot resistance, higher yield.

We can expect crops better able to prosper in spite of drought or excessive rainfall, early and late frosts, specific nutrient deficient soils, and other regional, climatic, and seasonal variations which have in the past strictly limited the entire character of agriculture throughout the world.

At least on a laboratory scale, the day of the tailormade plant seems close at hand. In the long run, we can expect many new variants of present horticultural types, new colors and new sizes—perhaps even varieties which lend themselves more readily to mechanical harvesting and processing.

Promises of what might grow out of atomic agricultural research must be tempered by comparison with tangible present accomplishments. Applications which are now in practical, commercial, dirt-farmer use are still few in number. Work with many plants is now going on in agricultural research centers. Some results from this work have gone into test and development stages at experiment stations.

Parallel studies are being made of spontaneous mutations of disease organisms. The plant breeder develops, for example, a wheat strain having a high resistance to black stem rust, but suddenly this work is undone by the spontaneous emergence of a new rust. Recent work has shown that radiation will produce new varieties of blights with increased virulence. By developing these under controlled conditions, geneticists may be able to breed plants resistant to them before the new and virulent blights appear in the field.

Relatively few applied agricultural research centers are devoted to this work, even in the United States. In many other countries where the needs are greater for increased food production, such experimental work is still in the basic research stage or nonexistent.

5.2.2. Tracer Research

Radioisotopes give new tools to agricultural researchers. These isotopes in elementary or compounded forms behave chemically as nonradioactive forms do, yet emit radiation which can be traced through living organisms with counting instruments. Minute but still identifiable substances, tagged with radioactivity, are introduced into complex systems—soils, plants, or animals—and followed through the dynamic processes of life.

Current tracer research ranges from studies of the uptake of fertilizers by growing plants to the digestive and milk-producing processes of cows.

These uses of radioactive isotopes began when such materials were first produced in high energy particle accelerators. But nuclear reactors in operation today—both research and production—make them cheaper and more readily available. By use of tracer tools, research and development in agriculture can be undertaken on a large, rapid scale.

Radioactive tracers of most of the elements important in plant nutrition are available. They permit investigators to follow these elements as they move through root, stem, and leaf. We are learning how to judge the efficiency of different kinds of fertilizers. We are learning how, when and in what amounts to apply commercial plant foods.

Tracer studies of animals will make possible cheaper feeding and better management. Before radioactive tracers became available, studies of foodstuff values were often misleading.

Studies of photosynthesis—the plant process of combining air and water with sunlight to make living tissue—hold far-reaching promise. Although not yet understood completely, researchers can now duplicate many of the steps involved. Radioisotopes provide valuable tools for speeding this research. It is within the realm of possibility that the time will come when man does not have to depend on plants to produce edible energy in the form of starches, sugars, fats and proteins, and we may see this done chemically—at least for fodder—on a commercial scale.

5.2.3. Blight and Pest Control

Radioactive isotopes and atomic radiation both contribute to new methods of blight and pest control. Tracers permit study of insect life cycles, thus showing us how insects are vulnerable to human control. Radiation has proved directly useful in eliminating certain animal infestations such as the screwworm fly in cattle and trichinosis in hogs. Radiation is helping us develop more virulent plant and animal diseases in laboratories, so we can in turn develop plants and animals able to withstand them. Farmers may be given new plants which can remain disease free longer, although in the long run, natural evolution of new diseases and insect varieties will catch up with these new types, too. Natural evolution is a continuing process, and only by continuing this type of research can we keep ahead.

5.2.4. Crop Storage

All crops naturally deteriorate in storage. Chemical treatment to slow down deterioration is only partially successful. Atomic radiation can be used to accomplish more complete protection. Radiation of grains and potatoes, for example, has been of demonstrated effectiveness in prolonging storage life. These techniques are beginning to go into commercial practice and may substantially reduce food production losses due to spoilage in storage. These developments are more fully discussed in chapter 6.

5.2.5. Irrigation

Irrigated lands produce a substantial percentage of the world's foodstuffs. Some people have hoped cheap atomic power could be used to irrigate more land, either full time or during dry seasons. Atomic electric power may compete with electricity generated from coal, oil, or gas (see ch. 2). But the most imaginative examinations of the use of atomic energy either for pumping irrigation water or de-salting sea water are thus far discouraging. The most optimistic estimates of atomic capability do not as yet support hopes of commercial feasibility in these fields. (See vol. 2, ch. 5.)

5.3. DOMESTIC IMPACT

The impact of peaceful uses of atomic energy on agriculture will derive from its importance as a tool available to the agricultural researcher. As in the overall view, only net beneficial effects have come from all previous agricultural research, so these effects will be speeded by the addition of radioisotopes and radiation to this field of development. The specific impact of this kind of development is different for individual efficient farmers on adequate lands than it is for our Nation as a whole; for these individuals atomic developments may mean benefits. For some marginal farmers, they may mean little or even added disadvantage. For the Nation, they appear likely to add to the problem of farm surpluses.

As new crops are tailored to the vagaries of climate and geography, farmers may have a better chance of profitable crop yields, despite variations in temperature, rainfall, early and late frosts, winds, and other unpredictable fluctuations of weather. Fertilizers will be able to be used more efficiently. Meat producers will have new knowledge about feeding and caring for livestock. There may also be effects on prices from increasing crop surpluses. To the extent that farmers make use of all new advances in agriculture—whether of atomic or conventional origin—they should have a chance to lower their costs, while at the same time permitting consumers to get food at lower prices.

A principal fact of the American way of life is that it is based on abundance. Food is an outstanding example. Currently the United States produces more food and fibers than it consumes and exports. And it must be remembered that consumption in this context includes losses due to spoilage, insect infestation, and the like. Our actual intake and maximum possible daily intake of food per average person are not far apart. The typical American consumes 3,130 calories a day. Shifts from one food to another are more probable than increases in the gross amount of food eaten. In only four countries do people eat more each day than in the United States: Argentina, 3,190 calories; Denmark and Australia, 3,160; Norway, 3,140. These rates cannot increase much. On the other hand, underdeveloped nations are often undernourished. In India, for example, the daily food intake averages only 1,700 calories per person.

Our population is increasing and living longer. Yet these factors alone are not absorbing farm surpluses.

Present rates of farm production are low, compared with what they could be if existing improvements to mechanical equipment, crop varieties and farm techniques—now in use on the most efficient farms—become widespread. Further mechanization, new crop varieties, and still better fertilization and pest control will bring about higher yields than those even now realized on our most efficient farms. Atomic applications may speed the adoption of modern techniques through the general popular appeal of atomic energy. It is thus clear that atomic energy can contribute to making possible the production of more food per acre at lower cost.

5.4. FOREIGN IMPLICATIONS. (SEE VOL. 2, CH. 5)

Foreign markets appear to offer no solution to United States farm surpluses. United States tariffs and low foreign buying power tend to restrict world trade in farm produce. We export only about 6 percent of our farm output. Dumping of agricultural surpluses abroad upsets foreign economies. Even giving surplus farm produce free to undernourished nations provides no answer: resistance is too great from local economic interests. And "free" foodstuffs are not free: it costs money to transport them.

Comparisons between dinner pails in America and many underdeveloped nations now make tragic reading. But, as modern agricultural methods—including atomic developments—are adopted in underdeveloped nations, world farm output will inevitably rise. The same atomic developments and techniques which may only add to United States crop surpluses will help bridge the gap between scarcity and plenty abroad. Here, again, the universal interest in atomic energy may speed adoption of modern agricultural practices. Underdeveloped, undernourished nations are among those most vocal in asking for nuclear powerplants. Electric power is only one segment of an industrial economy, however, and in itself can make little contribution to the basic problems of famine and disease facing primitive agricultural economies. The techniques of the atom in agriculture can help these nations to accomplish sooner, more directly and more effectively their transition to balanced economies and higher living standards.

We believe that it is to the Nation's interest to do everything possible to bring the agricultural benefits of atomic energy to undernourished and underdeveloped countries. The United States must press these atomic agricultural benefits forward with a high sense of urgency so that the humanitarian ends which they serve may spread throughout the world.

The results of atomic research in new grains, plants, fertilizers, and methods of cultivation, and storing and processing crops should be broadcast to the world for use in all lands, especially by the underdeveloped countries. It must be kept clear, however, that the application of atomic techniques in agriculture, as they now appear most likely to develop, are particularly the tools of an advanced and mature technological and industrial community. The broader implications of a realistic foreign policy would indicate the desirability of extending to such countries the specific technological assistance to make such developments useful, in the solution of their specific problems.

5.5. CONCLUSIONS AND RECOMMENDATIONS

Peaceful uses of atomic energy in the field of agriculture are significant additions to the many other modern methods of improving farm technology.

Man can already produce the food he needs if he takes advantage of the modern techniques available today. Atomic contributions will extend this ability to a still higher level, thus accentuating farm surplus problems in the United States. The extent of this impact will depend upon the rate of speed of development and the breadth of application. Efforts to speed the contribution of atomic energy to agriculture will inevitably increase the urgency of meeting the challenge to the Nation posed by farm surpluses.

Benefits of atomic applications to farmers can be as real and as immediate as each individual wishes to make them. The cumulative impact will be an increase in the farmers' ability to specialize, diversify, and better deal with their traditional worst foes—weather, pests, and diseases.

Peaceful uses of atomic energy in agriculture can help the undernourished peoples of the world have more to eat, if technological assistance is provided. There can be no miracles, however, without research, education, and work are needed.

We recommend:

1. that the humanitarian benefits which can result from the application of atomic developments to agriculture require that this technological resource be fully explored with high priority;
2. that those charged with meeting the farm surplus problem take into consideration the fact that such atomic developments—as do other new farm techniques—will contribute materially to farm output; and
3. that the Agencies and Departments concerned with assistance to foreign countries develop a coordinated and vigorous program of high priority with technical assistance from the Commission, to focus atomic research where it can be useful soonest in undernourished countries. Only in this way can the United States bring to bear atomic contributions to agriculture, so as to demonstrate our historic sense of international humanitarian leadership.

CHAPTER 6—RADIATION PRESERVATION OF FOOD

6.1. INTRODUCTION AND SUMMARY

The atomic technique of food preservation is based on the use of radiation to destroy organisms which cause food spoilage. Radiation can kill all or most of the bacteria and insects present in some fresh fruits, vegetables, grain and meats, and thus contribute to checking deterioration. No residual radiation is left in the foods themselves. With proper packaging to prevent entry of new bacteria and insects, foods which lend themselves to preservation by radiation should have substantially increased usable life.

The time scale of development, to date, indicates that within five years radiation preservation of some foods could begin on a practical scale. Widespread commercial use of this technique cannot occur, however, until certain technological breakthroughs are achieved. Even then the technique will probably come into use gradually as a supplement to other methods of preservation.

The net long-term effect of economically feasible radiation preservation of those foods to which this technique proves to be adaptable would appear to be:

A decrease in perishability; and

An accentuation of present trends to mechanization in the food processing industry.

The food radiation preservation technique appears most readily useful in a mature industrial economy, because of the requirements for continuous mechanized processing and packaging. It will not reduce the overall need for such elements of a modern industrial society as rapid transportation systems, efficient distribution of goods, and adequate refrigeration capabilities from food processors on through to the Nation's homes. Radiation preservation of food will not, in itself, therefore, revolutionize the food portion of the living standards of underindustrialized nations.

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6.2. TECHNOLOGICAL STATUS

Experiments on human consumption of foods preserved by radiation are being conducted under the direction of the Army Quartermaster Corps. It is hoped by those conducting the experiments that there will be adequate experimental evidence accumulated, including adequate tests of toxicity to humans within 5 years sufficient to support the beginning of commercial application of radiation preservation.

While the radiation sterilization process can kill bacteria, it does not inactivate enzymes in living food tissues which, by continued action, change flavor and odor. Doses of radiation may range from large long-term preservative levels to low pasteurizing levels. Off-flavors and off-odors tend to result from doses large enough to kill all bacteria. Not all foods react alike, however, to given doses; some appear better suited to this preservation technique than others.

Present experiments suggest near-term promise that almost two dozen perishables can be successfully treated by radiation and stored for extended periods without refrigeration. (See vol. 2, ch. 6.) Among these are breadstuffs, chicken, pork, and some vegetables. Irradiation of milk, butter and cream, on the other hand, are examples of foods which develop strong, objectionable odors upon radiation treatment.

Pasteurizing amounts of radiation inhibit bacterial growth and apparently lengthen the refrigerated shelf life of another 2 dozen foods, with no major changes in flavor or odor. For example, mild treatment may eventually extend the refrigerated shelf life of beefsteak, lamb, fish, and tomatoes by as much as 5 to 10 times.

A third variation on the radiation preservation technique, using smaller-than-pasteurizing dosages, holds promise for early application to destruction of insects in stored grain and flour, inhibition of sprouting of potatoes and onions, and destruction of trichinosis parasites in pork.

Even if we have enough experimental evidence within 5 years to establish the commercial feasibility of the process, however, another 3 to 10 years more may have to elapse before the food-processing industry will be able to apply these new techniques on any substantial scale. This seems likely to be the length of time required to get official sanction and for consumers to become accustomed to the new development. But it also will be partially determined by the success of a pilot-scale operation by the Department of the Army scheduled for 1958.

Both electrostatic machines and radioactive byproducts from nuclear reactors can be used to accomplish the actual preservation. Preliminary economic data on which to base forecasts regarding the exact types of commercial radiation-preservation equipment most likely to come into general use are now being assembled and should be available by the end of 1956 as a result of the planning work for the Army pilot plant. No proven cost data will exist until the plant begins operation in 1958.

Accurate estimates of costs cannot be made at the present stage. Present rough estimates suggest that the costs of irradiating foods will range from 0.3 cent per pound to 10 cents per pound.

6.3 IMPACT OF RADIATION PRESERVATION OF FOOD

6.3.1 General Effects

In the foods to which it is adaptable, radiation preservation will undoubtedly be used wherever it offers economic advantage combined with qualities attractive to the consumer. Some food products preserved in this way will probably be accepted promptly. Others either may never lend themselves to this technique or never gain acceptance. Some of the effects seem to apply to the entire food industry and to consumers; others, which relate to specific elements of the industry, are discussed in separate subsections.

Present trends toward prepackaging and brand identification would likely be accentuated. Some foods, now kept under refrigeration, may then require only chill-tray protection; others may be placed on the drygoods shelves. Fruits and vegetables which must now be picked before they are ripe in order to get them to the dinner table before they spoil may be available to the consumer in field-ripened condition.

Radiation preservation has limitations. Its use in commercial practice would probably require the maintenance of new types of safety and health standards. Distributors, wholesalers, retailers, and consumers will have to learn new food-handling techniques. Although everything would seem superficially similar to practices in use today, fundamental differences may run deeper than can be foreseen.

These innovations in food processing and distribution seem unlikely, however, to be more extensive than others to which these same industries have already adapted. The introduction of frozen foods illustrates the flexibility of these industries. Radiation-preservation techniques should mean increases in the trend toward mechanization, thus better wages and better working conditions.

Consumer preferences, cost, and tradition, however, would undoubtedly result in the continued use of other preservation techniques. Home refrigerators would seem to be needed indefinitely to keep lettuce fresh, to keep bottled beverages cold, and to store leftovers. Home freezers are likely to continue to be a more convenient way for householders to preserve their purchases and garden produce.

As much as 50 percent of some food items is now lost through spoilage between the farm and the table. Every perishable pound of food which has its usability extended by radiation preservation should mean lower costs to consumers, and to producers should mean marketability of a greater portion of their produce. The overall effect, however, may mean increasing the Nation's food supplies without expansion of the quantities of food produced.

The impact of the development of radiation food preservation will not be uniform for food producers, processors, and consumers everywhere in the world. This new technique appears most readily useful in a mature industrial economy because of the requirements for continuous mechanized processing and packaging, as well as rapid transportation systems, efficient goods distribution systems, and adequate refrigeration capability at all stages of food storage and handling.

6.3.2. Impact on the Food Processing Industry

The food-processing industry markets an annual volume of $65 billion. Of total domestic food product, an estimated 63 percent is processed in some form. Radiation preservation, if successful, could increase the percentage of food processed. In addition, the rate of spoilage of fruits and vegetables, which are to be canned or frozen, may be retarded, thus allowing processors additional time in which to preserve their produce by present methods. This could be significant when the canner or freezer is confronted with daily receipts in excess of his capacity. In this way radiation could supplement, rather than supplant, present techniques.

6.3.3. Impact on the Food-Packaging Industry

Irradiation of foods, if widespread, could result in a new and more critical role for the packaging industry. Proper packaging of foods preserved by radiation is essential to the accomplishment of any lasting benefit. Radiation only destroys the bacteria present at the time of treatment. If new bacteria or insects are not kept out of the food product, the benefits of this preservation technique are lost. This will apparently be as true for radiation-deinfested grains as for meats, fruits, and vegetables. Radiation-preserved food will not be able to be handled, stored, or shipped without care to insure proper packaging exceeding the care common today for many packaged foods. Rigid or tough containers may be required in many cases where flexible wrappings without perfect sealing now afford sufficient protection in combination with refrigeration.

6.3.4. Impact on the Food-Machinery Industry

No significant effects may be expected on the food-machinery industry. This industry manufactures highly mechanized, continuous-flow food handling and processing equipment and could easily adapt to the manufacture of even more complex models, if the commercial adaption of radiation preservation techniques should demand.

6.3.5. Impact on Food-Merchandising Industry

Food distributors and retailers could conceivably benefit from the marketing of irradiated foods if the public adjusted its buying habits. As a result of confusion with radioactive fallout of atomic weapons, many persons fear all forms of radiation. The public would have to be convinced that radiation of food is not harmful.

On the other hand, the public normally welcomes new food varieties and flavors. Such possibilities as availability of year-round garden-fresh fruits and vegetables, from reduction in food spoilage which would bring economies in distribution costs and, hence, lower prices are factors in favor of public acceptance of this technique.

6.3.6. Impact on the Meat Packing Industry

For meat packers, radiation processing may create new opportunities for introduction of prepackaged meats carrying house brands or labels. Thus, new techniques for sales promotion may become available.

Savings accomplished by central meat cutting and packaging at the packing plant would mean lower costs for the consumer. This method could also permit retailers to make more profitable use of available store space. Inventory problems for the entire meat packing and distribution industry might eventually be simplified if radiation-preservation techniques develop successfully.

6.3.7. Impact on the Transportation Industry

Widespread application of radiation-preservation techniques would bring about little change in the transportation industry in the United States. This conclusion is based on the fact that many radiation-preserved foods would still appear to need protection against dehydration during shipment from production centers to markets, as well as protection against excessive heat or cold. These are the same requirements which food shippers now meet by transporting fresh and frozen foods in refrigerated freight cars and trucks.

To the extent that such radiation preserved foods displace similar foods preserved by techniques requiring refrigeration in transit, the demand for special transportation may be reduced. This in turn might result in lower shipping costs. We do not foresee these changes as coming about rapidly, however, or on such a scale as to dominate or even seriously influence the domestic transportation industry.

These developments might, at first thought, seem to lessen the need for modern transportation systems in now-primitive areas of the world lacking well-developed railroads and highways. Yet radiation food preservation is an advanced industrial tool which cannot by itself solve the food distribution problems of underdeveloped countries. This is not intended to imply that this new technique provides no benefits in such countries, but merely to focus attention again on the precept that real improvements depend on raising the level of all parts of the economic structure in underdeveloped areas.

6.3.8. Impact on the Refrigeration Industry

Many foods preserved by radiation would still require refrigeration at some point between the field and consumption. Though some foods may require no refrigeration for storage while they are properly packaged, even these would apparently require refrigeration after the package is opened. Thus home refrigerators, which make up 80 percent of the gross sales of the refrigeration industry, would continue to serve a vital function.

Applications for early use, such as deinfestation of grains and flour, affect food commodities with which the refrigeration industry is not concerned. Pasteurization levels of radiation certainly do not eliminate the need for refrigeration. Some essential ingredients of a balanced diet, such as dairy products, appear unlikely to be successfully freed from dependence on preservation by refrigeration as a result of any radiation experiments conducted thus far.

6.4. CONCLUSIONS AND RECOMMENDATIONS

Radiation preservation of food does not appear likely to replace other methods of food preservation to any substantial extent in the foreseeable future. When economically feasible, it would be a supplement to other methods.

It appears that nothing but benefits can come from success in this field for both the consumer and for the economy as a whole. Higher proportions of skilled workers would probably be needed in the food industry, but the levels of skill should not be difficult to meet by retraining.

As radiation preservation is adopted commercially, more of the food produced in the Nation would reach consumers in usable condition. This would have the effect of adding to food supplies without relationship to any increases in food production. Radiation deinfestation of grain, a technique now available, could lead to greater surpluses.

Radiation preservation techniques appear to be new tools of an advanced and mature technological and industrial society, and are not likely to be readily applied to industrially underdeveloped areas of the world.

We see no need to change the present rate at which development of radiation preservation techniques is going forward, except insofar as military needs may require.

Therefore we recommend:

1. that the present program for development of radiation preservation techniques for foods and other perishables be supported at present and projected levels; and
2. that those charged with meeting the farm surplus problem take into account the fact that radiation deinfestation of grains, a technique now available, could lead to greater surpluses.

CHAPTER 7—ATOMIC PROPULSION

7.1. INTRODUCTION AND SUMMARY

The American economy and standard of living depend upon an extensive, highly developed transportation system. Motor vehicles, aircraft, ships and locomotives utilize approximately 25 percent of the total energy consumed in the United States. Looking to the future, the energy requirement for transportation can be expected to keep pace with the growth of the Nation's overall energy requirements. The continuing demand for more and better transportation focuses attention on nuclear energy as a potential new source of propulsive power.

Possibilities of applying nuclear energy to propulsion were recognized early in the atomic-energy program. To date, actual work in the field has been limited to military applications. The Navy and Air Force are engaged in extensive research and development programs directed toward atomic-powered submarines, surface vessels and aircraft.

An atomic-powered submarine is already in operation. Nuclear energy could become a significant source of power for commercial shipping within the next 10 to 15 years. The actual rate of development will be dependent on: (1) the relative competitive position of nuclear power as it is determined through experience; and (2) the basic governmental decisions concerning the requirement for atomic propulsion in the American merchant fleet which is maintained in part as a reserve for wartime emergencies. If commercial vessels with atomic engines are developed, they would probably be constructed as part of the normal replacement program which must be carried out if the United States merchant marine is not to become obsolescent. The introduction of atomic propulsion to commercial shipping in this manner should not result in any major dislocations in the shipping industry.

Atomic propulsion of aircraft appears to be technically feasible in terms of foreseeable technology. However, problems still to be solved before aircraft developed for the military could become economically feasible for commercial aviation are of such a serious nature that impact on commercial aviation during the next 15 to 20 years is unlikely. The possible impact of nuclear propulsion on commercial aviation after that period cannot now be judged.

Atomic propulsion for locomotives is apparently technically feasible now, but is far from economic feasibility. Unless urgency arises from military requirements for atomic powerplants easily adaptable to locomotives, it seems unlikely that a development program will be undertaken of sufficient intensity to bring about economically competitive locomotives. Of course, this picture could change with a major breakthrough in reactor technology. If atomic-powered locomotives were to be introduced, the changes and effects which would follow would probably not result in any substantial decreases in railroad operating costs.

There are no foreseeable prospects for atomic-powered motor vehicles, such as cars, buses, or trucks. Such applications would require a technological breakthrough not now in sight.

For the most part, we find that the basic economic data which would determine the eventual competitive role of atomic propulsion have not yet been developed. In fact, adequate data on which to base practical decisions as to the economic feasibility of some of these applications may not be available for a decade or more.

7.2. PROPULSION OF COMMERCIAL SHIPS

7.2.1. Technological Status

There is at present no Government program directed specifically to the development of atomic engines for commercial ships, although the Maritime Administration has requested 23 firms to submit, by March 16, 1956, proposals for the design of an atomic-powered oil tanker to be completed by mid-1959. Technical feasibility of atomic propulsion of naval ships was demonstrated by the submarine U. S. S. *Nautilus* in January 1955. More advanced reactors for submarines and surface vessels are at present under development. Research and development on submarines alone are programed at over $300 million.

Early development of atomic propulsion for naval vessels reflects the fact that this type powerplant can be more easily applied to large ships than to other forms of transportation. Naval and commercial vessels differ in requirements for shock characteristics, performance, and costs.

It should be possible to provide adequate radiation shielding on large commercial ships, thus reducing the problem of nuclear hazards. Cargoes may also serve as shielding. Although a major nuclear disaster at sea appears remote, experience in the operation of atomic-powered ships is needed to place this hazard in its proper perspective.

7.2.2. Economic Feasibility

The success of the naval program has stimulated interest in the possibility of applying atomic propulsion to commercial shipping. Yet the fact that reactors have been successfully developed for use in naval submarines does not in itself indicate that they can be economically practical for commercial shipping.

In considering the economics of commercial shipping it must be recognized that the United States merchant marine is subsidized in order to maintain a standby reserve of shipping for use in case of war. Commercial vessels powered with atomic reactors might have special wartime value since the ranges of operation free from dependence on fuel afforded by atomic power could be significant. This would be particularly true if United States naval forces were largely converted to nuclear propulsion. In the absence of economic competitive status, however, there will probably be insufficient incentive to apply this development on a wide scale.

The initial capital investment in an atomic-powered commercial vessel utilizing present technology appears likely to be much greater than that required for a conventionally powered commercial vessel. For example, it has been estimated on the basis of present technology that the cost of a conventional $10 million oil tanker would be approximately doubled by the installation of a nuclear powerplant. Unless these very high capital costs can be reduced or balanced by savings in the cost of nuclear fuel or other economies, such a ship obviously cannot be competitive. To accomplish this cost reduction, a great deal of technological development remains to be done. The other operating expenses of a nuclear-powered ship should be about the same as those for conventional power, except for the cost of fuel.

Atomic propulsion should have the best chance of being competitive in the case of large, high-powered ships which carry heavy bulk cargoes in unlimited supply and spend the maximum amounts of time at sea. Ships with these characteristics could utilize the heavy investment in nuclear powerplants to the maximum advantage and could employ effectively the space saved by eliminating fuel supplies to increase the cargo payload. The Maritime Administration considers oil tankers and bulk ore carriers the best examples of these types of commercial vessels. A modern oil tanker, for example, has a very large cargo payload and spends up to 90 percent of its life at sea. The fuel oil required by a tanker for a long voyage may amount to as much as 10 percent of the payload of oil delivered. The elimination of this fuel oil requirement by atomic power could be translated directly into an increased payload of oil. This could result in additional revenue for a single 20,000-ton tanker equal to about $1 million a year.

At the present stage of development, many vessel types do not meet any of the requirements for effective utilization of atomic power. Size and speed of dry-cargo freighters is normally held down by availability of cargo; thus, extra hold space is at no premium. Ships which spend 50 percent or more of their lives in port being loaded or unloaded probably cannot obtain an adequate return on the high capital investment required in atomic marine engines.

7.2.3. Impact on Commercial Shipping

Practically the entire United States merchant fleet will become obsolescent between 1960 and 1965. This possible replacement requirement makes it wise to determine at an early date the actual competitive position of atomic power.

Approximately 93 percent of the 3,255 United States merchant vessels of over 1,000 gross tons at present in service will reach obsolescence—that is, become more than 20 years old—between 1960 and 1965. This obsolescence will include 336 of the 430 oceangoing tankers presently in service. It will be necessary to replace a substantial number of these ships unless the United States is willing to reduce its maritime position. It would appear that nuclear propulsion might be introduced for at least specialized applications such as large tankers if experience indicates that these applications are even marginally competitive with conventional vessels.

Atomic-powered ships do not seem likely to change the competitive position of the United States in world shipping. The United States merchant marine is at a basic disadvantage in world competition primarily because our labor costs both in the shipbuilding industry and in operations are above those prevailing in other countries.

The hulls of nuclear-powered ships would presumably be constructed by the same shipbuilders as today. Atomic-powered replacements for all present United States oceangoing tankers exceeding 15,000 tons deadweight, in the period 1960–65 on, would result in construction of 300 or more such vessels over a period of 20 years. At the $10 million figure per atomic engine, estimated by the Maritime Administration (see vol. 2, ch. 7), this would amount to an average yearly business of $150 million and would result in an installed atomic power capacity aboard ships on the order of 15 million kilowatts of heat in the 1980 period. This would be equivalent to roughly 7 percent of the lower estimate of central station atomic power which, as we have noted in chapter 2, might be installed in the United States by 1980. Thus we can see a possibility that commercial shipping using atomic power could create sizable demands for the construction of atomic marine engines and for production and processing of nuclear fuels. Special dock facilities might be required for servicing atomic-powered ships. Location of such service facilities would, of course, have to take into account the hazards which may be involved.

In general, atomic ship propulsion, if it becomes economically competitive, seems likely to have only good effects on the United States economy. The requirements of commercial shipping for fuel oil might be reduced, but American ships at present consume only approximately 3.5 percent of total United States petroleum production. The oil tankers alone which appear to be the most logical candidates for atomic propulsion account for almost one-half of these petroleum requirements.

7.3. PROPULSION OF COMMERCIAL AIRCRAFT

7.3.1. Technological status

The Commission and the Department of Defense are engaged in a joint research and development program directed toward practical atomic propulsion for military aircraft. On the basis of the work of this program to date, atomic propulsion of aircraft appears feasible—

if technological developments proceed as now foreseen. The program is thought likely to require between half a billion and 1 billion dollars to accomplish, and has as its objective a military airplane in which economics are not a primary consideration.

One of the fundamental deficiencies of conventional, chemically powered aircraft is the inherent limitation on operational range imposed by fuel requirements. Since a nuclear reactor can theoretically operate at high power for long periods of time with negligible consumption of fissionable material, future aircraft with atomic propulsion could in principle achieve practically unlimited range. There are, however, many barriers which must be overcome before this goal can be achieved. Lightweight reactors operating at high temperatures and power levels are very difficult to achieve. Crews and equipment must be shielded from radiation. Size, weight, and payload must all fit practical operating and maintenance patterns.

7.3.2. Economic Feasibility

The military worth of atomic-powered aircraft with virtually unlimited range may balance high costs and associated hazards. If nuclear propulsion is to be extended to commercial avaition, however, it must be economically competitive with chemically powered aircraft. The quantity of shielding required to reduce radiation to acceptable human tolerance levels would appear at this time to rule out commercial passenger application. Commercial attention in the period after achievement of atomic-powered flight would undoubtedly focus initially on cargo aircraft, where shielding to meet human tolerances would be required only for the crew compartment.

No usable estimates of eventual costs of construction and operation of atomic-powered commercial cargo airplanes are yet possible. The initial capital investment would seem likely to be much greater than for comparable chemically powered aircraft. Atomic-powered planes would in this event only be competitive in cases where the savings in operating costs over the life of the aircraft were sufficient to compensate for the much higher original investment. Beyond a few thousand miles, operating costs per mile for conventional chemically powered aircraft rise very rapidly, while operating costs per mile for atomic-powered aircraft would be essentially the same for flights of any distance. Thus large atomic-powered cargo aircraft operating over distances of more than several thousand miles might be competitive with conventional aircraft operating nonstop over comparable distance. The actual economic competition, however, would also be influenced by such factors as special maintenance facilities and personnel for atomic-powered aircraft compared with conventional aircraft needs for overseas refueling points and cost of conventional fuels at such overseas airfields. Even if nuclear propulsion systems are perfected, however, accidents involving such aircraft, occurring in heavily populated areas, might result in local radioactive contamination of serious proportions. Airfields servicing early models of atomic-powered aircraft would presumably be located remote from urban areas, which would adversely affect comparative operating costs.

7.3.3. Impact on Commercial Aviation

Commercial atomic-powered aircraft seem achievable only as byproducts of military development. Were it not for military urgency, emergence of such airplanes would lie far in the future because of the high costs involved. Even with successful development for military purposes, commercial atomic-powered aircraft are unlikely to appear for a decade or more after military types are first operated. This application of nuclear energy should not, therefore, have any real impact on civil aviation in the United States during the next 15 or 20 years.

Despite this pessimistic appraisal of the short-term prospects of atomic propulsion for commercial aircraft, it does represent a potential propulsion source for the future. Results of the United States military program in this field during the next decade should give a fair basis for evaluating possibilities of commercial application. It is premature to attempt to evaluate now, however, the eventual impact of nuclear-powered aircraft on commercial aviation and the United States economy.

7.4. PROPULSION OF LOCOMOTIVES

7.4.1. Technological Status

There is no real program, Government or private, at present concerned with the development of atomic propulsion for locomotives. The work going on is all of a study nature and on a small scale. Scientific and engineering data developed in the ship and aircraft programs indicate, however, that atomic-powered locomotives would be technically feasible in terms of foreseeable technology. Industrial interest has so far apparently been limited to a total expenditure of not more than several hundred thousand dollars. A major development program would involve tens of millions of dollars. Industrial decisions on nuclear locomotives will probably be made on the basis of information that evolves during the next decade from the current military programs for nuclear propulsion of ships and aircraft, and on information obtained from the "demonstration" atomic electric power program. Future developments in this field, therefore, will be dependent upon the level of interest maintained by the railroad industry over a period of years. Any development which does get underway would require access to advanced work on military propulsion systems.

The design of atomic-powered locomotives would appear to be determined by the characteristics of existing railroad rights-of-way and facilities. The critical dimensions of height and width are limiting design factors. Shielding to permit operation without danger from radiation to the crew or to people near the locomotive, however, appears achievable.

7.4.2. Economic Feasibility

Sufficient information is not available at present to justify discussion as to when atomic-powered locomotives might achieve competitive economic advantage. Diesel locomotives averaging 1,500 horsepower per unit are used in combination of from 1 to 6 units, thus permitting a high degree of operating flexibility. Atomic locomotives would, therefore, start out with difficult competitive standards.

The initial capital investment in atomic-powered locomotives would probably be greater than in present diesel electric locomotives which now cost approximately $134 per kilowatt of capacity. The capital cost per kilowatt for small, compact atomic propulsion plants would presumably be considerably higher. Atomic locomotives, therefore, would be competitive only if savings on fuel compensated for the higher initial capital investment. Small compact reactors for locomotives would not permit the best of fuel economies. Atomic fuel costs for atomic locomotives, therefore, seem likely to be more expensive than atomic fuel costs for large atomic electric power stations.

Atomic locomotives would be subject to the same accident hazards as conventional locomotives. A major accident could conceivably result in serious radiactive contamination. This danger should not be minimized and will certainly constitute a retarding influence on this line of development.

7.4.3. IMPACT ON RAILROAD INDUSTRY

Although any early achievement of economically competitive atomic-powered locomotives appear unlikely, it is useful to consider the impact such a development might have on the domestic railroad industry.

The shift from steam to diesel-electric locomotives, which took place in little more than a decade, has been almost completed. The 25,000 diesel-electric locomotives currently in operation represent an electric power capability of roughly 30 million kilowatts. This is equal to 25 percent of the total electric power capability of the United States. All diesel-electric and oil-burning steam locomotives at present, however, consume only 3.3 percent of the total petroleum consumed in the United States. Thus, maximum impact on the oil industries which could be accomplished by complete conversion from diesel to atomic power would in fact be considerably less significant than was the impact on the coal industry of the switch from coal-fired steam to diesel-electric locomotives. The railroads which consumed 25 percent of all United States coal production 10 years ago, today consume only 3.6 percent. Thus, the coal industry would feel little impact from the loss of this customer.

Complete replacement of the 33,000 units of motive power at present in use by American railroads with atomic locomotives would represent a potential market of $10 billion, assuming capital costs of $250 per kilowatt. The railroad industry has demonstrated its capacity to meet an investment requirement of this same order in the purchase of $4 billion worth of diesel-electric locomotives in little over a decade. Manufacturers of diesel locomotives appear to have many of the basic engineering skills needed to produce atomic locomotives, hence should be able to hold their own in the event of such a development.

Changes in rail rates and freight patterns seem unlikely to arise from this particular application of atomic energy, although we have noted (see ch. 2) that atomic electric power development might have some effects on railroads as a result of changes in industrial plant location. Few, if any, changes in existing railroad facilities would be caused by atomic locomotives since, in order to be economic, they would have to be designed in accordance with size and weight limitations of present railroad ways and structures.

7.5. MOTOR VEHICLES

Nuclear energy does not appear to be a feasible source of power for commercial or civilian vehicles in the foreseeable future. Technically, there seems to be no prospect of designing a properly shielded atomic power source consistent with the size and weight of present-day motor vehicles. The cost of even the smallest reactor system would be entirely out of line with the acceptable capital investment in a motor vehicle. Another serious deterrent is the potential radiation hazards arising as a result of accidents.

The fact that nuclear energy will not find application to motor vehicles is in itself of considerable significance to the total American energy economy. At present 41 percent of all the petroleum products consumed in the United States goes to motor vehicles. This amounts to almost 20 percent of the total energy demand of the United States. It appears, therefore, that the oil industry can count on large and rapidly expanding requirements of motor vehicles for a period extending far beyond 1975. The ability of the oil industry to meet this demand will be enhanced by the availability of atomic power to pick up other energy loads now met by petroleum. In this way, nuclear energy and conventional sources of power will complement rather than compete with each other.

7.6. CONCLUSIONS AND RECOMMENDATIONS

7.6.1. Propulsion of Commercial Ships

Atomic propulsion of commercial ships is technically feasible. However, economically competitive atomic ships are not generally yet in prospect. A limited number of applications, such as ocean-going tankers, may have economic advantage. The possible need to replace a large portion of the United States merchant fleet in the 1960–65 period makes it desirable for the Atomic Energy Commission, the Maritime Administration, and the shipping and shipbuilding industries to work out a program for exploring the economic feasibility of atomic-powered ships. Only in this way can adequate engineering and operating data be obtained in time to permit determination of the advisability of construction of any substantial number of atomic-powered commercial ships a decade hence. Advantages of such ships during any future war, as well as maintenance of United States maritime prestige, give a degree of urgency to this line of development.

7.6.2. Propulsion of Commercial Aircraft

Though technical prospects for military aircraft with atomic propulsion are considered good, prospects for economically competitive commercial applications seem unlikely until some experience with military prototypes has been acquired. If commercial types ever come into use, they will probably be byproducts of the military program. Foreseeable impact, even so, is not substantial since only very long range cargo aircraft appear likely to be able to make profitable use of atomic power. The prospect of nuclear crashes in populated areas and resultant radiation hazards could serve as additional deterrents to extensive use. There appear to be no advantages inherent in commercial atomic aircraft worth additional efforts now, over and above those being expended on achievement of military objectives.

7.6.3. Propulsion of Locomotives

Atomic locomotives could in all probability be built and operated successfully, but appear to offer no economic advantages until substantial improvements in reactor technology are made. There is no real industrial development program directed at atomic locomotives today and no directly comparable military atomic power projects are underway, but the technical and engineering data being developed will undoubtedly improve the outlook for economically competitive atomic locomotives in the years ahead. There appears to be no incentive or necessity for Federal support of an atomic locomotive development program, but the Commission should cooperate within the limits of national security with any industrial efforts.

7.6.4. Propulsion of Motor Vehicles

Atomic-powered civilian automobiles and commercial trucks and buses are not technically feasible today and apparently will not be in the foreseeable future.

7.6.5. Recommendations

We recommend:

1. that the Atomic Energy Commission, the Maritime Administration, and the shipping and shipbuilding industries work out a program for exploring the economic feasibility of atomic-powered ships; and
2. that the Commission cooperate within the limits of national security with any industrial efforts to develop atomic locomotives.

CHAPTER 8—GENERAL INDUSTRIAL USES

8.1. INTRODUCTION AND SUMMARY

The $1 million worth of radioisotopes now being sold annually by the Commission to industry are making possible savings through process and quality controls estimated at $100 million annually. This important business is growing larger with every new idea. It contrasts sharply with atomic electric power from which few, if any, have so far made money.

Produced as byproducts of nuclear reactors, these radioisotopes provide industry with small sources of radiation and tracers. These atomic tools are so cheap, require so little capital investment, permit such prompt returns, and are so free from information control restrictions that their use is expanding rapidly. Radioisotopes are already contributing to increased industrial productivity on a broad front.

Radioisotopes are already being used in industry, but greater significance may lie in future utilization of atomic heat and radiation. Process heat and radiation in such industrial fields as food preservation and industrial chemical production hold important promise. Many other major areas undoubtedly exist for both atomic heat and radiation. These goals for industrial research and development could make real contributions to our economy. They are within the competence of existing industrial research strengths.

Use of atomic energy for space heating is limited by practical economic considerations imposed by high capital and fuel costs and heat losses in distribution. No substantial space heating uses are in prospect either for residential or commercial purposes.

8.2. RESEARCH AND CONTROL APPLICATIONS

Radioisotopes can be used for the study of inorganic substances and industrial processes in the same way as they are used in such other fields as agriculture and medicine. Some industrial applications have been conducted on a small scale for many years, using radioisotopes produced in high-energy particle-accelerating machines. Still other applications originally came into practice through adaptation of X-ray equipment. However, nuclear reactors have made radioisotopes and radiation sources available at costs which permit new and broader applications.

8.2.1. Technological Status

Radioisotopes are being used by approximately 1,200 industrial firms as sources of radiation and as tracers in production processes and basic research. These isotopes in elemental or compounded forms behave chemically as nonradioactive forms do, yet emit radiation which can be traced with counting instruments. The diversity of the applications of radioisotopes already in use suggests the breadth of promise for the future.

Some 350 industrial firms are at present using radioisotopes in radiography to inspect metal castings and welds for possible flaws. Radioisotopes have a major advantage in these applications over radium and X-rays as a result of their lower costs and increased versatility. A quantity of radioactive cobalt 60, costing $100, for example, is equal in effectiveness to $20,000 worth of radium. About 300 industrial firms are using a large variety of radioisotope gages to measure the thickness and density of such materials as sheet metal, rubber, paper, and plastics. The tobacco industry, using radioisotope density gages to determine the quality of cigarettes, now employs more of these gages than any other single industry.

Radioisotopes are also being used in actual industrial processes. The techniques employed are essentially the same as those which have been developed so successfully in medicine. Just as radioisotopes are used to trace the movement of blood in the human body, they are used to locate the dividing point between two different petroleum products flowing through overland pipelines. Tracer techniques in industrial research already in common use are exemplified by studies of engine piston wear which have already resulted in improved motor oils. The availability of radioisotopes seems likely to stimulate new interest in the application of luminescence, heretofore almost completely limited to watch dials, instrument markings, paints and tapes.

8.2.2. Impact of Research and Control Applications

Continued rapid expansion of specialized industrial applications of radioisotopes should make great savings for industry possible over the years ahead. These applications will contribute to increased productivity and lower costs for American industry. As in the case of medicine, it is not easy to place an actual dollar value on these potential contributions, but improvement of existing products and development of new products will certainly result.

American industry has already invested about $25 million in instruments and equipment to use radioisotopes. Yet supplying radioisotopes for these instruments amounts to only several hundred thousand dollars of annual business today. Although the instrument and equipment industry is likely to grow substantially, there appears to be no prospect that the demand for radioisotopes for these applications will be sufficient to in any way affect the basic economics of atomic powerplant operation.

8.3. PROCESS APPLICATIONS OF HEAT AND RADIATION

American industry consumes vast quantities of energy directly as heat in a great variety of different processes. Atomic reactors are a potential new source of energy for such "process heat" applications. Atomic reactors also yield energy in the form of radiation. The use of radiation in industrial processes is a new field which is just beginning to be explored but which shows real promise.

8.3.1. Technological Status

There have been no development programs as yet directed to the utilization of atomic reactors for either process heat or process radiation. However, limited preliminary studies on these problems are underway both under Commission and industry direction.

This Nation now utilizes approximately 10 percent of its total energy consumption as process heat in the production of such basic materials as metals, chemicals, cement, glass, paper, petroleum, and rubber products. These industrial processes which employ heat directly would seem to be natural early markets for atomic heat. A projection made for us by the Commission indicates that the demand for process heat might triple by 1980.

However, many such processes require temperatures of 1,500° F. to 3,000° F., which cannot be achieved in reactors incorporating even the most advanced atomic and metallurgical technology known today. The Commission and the Bureau of Mines of the Department of the Interior are making preliminary feasibility studies of the possibility of accomplishing the gasification of coal with an atomic reactor. Several chemical companies have expressed interest in the possibilities of using atomic reactors for high temperature chemical reactions. Actual work, however, has not yet proceeded beyond the stage of preliminary feasibility studies.

Atomic reactors have been suggested as a means of obtaining low-cost heat necessary for economic production of fresh water from salt water for use in agricultural irrigation or municipal and industrial water. No conventional power sources are sufficiently low in cost to do this today. Preliminary studies by the Commission do not indicate any economic advantages of atomic heat over fossil fuels. Atomic projects large enough to accomplish this goal economically appear to be as expensive in terms of total dollar outlay as engineering projects on the scale of diverting the flow of rivers from one basin to another. (See vol. 2, ch. 8.)

The massive quantities of radiation made possible through development of atomic reactors open up the possibility of entire new areas of scientific development in chemistry and other fields. Radiation energy cannot be thought of in the same terms as heat energy. For example, while an ordinary 1-watt light bulb produces a barely perceptible amount of light or heat, a 1-watt source of gamma radiation could kill a man in less than 1 hour. Research at Commission and industrial laboratories has demonstrated that radiation can be used to supply energy to initiate some chain chemical reactions and to supply all of the energy required in basic chemical reactions. Radiation energy can also accomplish changes in the structure of materials and even create new materials which are difficult or impossible to produce by other known methods. It can, for example, replace catalysts, in the polymerization of plastics and can produce new types of plastics by "graft copolymerization." The fact that irradiated polyethelene can withstand higher temperatures than ordinary polyethelene plastics has already been applied by industry on a limited scale in the production of heat-resistant plastic laboratory equipment.

8.3.2. Impact From Process Heat and Radiation

We have noted above that demand for process heat in the United States by 1980 is forecast at three times present levels. Although atomic energy is not now being used for industrial process heat, some eventual use of it for this purpose seems probable in view of this rise in demand. The amount of such heat obtained from atomic energy will depend on when such developments really get started and on how fast they become economically competitive. No applications seem likely for at least the next 5 years, since development would itself require that much time.

An estimate provided us by the Commission indicates that the rate of growth, after atomic heat proves technically and economically competitive, might conceivably permit it to meet as much as 10 percent of total process heat requirement by 1980. The atomic reactor capacity required to meet such a demand would be equivalent to the reactor capacity required for roughly 25 million kilowattts of atomic electric power. This would amount to approximately 20 percent of the higher forecast and 50 percent of the lower forecast discussed in chapter 2 for atomic power capacity which might be installed in the United States by 1980.

In the absence of any development programs for process heat, we do not have adequate data to establish a time table for developments in this field, and we do not have a basis for an impact forecast. Nevertheless, the application of atomic energy to process heat apparently could begin on a moderate scale during the next 10 to 15 years.

The future of atomic radiation is equally speculative since little is known concerning the effects of massive quantities of radiation on various industrial processes and materials. Yet the prospect of substituting radiation energy for heat energy appears to offer real prospects in the food processing and chemical industries and may conceivably indicate a new direction from which future supplies for a different kind of energy than that now commonly used may come. Remembering our comparison of a 1-watt light bulb and a 1-watt gamma radiation source, it is apparent that a small amount of energy in the form of atomic radiation energy can be substituted for a relatively large amount of heat or electric energy in some industrial process.

8.4. SPACE HEATING

Within the term "space heating" are included all of the efforts necessary to modify the temperatures in commercial, industrial and residential buildings and enclosures. Both heating and cooling are involved. Space heating now uses 30 percent of the energy consumed in the United States. Air conditioning has accounted for a substantial portion of the increased demand for electricity in some part of the United States in recent years, and the demand is still rising rapidly. Since atomic energy can produce heat, it must be considered a potential source of energy for these purposes.

8.4.1. Technological Status and Impact

Waste heat from a research reactor at Harwell, England, has been used since 1948 to provide space heating for adjacent buildings. Similar applications under Commission direction have been made at Hanford, Wash. Despite the special applications, there are, however, no other real development efforts underway directed toward the use of atomic energy for space heating.

Heat from atomic energy is no different from any other form of heat. It cannot be transported more cheaply or for greater distances. Consequently, central heating systems for complexes of buildings, called "district heating", are confined to very heavily populated metropolitan areas and account for only about 1 percent of the space heating requirement of the entire country. Atomic heat will probably eventually be competitive with conventional power sources for this type of "district heating". However, the rate of growth of this type of space heating will be limited, as it is now, by the very high costs of the distribution system. In this connection, it is significant that conventional electric power stations today do not generally find it worthwhile to sell waste heat for space heating. There is nothing in the technology of atomic electric powerplants which would appear to change this outlook.

Atomic home furnaces are theoretically feasible, either in the form of small reactors or as devices containing radioactive fission products. However, these applications of nuclear energy do not appear to make any sense on the basis of foreseeable technology. Small reactors suitable for residential space heating appear certain to cost many times as much as comparable sized conventional home heating systems. The upper levels of atomic power growth in the entire next 25 years appear to yield only enough radioactive fission products to heat a few thousand homes.

8.5. CONCLUSIONS AND RECOMMENDATIONS

Radioisotopes and radiation are already being used by industry for process control and inspection and for research. Savings in the form of reduced scrap, reductions in additional work performed on faulty products in process, and in better knowledge of what is happening in complex processes undoubtedly will be large in the years ahead. These have become natural tools of industry.

Atomic heat for industrial processes could be of significance in the future. No active research and development program on this problem is in progress. In view of the nature of the potential industrial applications of process heat, it would appear that private industry must bear the primary responsibility for the development of specific applications. However, at the present time, only the Commission has the facilities required to conduct the metallurgical research essential to the development of high temperature reactors.

Atomic radiation may be very important as a new form of energy for the chemical and other industries. Present Commission support could profitably be stepped up in these areas of fundamental exploration. However, here again it appears that the development of specific applications will be most successful if they are carried out by the actual industries which are prepared to exploit them.

Atomic space heating, while theoretically feasible, appears unlikely to prove economically competitive on any substantial scale. Nevertheless, since space heating requirements are a large fraction of total national energy demand, any efforts on the part of private industry to explore promising ideas should be encouraged by the Commission.

We recommend:

1. that the Commission step up fundamental research in areas relating to the use of atomic radiation as a new form of energy for material processing; and
2. that the Commission encourage any efforts by private industry to explore promising ideas relating to atomic space and process heating.

CHAPTER 9—IMPACT ON THE UNITED STATES OF PEACEFUL ATOMIC DEVELOPMENTS ABROAD

9.1. INTRODUCTION AND SUMMARY

Historically, the United States has responded vigorously to the challenge of bringing humanitarian and economic help to other people throughout the world. Peaceful uses of atomic energy offer opportunities for continued leadership. Positive actions, above and beyond those now underway, are urgently needed. An alert, forward-looking Commission organization and specific goals for United States research and development to meet the needs of other nations are dictated by this urgency. The United States should speed decisions to do everything possible to assist, primarily through technological aid, in bringing atomic power to early realization abroad. With nations desiring such prompt assistance, an interim control plan adequate to protect against diversions to military use can be devised without conflict with our international disarmament aims. Atomic energy could be decisive in the struggle to bring peace and plenty to the world.

The speed with which the United States and other nations of the free world act to bring the constructive benefits of atomic energy to all peoples will influence the achievement of lasting peace. The bright promise of radioactive materials and radioisotopes provides even non-industrialized countries with opportunities for improvements in health and agriculture. The United States has a great challenge to assert its leadership, as it has in the past, in the lessening of poverty and distress among all peoples.

The two main categories of peaceful uses of atomic energy are:

(*a*) Humanitarian atomic applications which deal with medicine, biology, and agriculture. They are concerned specifically with providing nourishment, improving health, and saving lives. Information and help in these fields have always been exchanged between nations of the free world without boast or fanfare. Such things as these, which so directly affect men's lives, have higher missions than to serve as barter in chanceries and foreign ministries.

(*b*) Atomic power and other atomic industrial applications have captured the imagination of the world because of the broad vistas of economic development which they seem to open. Many have been led to believe that the solution to the problems of the world lies with these developments: power for power-short areas; a kernel around which the economies of underdeveloped areas could grow; even a source of energy to provide water to make deserts bloom. In time, some of these applications may indeed be realities. Atomic electric power, with all its eventual far-reaching consequences, can at present reasonably be expected to be economically justifiable soon only in high-cost areas where fossil fuels are scarce or expensive.

9.2. HUMANITARIAN APPLICATIONS

Want and plenty are hard to reduce to indexes. Every point on the scale between these two absolutes marks the state of many people in every nation, no matter whether the nations be highly or slightly developed economically. Yet if any figures can suggest the many lives lived in quiet desperation, they are those which tell of undernourishment and shortened life expectancy. For hundreds of millions of men and women in the world, there is only barely enough food to sustain life and little prospect of living beyond, or even to, the age of 50.

To the extent that atomic energy can help people everywhere lead healthier, longer, and more productive lives, contributions by the United States directed toward the needs of others can go far in bringing to the world an appreciation of the benefits of a free society.

The minds of men are waiting to be won. Food and health are not the only essentials of life, but they are two of its most critical elements. In underdeveloped countries where these are in short supply, the peaceful uses of atomic energy could be most significant.

9.2.1. Agriculture

We have seen in chapter 5 that a basic fact of American agriculture is overproduction, and that the contributions of atomic energy to farming in the United States can contribute to expanding crop surpluses. In nations where primitive farming methods and low productivity tie most of the population to the soil, however, atomic energy can open paths to improved food supply, thereby releasing more people for industrialization.

Radiation-induced genetic mutation techniques are bringing closer the day of tailormade plants. Agricultural experiment stations should be at work throughout the world breeding crop types suited to local temperatures, rainfall and soils, as well as crops most resistant to local diseases and blights. Experimenters should be using atomic tracers to learn how best to fertilize local crops, feed local livestock, fight local pests.

Yet it must be noted that famine in underdeveloped countries is often as much the result of inadequate food storage, handling, and transport facilities as of crop failures. Contributions of atomic energy to solving these problems are in prospect but are hardest to achieve in the absence of an industrial base, hence more distant in time. Free distribution of United States food surpluses can only take the form of emergency measures for the relief of famine. Any long-term correction of food deficiencies must come about from overall improvement in the economies of the areas involved.

9.2.2. MEDICINE

Nations most highly advanced medically usually have the highest life expectancy rates. In these advanced countries, the effort of medical research is for the most part directed at local problems. Germs, viruses, and parasites preying on large segments of humanity elsewhere receive minor attention. Atomic energy applications in medicine can help the less advanced countries, but they will make no real headway against high mortality rates until sufficient number of properly trained medical researchers and practitioners are available to employ modern methods in the diagnosis and treatment of endemic diseases. A lengthening of the life span, however, can be a cruel disillusionment unless accompanied by improvement in food supply, higher standards of living, education, and personal and political freedom.

9.3. FOREIGN INDUSTRIAL APPLICATIONS OF ATOMIC ENERGY

Although world attention has tended to focus on atomic power as the principal industrial application of atomic energy, we have noted in chapters 7 and 8 that there are a great many others, some of which have already been put to use on a substantial scale on the industrial scene. The use of radioisotopes in industrial research and the application of radioisotope control devices in various industrial processes have not only begun but have even been pioneered in some instances in foreign countries.

Sweden, England, Russia, and Japan, among others, all reported on such developments at the Geneva "Atoms for Peace" Conference in August 1955. It is important to note, however, that introduction of atomic energy in its many forms in underdeveloped countries can only be successful as an integral part of educational, health, economic, and industrial development.

We have long recognized that rising standards of living throughout the world not only mean better material lives but also generally mean more stable political patterns, and also healthier economic relationships between nations. Thus, it seems clear that exercise of the United States leadership to speed achievement of the benefits of general industrial atomic developments by nations where the need is great would redound to our benefit in better friends, in maintenance of our international prestige, and in improved outlook for international trade.

Atomic power has already received widespread attention as a means for extending the economic strength of industrialized nations and for opening new ways to develop economic strength in countries undergoing industrialization.

9.3.1 FREE WORLD NEED FOR ATOMIC POWER

Very rough estimates of the potential demand abroad for additional electric power indicate that atomic power plants to provide in excess of 100 million kilowatts generating capability might be installed in the free world outside the United States by 1980. The factors which might motivate choice between conventionally fueled and atomic powerplants are not the same for all areas. For some, the virtual elimination of the cost of transporting conventional fuels made possible by substitution of nuclear fuels may be important. For others, where the domestic supply of fossil fuels or falling water is limited, atomic power may offer a new energy source of great importance. Still other areas, which possess adequate conventional energy sources, may need atomic power only as a stabilizing influence to retard increases in conventional power costs or to free them from international political pressures. In many areas a combination of high electric generating costs, and restricted or high-cost fuel and hydro resources provide sound economic reason for installing atomic power. We must note, however, that in some countries, particularly those in which understanding of the problems involved is incomplete, it may not be presently possible to choose intelligently between conventional and atomic power, especially where all industrial development costs are high.

Based upon present costs in some countries, atomic power would be competitive—even as generated from present reactor designs which, although high in cost, have been proven technically feasible. The present program for expansion of the government-owned British electric system, through the construction of approximately 100,000 kilowatts of atomic power capacity by 1958 and 1.5 to 2 million kilowatts by 1965, appears to be based on this conclusion, as well as the shortage of domestic coal production. The growth of atomic power abroad is likely to take place more rapidly in high-cost or energy-short countries than in the United States.

In highly industrialized nations—and in some which are in the process of industrializing—the scale of capital requirements, including foreign exchange, to support atomic power programs need not be limiting factors. Atomic power projects will have to compete, however, for such funds with many other demands. Capital formation is usually rapid as industrialization proceeds. In underdeveloped areas, however, the availability of capital and foreign exchange may be limiting. Atomic power may contribute to economic growth in such areas. Yet it is difficult now to judge whether the economies of these areas can be organized so as to assure a sufficiently high rate of capital formation and of industrial and technical competence. Historically, this process has not taken place rapidly without technical and financial assistance from the outside.

9.3.2. Ability To Fill World Atomic Power Needs

The only significant capability to manufacture atomic powerplants and sell them in the growing world market now rests with three countries: The United States, the United Kingdom, and the Soviet Union. All three will be competing in one way or another. This situation will probably continue for several years. Although other nations are developing self-supporting atomic power capabilities, the limited availability of nuclear fuels and of scientific and engineering personnel will retard their competition for the furnishing of complete atomic power systems in world markets. Development of specialized capabilities in the manufacture of reactor components, controls, pumps, and similar products will probably occupy such other nations for the next several years.

9.3.3. International Consequences of the Growth of Atomic Power

World interest in obtaining the benefits of atomic power promptly is now at a very high level. If anything, it has grown more rapidly than have the technological developments needed to justify this interest. Some fear damage to our national prestige if we now make available reactors that might soon be superseded by more advanced types. This fear in part seems to stem from the fact that certain relevant engineering and economic information on reactor technology in the United States still remains classified. If other nations need atomic power now, if they seek advice in the United States, we believe that there is an obligation to make a full and frank disclosure of present and prospective states of the art concerning the most advanced technical and economic designs of atomic powerplants, including nuclear-fuel prices, insofar as realistic considerations of national security permit. The decisions of these countries must be their own and should be based upon access to all the pertinent facts.

The returns to be expected from such frank international policy are substantial. In the uncommitted areas of the world, American leadership in making atomic power available could be a strong influence in guiding these areas toward the course of freedom. In this sense, atomic power acquires great importance in international relations. This consideration should strongly influence our national policy as to the rate at which the development of atomic power suitable for such purposes is pressed. There is urgency for the development in the United States of atomic powerplants suited to the needs of the other nations of the free world. Generally speaking, this means the smaller sized plants on which all-too-little development work has been done as yet. (See ch. 2.)

This urgency which exists for foreign atomic power has domestic benefits as well. The growth of an atomic power program will probably not become significant before 1965. A gap may occur for the power equipment manufacturing industry between present domestic interest in atomic power reactors and actual sales in substantial volume. If the equipment manufacturers, operating in our free-enterprise tradition, are to be expected to carry forward research and development directed toward making atomic power competitive in the United States, the foreign market for power reactors with its high near term growth potential may offer a solution to bridging this gap. The potential demand may represent a $30 billion market. In chapter 2 we discuss the steps we believe proper for assuring that this level of urgency is met.

Definite goals for the installation of atomic power abroad should be set. These goals, and the role of the United States in meeting them, can be established by holding a series of small international conferences with friendly nations needing assistance. We do not see that such action is inconsistent with the establishment of the international agency now being discussed. In fact, by such an approach, part of the objectives of such an agency will be accomplished in advance of its organization.

We specifically note, however, that special subsidies from the Commission, such as free plant construction, free fuel or higher prices for byproduct plutonium and uranium 233 than paid domestically, should not be used in connection with a foreign power reactor program. Financing of all foreign installations, atomic and conventional—to the extent to which the Federal Government becomes involved—must be kept within normal channels for the extension of financial assistance abroad. Any other course will complicate to the point of unworkability what should be a straightforward comprehensive policy covering international economic activities of the United States.

9.3.4. The Need for International Atomic Control Measures

There are consequences of the growth of atomic electric power abroad that may be of great military importance. Operation of atomic power reactors results in byproduct plutonium or uranium 233, useful in weapons manufacture. The establishment of atomic powerplants throughout the world, therefore, presents the problem of controlling these byproducts in such a way as to prevent diversion to military purposes.

One method for controlling military atomic activity obviously lies in the achievement of complete international control of such activities. Ten years of negotiation toward this end have not been fruitful. An alternative control mechanism lies in the more limited approach offered by controlling byproduct plutonium and uranium 233 derived from peaceful atomic applications. This type of control appears to hold some promise of achievement.

The character of control measures must be considered if the economics of atomic powerplants are not to be burdened with the costs of stringent security safeguards. Elaborate systems for checking the flow of materials through reactors and fuel processing plants, and for inspection teams and physical security measures would add greatly to the cost of plant operation. Yet these are the types of measures considered essential in order to insure against byproduct diversion to weapons manufacture.

The prestige of the United States is at stake. Atomic power must be made available now. Therefore, the problem of control must be treated with a greater sense of urgency than is presently evident. Negotiations looking toward formation of an international agency are now underway but by their very nature are lengthy and time consuming. Skilled personnel must be trained, and understanding of the complex problems that may arise must be achieved. The Commission training schools for foreign technicians and joint State Department-Commission negotiation of 27 bilateral agreements providing for United States assistance in nuclear research are necessary steps. However, action still more prompt and positive is required.

As we have noted, the United States should take the initiative in bringing about the establishment of immediate goals for the installation of atomic power in friendly power-short countries needing greater industrialization. We believe the United States should get on with making atomic power available now to these nations. We believe that this can and should be done on an interim basis with bilateral agreements permitting appropriate inspection, providing for fuel reprocessing in the United States, and providing for earmarking plutonium and uranium 233 thus recovered exclusively for further peaceful uses. Other control mechanisms of a broader nature can be devised and agreed upon later.

9.4. CONCLUSIONS AND RECOMMENDATIONS

The humanitarian applications of atomic energy can make significant contributions to the health and prosperity of peoples throughout the world. These techniques offer the United States an opportunity to establish specific research goals, the accomplishment of which could demonstrate the benefits of our concepts of freedom and the importance of the individual in society. There are many ways in which United States leadership in application of humanitarian uses must be pressed forward with imagination and vigor.

Atomic power may be the most tangible symbol of American's will to peace through the peaceful atom. Our domestic needs cannot be our only motivation. Otherwise, we leave without effective rebuttal the argument that America is so rich, so prosperous, that a revolutionary new energy resource can emerge without any urgent need on our part to put it to man's use. This must seem a strange position indeed to peoples possessing neither conventional fuels nor technical capabilities to put the atom to work.

If we fail to act to bring atomic power to the free world, other countries will do so ahead of us, or progress will proceed at a slower pace.

Peaceful uses of atomic energy will inevitably be developed throughout the world. The United States must lead.

Therefore, we recommend:

1. that the executive branch establish specific research and development goals to meet the needs of friendly nations; and that attainment of these goals be assured by provision of technical services, including the conduct of projects at home and abroad aimed at developing crops and farming methods, medical practices, and education and training in basic science and in applied atomic techniques adapted to the problems of specific friendly nations;
2. that the Commission center its responsibilities with respect to international development of peaceful uses of atomic energy in one alert, forward-looking organizational unit;
3. that adequate research and educational equipment and facilities be provided to friendly countries, accompanying research reactors sponsored by the United States, so that atomic scientific, agricultural, and medical benefits can be brought to bear promptly where most needed;
4. that the United States encourage other nations to decide for themselves the rate at which they wish to apply atomic power and other industrial uses of atomic energy to their own economies, to which end, we further recommend:

    I. that the United States promptly convene a series of regional conferences of our bilateral partners for the immediate establishment of realistic goals for the installation of atomic electric generating plants in specific countries;

    II. that the United States, in issuing invitations to such conferences, announce that it is prepared to furnish nuclear fuels, provide necessary technological assistance and permit contracts for the installation of at least 1 million kilowatts of atomic generating capacity outside the United States as soon as possible—we hope by 1960. The attention of the world should be called to the fact that such a program would parallel and possibly exceed the capacity installed during the same period at home;

III. that financial assistance, when required and where justified for this program, be made available through normal governmental and private channels, not through the Commission; and

IV. that atomic powerplants constructed under these programs be subject to interim control plans involving appropriate inspection to be agreed upon by each participating bilateral partner, and requiring reprocessing of spent fuel and recovery of plutonium or uranium 233 in the United States; materials thus recovered to be earmarked for further expansion of peaceful uses.

CHAPTER 10—PUBLIC AND PRIVATE ATTITUDES AS THEY AFFECT DEVELOPMENT OF THE PEACEFUL USES

10.1. INTRODUCTION AND SUMMARY

The Atomic Energy Act of 1954 encourages a Federal Government attitude favorable to the development and application of peaceful uses of atomic energy by private enterprise. These encouragements are conveyed as much by the general language of the 1954 act as by its specific provisions. The Commission is called upon "to strengthen free competition in private enterprise." Licensees seeking to conduct experimental work are to be subjected to the "minimum amount" of regulations. Services are to be made available to private industry in such a way as "will not discourage the development of sources of supply independent of the Commission." In other words, development of peaceful uses of atomic energy are to go forward in a climate favorable to private activity without jeopardy to the public safety or interest.

"Climate" and "attitude" are by no means definite words, yet they do convey the sense of that with which the Congress was apparently attempting to deal. "Climate" and "attitude" cannot be legislated. Men cannot be forced by law to take a particular attitude; they can only be called upon to act or not act on specific issues in specific ways. Yet attitude and climate relating to peaceful uses of atomic energy are perhaps the most critical aspect of the entire pattern of Government and private actions.

How the Commission acts or does not act in specific situations will inevitably be the result of the balancing of many conflicting interests. Among these are: policies relating to exercise of United States leadership in international development both of peaceful uses and of control of military uses of atomic energy; actual expressed needs, both public and private, for the potential benefits of various peaceful uses; congressional attitudes regarding big business, small business, privately owned electric utilities, public power, budget balancing, and many other subjects; and, of course, military requirements.

Despite the many delegations of authority to the Commission in the 1954 act, exercise of this authority, especially in the absence of more definitive standards in the law, requires interpretations not only of the language of the 1954 act but of diverse public and private attitudes.

10.2. INDUSTRY ATTITUDES AND ACTION

Leaders of the American business community testified in strong support of the new law in 1954. They supported the conclusion that the time had come to end the Government monopoly. Since the passage of the 1954 act, some of the technical and economic problems standing in the way of a large and profitable atomic business have begun to be more widely appreciated. Such comments as these are being heard:

That the Commission set the guaranteed price, to be paid for byproduct plutonium produced in private atomic power plants, too low to permit prompt profitability;

That the 7-year guaranteed price period for such material is not long enough to permit assured recovery of investment;

That the requirement that industry bear the total insurance liability for private activities is an excessive burden, and that Government should assume the responsibility in whole or part;

That the Commission should give more financial aid and research assistance to potential licensees; and

That Americans should have more freedom to sell atomic equipment abroad.

The actual approaches by private enterprise to the Commission seeking licenses to conduct activities involving millions of dollars have, with only two exceptions, called for Commission contributions also measured in millions. All private atomic power proposals apparently are heavily dependent on continuance of planned Commission research and development projects. None of the announced private development centers are as yet much beyond the planning stage. And no completely privately financed experimental or "demonstration" reactor seems likely to be operated before 1959.

These comments and actions do not necessarily mean that private enterprise cannot do the job. They do suggest that the technical and economic realities of this stage of development of peaceful uses, especially in the field of atomic power, are not as yet entirely favorable, that present profitability is doubtful, and that future profitability is still not certain.

Some highly publicized statements, however, do not take these facts into serious consideration. Announcements of plans are sometimes mistaken for accomplishment of objectives. This would be of no serious consequence in itself, if it did not tend to affect future conditions. Words sometimes outrun deeds.

Some real facts, such as the use of the threat of development of low-cost atomic power as leverage over conventional fuel and transportation costs, may well be magnified out of proportion in the public mind. This overmagnification in the public mind might add up to real losses of potential atomic benefits and reduce the value of peaceful atomic development as an element of United States leadership.

10.3. EFFECTS OF UNITED STATES GOVERNMENT AND INDUSTRY ATTITUDES AND ACTIONS ABROAD

A variation on the pattern of public misunderstanding can be observed abroad. In some parts of the world, where people are not well versed in atomic energy or industrial techniques, people have been encouraged to expect very much from the peaceful atom very soon. They expect their deserts to bloom and industrialization to take place swiftly. Other countries, eager to win foreign sympathies and markets, have been stimulated into trying to outdo American spokesmen.

The promises are genuine; the hopes are well founded; but understanding of the time scale involved seems all too frequently to be inadequate. If promises—stated or implied—do not become realities, who will be blamed? What motives will be attributed? What will be the consequences?

Technical facts are frequently stretched beyond reality in speeches, articles, and statements by highly placed officials in both the executive and legislative branches. American businessmen of international stature also make the same error. Atomic energy is established as newsworthy in itself and receives international news coverage. There seems to be a natural tendency for each speaker or writer to outpromise the last. Such actions can be a basic disservice to the vast millions who are uninitiated to atomic facts. The objectives of our research programs cannot be accomplished by wishful thinking.

10.4. INTERNATIONAL CONTROL AS IT AFFECTS COMMISSION ATTITUDES ON DOMESTIC AND FOREIGN DEVELOPMENT

As noted in chapter 9, atomic fuels can be diverted to military uses unless there is an effective system of controls. Although private organizations are anxious to manufacture and sell atomic equipment throughout the world, the political responsibility for development and integration of sound and compatible policies for control of fissionable materials at home and abroad certainly does not lie on industry. It lies on the Government. Yet examination of various official Government speeches and documents does not reveal any central executive policy with regard to the basic aspects of American participation in the development of peaceful uses of atomic energy in foreign countries. Individual policy decisions are made one at a time, but there does not appear to be any integrated or thoroughly thought through policy.

The United States cannot move forward in encouragement and assistance to foreign countries in the achievement of the peaceful benefits of atomic energy, especially atomic electric power, without insuring that these actions will be compatible with United States policy relating to the international control of atomic weapons. Whether the United States can successfully devise workable and acceptable solutions to the problems: (1) of encouraging foreign peaceful applications and (2) of safeguarding against diversion of fissionable materials for military purposes, may determine the ultimate success or failure in achieving international control of atomic and thermonuclear weapons. The stakes are high. United States actions in the peaceful uses must not be taken in such a way as to undermine the prospects for international military control. Our actions must demonstrate conclusively to Russia and others that workable control mechanisms can be devised which will permit achievement of peaceful benefits without increased military risk.

Since 1945, the Soviet Union has consistently obstructed the efforts of the United States to establish international control of atomic energy. Since late summer of 1955 renewed efforts have been underway in the executive branch to arrive at new approaches to compatible, workable policies and plans relating both to peaceful uses and military controls. Those responsible for administering the Atomic Energy Act of 1954 are to some extent marking time, awaiting the completion of these policies and plans. Though these months of delay are unfortunate, the responsibility for failure to come into accord thus far rests squarely on Soviet obstruction. For us to act precipitously, however, might be tragic.

Yet this entire deterrent barring achievement of sound Federal attitudes regarding development of the peaceful uses of atomic energy is one which can be dealt with now. The United States can and must move ahead in helping other nations in peaceful atomic development, or suffer the charge of withholding such aid willfully. Skillful planning and diplomacy can do much to offset such charges, especially if plans for immediate assistance are forthcoming. (See sec. 9.4.) It behooves industry and Government to recognize this problem and act in the common interest for its solution.

Those who must administer the Atomic Energy Act of 1954 are inevitably forced to conduct themselves in a flexible manner in the interim. There are in the law encouragements to cooperate with friendly nations for the development of peaceful uses of atomic energy. Without integrated policy guidance, the administrators are given a responsibility beyond that which should be entrusted to them. Under these circumstances, it is certainly easier to criticize the Commission than to serve on it or in its organization.

10.5 COMMISSION ATTITUDES AS THEY AFFECT PEACEFUL DEVELOPMENT

The public attitude which now exists could result in the Commission's being charged with delaying accomplishment of the full benefit of peaceful uses of atomic energy. Before the propriety of such charges can be determined, the interaction of Commission attitudes and those of the public, Congress, and the world at large should be examined.

The Commission is the central Federal agency for development, production, and regulation of both military and peaceful uses of atomic energy. The personnel of the Commission and its operating contractors were fully concentrated on their own centrally directed programs until the latter part of 1954. The 1954 act did not relieve the Commission of its primary responsibility for military development and production. It added to that responsibility a complex of regulatory and encouragement functions in the peaceful field not wholly compatible with the military tasks.

Commissioners and the Commission organization have reason to be proud of the Commission's accomplishments. There are good reasons why some things may seem to move slowly. No great volume of peaceful uses of atomic energy exists today. There is no table of experience in industrial atomic activities on which to draw in the preparation of rules and regulations. More technological and economic data than are now on hand must be developed before such experience becomes meaningful. The Commission is more aware of this than are many observers, even than some closely related to it. Drafted under pressure so as to open rapidly the peaceful uses of atomic energy to private enterprise, the language of the 1954 act sometimes seems to confuse hope for eventual development of a flourishing private industry with the misconception that such an industry is already in being. The Commission and its contractors are acutely aware of how much remains to be done and of the time all hands will need to accomplish it.

10.6. THE ROLE OF THE PRESS

Much of the answer to this problem of achieving a balanced and temperate public attitude lies with the press and other public information media. In the manner in which they present statements and views of public and private leaders, the press—both at home and abroad—has an opportunity to evaluate the true worth and new value of what is said. Such evaluation requires special knowledge of this field and good judgment. As more members of the press and other public information media make the effort to inform themselves of the available technical facts, the public's ability to evaluate these matters soundly will in the same measure increase. Past examples of statesmanship among those responsible in our society for informing the public will undoubtedly find repetition in this field.

10.7. CONCLUSIONS

Until there is a better informed public opinion—until there is more balance in programing what lies ahead—and until there is integrated policy to guide both our domestic development and our participation in international development of peaceful uses of atomic energy compatible with international atomic control, attitudes and climate alike are apt to shift from day to day and week to week. Stabilizing these in the framework of sound public policy is a task which requires the concerted, responsible attention of all those seriously interested in the future of America in the atomic age.

With the opening up of applications of peaceful uses of atomic energy to private enterprise, however, the Congress clearly needs the full benefit of a well-informed and vocal public opinion. This is necessary to provide a balance to special-interest pressures. In the normal course of the democratic process there are pressures concerning public and private power, concerning guaranteed ore and by-product purchasing programs, concerning Federal encouragement of developments which, it is feared, may cause dislocation of workers or obsolescence of capital investment. These and other pressures can best be kept in balance by an informed and critical public, and an intelligent, freely functioning press. It therefore follows that the inherent requirement for less secrecy and freer flow of significant information concerning the peaceful uses of atomic energy is greater than the encouragements to this end contained in the 1954 act.

CHAPTER 11—CONTROL OF INFORMATION

11.1. INTRODUCTION AND SUMMARY

Throughout preceding chapters we have noted effects of the availability of information on the rate of growth of peaceful applications of atomic energy. Two basic precepts must guide the consideration of controls restricting the availability of information:

First, the interests of national security must be considered paramount. Therefore, the disclosure of military information of value to potential enemies must be prevented.

Second, basic nuclear science knows no national boundaries. Wherever competent men and women and basic scientific research facilities needed to conduct research come together, scientific facts are certain to be discovered; probably, they will be exploited. There can be no absolute monopoly of scientific knowledge in any one country. At best, only a temporary lead can be achieved.

The existence of two information control systems—one for atomic data, one for "defense" data—is based on the vital role of atomic weapons in our defense. These dual controls had greater validity when the United States had a monopoly of atomic development. With the growth of nuclear capabilities in other countries, dual controls would appear to be cumbersome, and without substantial offsetting benefits.

Other countries now have developed and applied atomic energy to peaceful as well as military uses. As a consequence, in recent months, techniques have been devised by the Commission for making more classified peaceful uses data available to more people. The Geneva "Atoms for Peace" Conference stimulated a great deal of declassification, as well.

Yet direct engagement in the Commission's own programs, either by contract or otherwise, is still the most effective way for firms or individuals to obtain full access to pertinent information. Resulting inequities could be somewhat relieved by vigorous actions to prepare compilations of all pertinent data on a regular basis and to make them uniformly available. Declassification by whole categories of knowledge—such as reactor technology—could also be explored profitably.

11.2 THE REASONS FOR SECRECY

Information relating to design, manufacture, or utilization of atomic and thermonuclear weapons, production of special nuclear materials, and use of special nuclear material in the production of energy is classified by the 1954 act, administered by the Commission, as "restricted data." Within these categories, the Commission must require the classification and control of all information from the moment of its conception, wherever it is conceived. It is "born" classified.

This conception of control assumes that the information involved might be so significant to the defense of the United States, or to the advancement of adversary military postures by foreign nations, as to require absolute and immediate control. The effect of this system of control is to limit access to classified information until it can be examined critically from every aspect. Only after it has been "born" classified can it be considered for release. Declassification requires balancing the assistance afforded to a potential enemy against the positive benefits which might result from free disclosure.

For example, development of a new technique for manufacturing a reactor fuel element with desirable characteristics would be considered classified because knowledge of it might permit higher levels of production of plutonium for atomic weapons in foreign production reactors. This knowledge might also indicate something of the future levels of plutonium production in the United States—thus indirectly exposing information about the future rate of growth of the United States weapons stockpile. On the other hand, this same information might permit more rapid industrial development of efficient—hence economically competitive—atomic electric powerplants.

The less relevance information has to the use of atomic energy for military purposes, the more easily its sensitivity can be gaged. Thus, the Commission has placed almost entirely out of the classification system some categories of information, such as the results of atomic research in the fields of medicine, agriculture, and food preservation. The 1954 act requires the Commission to review its classification guide continuously in the light of changing domestic and international developments. Questions most commonly raised by industrial firms and individuals and others about this system seem to go more to the judgment exercised by the Commission than to the appropriateness of the control-system concept.

11.3. PRESENT STATUS OF INFORMATION CONTROLS

There is no accurate measure of how much atomic information is now out from under control and how much remains classified. In addition to documents already declassified, the Commission is now in the process of reviewing 28,000 more for possible release. But certainly the number of declassified documents involved is unimportant by itself, since it is not known how much of the information is either significant or up to date. Where more exact recent data is retained as classified, publication of old data is more likely to do damage than to be of assistance. It can send those whom it is intended to benefit off in the wrong direction or lead them to do over again classified work already completed but undisclosed.

An attempt to resolve this impasse has been made by the Commission. It involves issuance of so-called "access permits" to potential or active participants in the development of the peaceful uses of atomic energy. Under such permits, persons with limited clearances—somewhat more readily attained than full clearances—are permitted access to certain categories of classified information. This mechanism is apparently proving helpful, but it does not solve the problem. The categories of information to which the permits apply are limited. The existence of other relevant information, to which access is not permitted, serves to introduce the element of the unknown which can be a strong deterrent to private investment.

About 500 organizations have now received "access permits." Of these about 100 have requested and received access to "secret" restricted data as well as "confidential" restricted data. The Commission has established what amount to library guides to classified information. All Commission field offices have been instructed to help "access permit" holders determine the kind of data needed and to help them locate it. Steadily increasing numbers of documents and reports are being reviewed and made available for the use of "access permit" holders. A start has at least been made.

A nuclear reactor, even an atomic powerplant, can be built today without access to classified information. Most peaceful uses of atomic energy not involving reactors can be undertaken without "access" to classified information. In many cases, however, the results will be less efficient, less economic, and less advanced than would have been possible with access to classified information. Responsible persons, as we have noted above, can get access to some restricted data after proper clearance. Even then, however, prospective peaceful applications must go forward without the benefit of much of the data developed for advanced military projects. Atomic powerplant projects, for example, are essentially isolated from atomic propulsion projects for submarines and aircraft—yet both involve reactor technology. Atomic fuel prices are classified, hence atomic power economics cannot be discussed effectively with potential customers.

Thus we observe that, for the most part, the machinery for making more information available to more people is running faster than it apparently did before the 1954 act. More people can get more data, but much data significant for peaceful uses is not available. Basically, however, the system is the same as before the 1954 act: most significant data is "born" classified and must await Commission action before it can be made available for general use.

The Commission is considering "declassification of all reactor technology," but it is not clear exactly what the word "all" would be interpreted to mean in this context. Even if the Commission defined this term most broadly, the Defense Department could impose military classification on the information relating to reactor technology having military applications.

Furthermore, by international agreement, the United States uses the same declassification guide as used by Canada and the United Kingdom. There is no assurance that a United States proposal to "declassify all reactor technology" will meet with acceptance by the other nations. Thus a policy of decision of far-reaching consequences could be involved; namely, that the United States sever its present three-nation information control agreement. No near-term decision seems likely in this area.

Recently the Commission advised of a new program for the compilation of series of technical books containing all the latest declassifiable atomic technology. A similar project, called the Nuclear Energy Series, ended in 1950. A high speed project limited in scope but of great general usefulness was performed for the Geneva "Atoms for Peace" Conference in August 1955. The time schedule for the new series is not established. The work does not appear to have high priority, and apparently is to be limited to declassifiable information. For the first time, however, there are plans to keep such a series up to date with future supplements. Assistance in the form of collections of this sort is not now available covering classified information relating to peaceful uses. There has been a classified journal of reactor technology published by the Commission. However, this journal has not been available to access permit holders because it includes military data.

11.4 IMPACT OF CONTINUATION OF PRESENT INFORMATION CONTROLS

There are three principal and direct effects of the present system of information control:

(1) Individuals interested in developing and applying peaceful uses of atomic energy can never be sure they know about classified information pertinent to their own activities. Therefore, at any moment, they may find their work made obsolete or ineffectual by an act of declassification or downgrading of classification by the Commission.

(2) Because problems as well as information are classified, fewer people can know about them and therefore the time required for progress in the development of peaceful uses may be extended. This is especially true of such pioneer areas as controlled thermonuclear power. This field is classified because a breakthrough could yield fissionable materials for weapons, as a byproduct to electric power.

(3) The dual system of classification by the Commission and classification by the Defense Department gives each system of classification, military and atomic, added staying power since perfect coordination of the two systems is never possible. When the Commission does not desire to release data someone wants, it can imply objections from the Defense Department, and vice versa. In the meantime, opportunity exists for accidental release of vital information through failure to coordinate.

There are also two strong indirect effects: First, contractors to the Commission have full access to all data needed in connection with their projects. They thus have an advantage over mere "access permit" holders. No absolutely foolproof system to prevent contractors from using data acquired in this way on their private work seems possible, therefore the contract route to information continues to be more effective than the permit route. Only by hiring ex-employees of the Commission or its contractors, or by placing their own employees as guest investigators in Commission laboratories, can "outsiders" partially offset this advantage.

Secondly, as more industrial organizations and individuals engage in development and application of peaceful uses under a controlled information system, the basic freedom of citizens and investors alike seem likely to be damaged. Imposition of a security system on a growing segment of American industry and normal life does not appear compatible with historic patterns. It is as though all radio and television research were classified because it might lead to improvements in radar, or as though all petroleum research were classified because it might lead to better fuels for military aircraft and missiles.

11.5. CONCLUSIONS AND RECOMMENDATIONS

National security requires that some information related to atomic energy be controlled. Important though the peaceful uses of atomic energy may be, military uses are vital to our defense. As long as world tensions continue, some classification system will be required both to reduce the knowledge of potential enemies about our defenses and to avoid making it easier for potential enemies to build military strength to be used against us.

The existence of a dual system of information control, one for "atomic" information and one for "defense" information, has less validity now that other countries have developed capabilities of their own in military and peaceful uses of atomic energy. We would think it appropriate for both the Congress and the executive branch to explore the possibility of reinstituting a single information control system with uniformly applicable penal provisions for violations. The concept that information is "born" classified is not compatible with the expeditious action required to make information available for the full development of peaceful uses. This concept should be limited to nuclear weapons.

As long as any atomic information remains under control, those interested in its development and applications will suffer serious handicaps. No administrative agency can ever give a guaranty that a private citizen has all the information needed for decisions and actions.

The Commission can take steps beyond those now contemplated, however, to improve the situation. The collation of all information pertinent to peaceful uses on some rapid and continuing basis is an important technique. Collections can and ahould be divided into classified and unclassified categories so that they can be made available to the maximum number of people. Without action of this sort, important data seem doomed to pile up in obscure documents, and never reach those competent to use them. Such data may not even come to bear fully on Commission work. If any significant quantity of information essential to development of peaceful uses is to remain classified, it would seem that a substantial number of people will have to become engaged, directly or by contract, in the tasks of digesting, collating, reviewing, and distributing it for those entitled to use it.

Therefore we recommend:

1. that the Commission remove all reactor technology from the restricted data category, including such areas as fuel element fabrication and processing techniques, leaving specific military applications of such technology to be protected, insofar as national security is involved, by the defense classification system;
2. that the Joint Committee reexamine the concept that atomic information in all fields is "born" classified; we believe that this concept is not compatible with the expeditious action required to permit rapid development of peaceful uses of atomic energy; and that therefore this concept should be limited to the design, manufacture, or utilization of atomic weapons; and
3. that the Joint Committee require the Commission to undertake the compilation of both classified and unclassified information relating to peaceful uses of atomic energy on a continuing and current basis so that it can be available in ready reference form for those entitled to use it.

CHAPTER 12—RESEARCH AND DEVELOPMENT

12.1. INTRODUCTION AND SUMMARY

One of the most important resources of any highly industrialized nation is its knowledge, from basic and applied research. Basic research includes scientific or engineering inquiry not identified with specific products or process applications. It has the primary objective of adding to the fund of pure knowledge. Applied research draws upon this fund for specific products or processes.

Modern technology is the result of application of the discoveries of past years. The technology of the future, the economic strength of the years ahead, lies in continuing application and in discoveries of new basic knowledge still to be made.

At no time has the importance of new basic knowledge been more dramatically evident than in the enormous atomic weapons development program of World War II, initiated by a single laboratory discovery. Scientific genius from many countries combined with American engineering ingenuity to condense decades of development into months. Perhaps this is a prime measure of our time: The speed with which new, fundamental knowledge is translated from theory to experiment to use.

Without new discoveries there can be no new applications. This is the simple and direct reason why total research has grown and must continue to grow, even though the motivations come in large measure from our concern with national security.

Commission research policy on the peaceful uses of atomic energy can encourage or discourage widespread participation. It can strengthen or weaken the respective concepts of the roles of Government and private enterprise. The need for balance is sometimes obscured by the desire for immediate material benefits. Some believe that continuation, even expansion, of Commission research is essential. Others hold that Commission action amounts to competition which will discourage private participation.

The Commission is in someway involved in most of the research now related to peaceful uses. Basic research is supported by the Commission in universities and conducted in its own laboratories. Applied research is almost entirely financed, sponsored, or controlled by the Commission. For full and expeditious exploration of every promising research route, the task, however, is beyond the capabilities of the Commission alone. The Commission laboratories serve both military and peaceful ends and cannot falter. Increased participation by others is essential if the economic and humanitarian benefits attainable are to be achieved.

The balance between continued Commission research strength and the healthy growth of non-Commission participation requires that the Commission continue its own present work but look toward the ultimate objective of concentrating on the frontiers of research. During the transition, the Commission must: Avoid competition with willing and vigorous efforts by others, provide complete and current statements of its own research programs; make available full information promptly in organized form; and encourage participation by others through research contracts wherever its own program will benefit thereby.

The Commission research strength can thus be maintained so that the interests of the Nation will be served effectively if other participation fails to develop.

12.2. CURRENT FRAMEWORK FOR RESEARCH AND DEVELOPMENT ON PEACEFUL USES

In 1953 the United States spent about $5.5 billion on all scientific and engineering research and development and has probably invested in excess of $6 billion in 1955. Two-thirds of all research and development is performed by industrial organizations; the balance is accomplished in Government laboratories and universities. The Government actually pays, however, for about half of all the above noted research work. Its share is primarily in connection with defense efforts.

There is no accurate breakdown between basic and applied research. It seems likely, however, that basic research accounts for only a small proportion of all research and development expenditures.

The Atomic Energy Commission spent $227.6 million in the July 1953–June 1954 period on all its research and development. Table I in chapter 2 outlines proposed Commission expenditures of $224 million between 1954 and 1962 for specific exploratory atomic power development projects. Private industry is presently proposing to spend $223 million on these same projects.

Out of a total manpower pool in excess of 550,000 scientists and engineers in 1953, 157,000 worked on industrial research and development of all types. Commission contractors currently employ about 14,000 scientists and engineers on all research and development. Of these, less than 1,700 are engaged in development of primarily peaceful uses and another 4,400 are occupied with peaceful uses part of their time.

The bulk of all research and development on peaceful uses of atomic energy is today performed in three national laboratories and other principal contractor-operated Commission laboratories. These are the only research centers in the country which now possess the very expensive facilities for such advanced work. Several large companies have announced plans to build large experimental centers, but none of these laboratories has as yet reached the construction stage. Some of the most promising lines of basic research and some applied work related to nonpower uses of atomic energy, however, do not require extensive facilities. Such projects are going forward in many university and industrial laboratories.

The Commission laboratories vary from those like Los Alamos engaged primarily on military research to Brookhaven National Laboratory where almost all work is of a peaceful nature. Los Alamos, Livermore, the Radiation Laboratory at Berkeley, Argonne, Brookhaven, and Oak Ridge all have substantial coordinated basic research programs, although their budgets reflect heavy applied research and development activities as well. On the other hand, laboratories such as those at Schenectady and Pittsburgh, and the National Reactor Test Station in Idaho are almost entirely applied development centers. Within these types, there are wide variations. For example, Brookhaven essentially reflects the research interests of universities in the Northeast. Los Alamos, on the other hand, is oriented to the military objectives. In between lie Argonne and Oak Ridge where both classified and unclassified work are performed.

There appear to be no conflicts in the field of basic research between the Commission laboratories, universities, and industry. Historically, most basic research has been conducted in universities; since 1941, much of it has been supported by government. In most instances, basic research in the national laboratories is sponsored in part because the scientists and engineers needed to conduct applied work require the intellectual stimulation which comes from basic research, and because the unique and expensive research facilities available there do not exist elsewhere.

Since industry has only recently been permitted by law to be active in the development of peaceful uses requiring large research facilities, there is as yet no substantial conflict with applied research performed in Commission laboratories. A foreshadowing of possible conflict can be seen in the problems associated with division of responsibility bebetween national laboratories and other contractor-operated development activities. Competition between Commission and industry projects for use of national laboratory facilities has also begun.

Unlike the specific military requirements, there appears to be no comprehensive statement of the objectives for research and development of peaceful uses of atomic energy within the Commission. The various laboratories report to different headquarters divisions and are under the direct administration of local field offices. Most projects—both basic and applied—have their origin in the laboratories themselves and are coordinated primarily through budget presentation. There is no specific mechanism for reflecting industry and consumer needs or desires in setting up programs.

12.3. GOALS FOR RESEARCH AND DEVELOPMENT OF PEACEFUL USES OF ATOMIC ENERGY

In chapters 2 through 9, we have noted levels of urgency attaching to development and application of various peaceful uses of atomic energy. We have established as a fundamental obligation of government—and especially of the Commission—the exploration of these areas of new knowledge. This obligation is most clear in basic research. Without continued and expanded Commission and general Federal support, basic research both in Government laboratories and in universities will drop to dangerously low levels.

While it is commonly argued that the Commission should not compete with industry in the application of peaceful uses of atomic energy, we have noted the disparity between Government capabilities for applied atomic energy research, as represented by the national laboratories, and the capabilities of industry. This imbalance will be improved by completion of industrial and university nuclear research facilities now planned.

This disparity in capability is not merely one of size, or of availability of equipment. Equally significant is the disparity in manpower which arises out of the shortage of scientific and technical personnel. (See ch. 13.) The growth in industry and universities of applied atomic energy research capability has not only been fostered by training courses given in the national laboratories, but has been characterized by the employment by industry of significant numbers of national laboratories personnel.

For private enterprise to participate in expanding peaceful uses of atomic energy, industry must have—

1. background information, so that investment in research can be wisely made;
2. applied research capability, in terms of facilities and personnel;
3. competitive incentives—such as patents—to stimulate investment in research; and
4. assurance that the Government will exert its present superior research capability in a manner calculated to encourage and supplement industrial initiative and investment.

In chapter 11 we have discussed the importance to industry of full and current access to all research and development related to peaceful uses. We have suggested ways in which the necessary information can and must be made available to industry, both in classified and unclassified form. If this information is not promptly available, private investment and public benefits may be deterred. Furthermore, duplication of research efforts may occur. The shortage of scientific and engineering manpower does not permit such waste.

With regard to adequate private research and development capabilities, we have already noted that sufficient facilities are not now available to carry out all development undertakings for which there is urgent need. It is thus clear that sale or lease of existing Commission laboratories to private hands would not improve the situation. These laboratories are now carrying most of the responsibility for development of peaceful uses and are also essential to our national defense efforts. Therefore, industry must expedite construction of the types of research centers now planned by some private groups. The Commission could encourage such efforts by placing contracts for the conduct of many types of research and development with such private centers even before they are completed. This should be in addition to the work already in progress and planned in Commission laboratories. If the Commission lacks statutory authority to enter into such contracts—a fact of which the Commission is not now certain—the Atomic Energy Act of 1954 should be amended to clarify this authority.

Staffing private centers will undoubtedly be difficult in view of the intense demands for nuclear scientists and engineers for military and peaceful developments. It is with this in mind that we have urged (in ch. 13) private and public support of adequate education in these fields. The Nation cannot afford the short-term disruption of existing peaceful and military development efforts which would result from rapid expansion of industrial research centers by extensive recruiting of personnel from Commission and contractor facilities.

Large-scale non-Government investment in research and development is a relatively high risk venture. It requires incentives which are normally developed only over the course of many years. We have noted in chapter 17 that patents are of particular significance in attracting risk capital to the support of research and development. The importance of various tax relief devices in the accomplishment of these same objectives is noted in chapter 16.

The problem of assuring that the Commission will exert its present superior research capability in a manner to encourage and supplement industrial initiative can be a more complex matter than any other affecting the growth of industrial research capability. The public interest demands that the continued vigorous conduct of full exploration of the potential new resources represented by peaceful uses of atomic energy be carried by the Commission until industry can and does assume its share of the burden.

In the field of research the Commission is in a transitional period. On the one hand it must encourage industrial participation; on the other it must insure that no line of research or development of potential value to the Nation remains unexplored. The objective during this transition must be the more equitable sharing of the total responsibility. The appropriate ultimate objective would seem to be exploration by the Commission of the frontiers of peaceful applications to chart the Nation's potential resources.

At the very least industry must know what the Commission is doing, the fields in which it is working, the scale of effort being applied, and how far work will be pressed. This means coherent and comprehensive definitions of Commission research and development programs related to the peaceful uses of atomic energy. Some portions may be classified; nevertheless, even these should be set forth clearly and information made available to those in industry authorized to receive classified information. Of course, the Commission's programs cannot be static, but complete descriptions can be kept current.

On the other hand, the combination of progress toward a normal patent system, continuation of the present compulsory patent licensing provisions to 1959, removal of all information related to peaceful uses from classification, plus compliance with the information reporting system required for licensees are mechanisms for bringing knowledge about peaceful uses research into the public domain. For the fullest development of peaceful uses in the shortest time, it is necessary not only that Commission information be made available to industry but that reciprocal action be taken by industry so that information developed by industry is made generally available to serve the public interest.

The national laboratories have a significant role in their own right. They must be available to serve the needs of the entire Nation. Commission research and development resources ultimately should be devoted only to those areas of peaceful interest which it is clear will not be explored expeditiously in the absence of Commission action.

12.4. CONCLUSIONS AND RECOMMENDATIONS

During the present transition from all-Government to Government and private responsibility for the conduct of applied research and development relating to the peaceful uses of atomic energy, a more equitable sharing of the burden should be the constant objective of the Commission and of industry. The research resources of the Commission should continue to be directed to exploration at the frontier and at the same time be available to insure that no promising area is left unexplored or receives insufficient effort to meet the national interest.

For industry to bear its responsibility, it must have facilities, personnel, current and full information, and detailed knowledge of Commission programs as they relate to peaceful uses. Normal competitive incentives must be available. To hasten progress a two-way flow of information between the Commission and industry is essential.

Continued expansion of basic research is, of course, essential to future progress. Such research should continue to be supported vigorously by the Commission in the university centers where, historically, the dual function of advancing fundamental knowledge and education has flourished.

In order to achieve these objectives, we recommend:

1. that basic research in universities be given generous support, both in funds and facilities, through all normal channels to insure continued expansion of fundamental knowledge in the fields related to the peaceful uses of atomic energy;
2. that the Commission be encouraged to place research and development contracts with universities and other private research centers—even in advance of actual construction of such facilities—in order to expand total research efforts and to aid in the prompt establishment of such private research capabilities; should additional contract authority be necessary, appropriate amendment of the 1954 act should be made promptly;
3. that the Commission be encouraged, and, if necessary, required to state its research and development objectives and programs in detail on a current basis so that industry can have a firm base in knowledge on which to make its decisions; and
4. that the present Commission laboratories continue to be supported as vital national assets for assuring the expeditious exploration of atomic energy. For exploration of our peaceful atomic resource, these laboratories, however, must be used to encourage non-Commission research capabilities as they develop. Their objective must continue to be research at the frontiers so that they can make the maximum contribution to peaceful and military applications of atomic energy.

CHAPTER 13—MANPOWER; EDUCATION OF THE PUBLIC AND THE INDIVIDUAL

13.1. INTRODUCTION AND SUMMARY

The speed at which the peaceful uses of atomic energy develop will be controlled by at least three factors: (1) The extent of public understanding; (2) the availability of people having proper knowledge and equipped with adequate facilities to use atomic techniques; and (3) availability of well-qualified, highly trained scientists, engineers, and technicians to carry forward research, development, design, and construction of atomic plants and devices.

While atomic energy still means weapons to many, the idea that the atom can be used effectively in peaceful pursuits is making progress. Yet the public must develop a real understanding of the peaceful uses, if they are to become widespread.

All citizens must understand some of the rudiments of atomic energy when they go to their doctors, if radioactive isotopes and radiation treatment are not to cause fear. Workers in food-processing plants must have some grasp of radiation hazards in the radiation-preservation of food, if they are to accept this new technique as part of a normal working environment. Consumers must be prepared to accept radiation-preserved foods as safe to eat, if this preservation technique is to have acceptance.

Thousands of men and women in hundreds of industrial plants have already accepted radiation thickness gages and measuring devices as "normal" in a modern technical society. This type of acceptance can be expected to spread generally, if the peaceful uses of atomic energy come into common practice without alarmist fanfare.

13.2. AREAS FOR PUBLIC EDUCATION

Construction and operation of atomic powerplants involving production and use of massive quantities of radiation will create a real need for public understanding. This understanding is now growing. Dozens of American communities have already come to accept, without serious qualms, the nearby presence of atomic production and processing plants. As each new plant is planned and built, the Commission and its contractors have undertaken local public education

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programs. It is to be expected that similar efforts will be needed whenever atomic plants are built, either by Government or by private industry, for years to come.

13.3. AN INFORMED PUBLIC

Two factors can disrupt this growing pattern of public understanding. The barrier of secrecy exists because peaceful and military uses of atomic energy are interrelated. That there cannot be widespread application of peaceful uses of atomic energy by private enterprise so long as this secrecy barrier exists, we have already noted in chapter 11. The same secrecy system—created to hinder a potential enemy's determining our weapons capability—at the same time hinders the American public in understanding benefits and hazards involved in the peaceful uses of atomic energy. Atomic hazards are different, but need not be abnormally greater than other industrial hazards. Certainly, it would take a freak series of events to cause an atomic accident on the scale of the Texas City chemical plant disaster. Recent disastrous floods in many parts of the country caused damage to persons and property far in excess of mishaps likely to come from industrial atomic applications. Of course, atomic hazards are real. Yet people can learn to live with them, if they understand the problems involved.

It is clear that with the national commitment to get on with peaceful uses of atomic energy both at home and abroad, so well set forth in the 1954 act, the era of atomic secrecy, except in extremely narrow areas, must come to an end.

Sensational speeches, articles, and books would soon be brought into proper perspective, if the facts were freely available. We cannot blame the general public for getting excited about fabulous or horrifying predictions when the information needed to evaluate such predictions is denied them, or when an atmosphere of secrecy encourages the belief that there may be hidden facts to support such fears or fables.

13.4. A SKILLED LABOR FORCE

Many workmen, with many different skills, will have to learn to work with the atom. In actual practice most of them will not need knowledge radically different from that which they already have. But like most new technologies, peaceful uses of atomic energy require new twists to old skills. Certainly, the X-ray technician working with a radioactive source, instead of an X-ray machine, will not find his job strange. The printing pressman will scarcely be aware that a radioactivated gage regulates the flow of paper through his press.

Some trades will be affected more directly. A good example is the welding trade. A review on this subject made for us by the Commission has concluded that construction of atomic plants calls for higher skill in welding than in any other trade. Yet, as plant after plant has been built, this has not proved an insuperable problem. Several thousand welders in the United States have today had experience in meeting the high standards required in atomic reactors and atomic processing systems. Many of these men have been retained at temporary special schools set up on the job. Retraining periods have seldom exceeded 10 days and costs, although widely varying, have seldom been high.

Commission, industry, and Labor Department experience indicates that the skills which will be required of the majority of affected workers can be met by present union and industrial practices, including on-the-job training, normal apprenticeship, and vocation training courses. Immediate needs of the young atomic industry obviously must be met from the existing pools of trained manpower. During the next few years it seems likely that enough skilled workers can be retrained at reasonable costs to accomplish the tasks at hand.

We do not anticipate a rate of growth of any peaceful use of atomic energy by itself which would appear to upset the normal industrial training pattern. There does appear to be cause for concern among those responsible for such training, unless the far-sighted efforts of some unions for an orderly approach to training for atomic work are pursued vigorously.

In short, we see a period of gradual buildup, in which living and working with atomic energy will become a part of the pattern of everyday life. With proper planning by appropriate private, labor, and Government organizations, this should move along at a sufficiently rapid rate to meet industrial needs.

13.5. PROFESSIONAL SKILLS

The manpower outlook for professional talent in the atomic energy field, particularly scientists and engineers, is different. Even a casual glance at trade journal and newspaper advertisements indicates the almost frantic search for scientific and engineering manpower with experience and training in atomic energy. We suspect that the competition for personnel in these categories may be greater than the competition for selling atomic products.

It is worthwhile looking behind this current demand. A recent survey by the American Institute of Chemical Engineers covering 42 engineering schools in the United States indicated that nuclear engineering has become a part of general engineering education only within the last few years. Pioneering efforts of few of our well-known colleges and universities are especially to be commended. In many schools, however, the facilities and faculties needed to present these courses are not available.

The extent of shortages of scientists and engineers in fields concerned with peaceful uses of atomic energy in the United States seems to need definition. We have taken special note in chapter 4 on medicine and public health of one specialized sort of shortage. But the broad manpower requirements, although difficult to meet, should be possible of fulfillment through an orderly attack on the problem. The Commission estimates that it is currently employing about 3,600 scientists and 2,500 engineers, through contractors, who are primarily or partly engaged on peaceful application of atomic energy. These are small numbers, when compared with the scientific and engineering manpower reservoirs of the Nation. The total of all scientists, engineers, and related managerial personnel employed by the Commission and its contractors totals less than 20,000 people. It is important to note that this is the full demand of professional skills for the conduct of a program involving several hundred millions of dollars of operating expenses per year. The numbers of graduates in these particular fields, however, do not keep pace with these needs.

As an experiment, in order to get a rough idea of the number of scientists and engineers needed in one atomic area which could conceivably expand rapidly, we requested the Commission to make estimates of the manpower requirements for atomic electric power. Assuming that 83 million kilowatts of atomic electric power generating capability were to be installed by 1975, the Commission estimates (see vol. 2, ch. 13) that a total of 16,000 scientists and engineers would be required to design, construct, and operate the plants as well as related fuel fabrication and chemical processing facilities. We would not be alarmed at the prospect of educating 16,000 scientists and engineers required in gradual development of atomic power over two decades, if it were not for the burgeoning demands for large numbers of highly qualified technical people throughout all fields in industry and Government. The provision of faculties and facilities to meet the needs is a task requiring the diligent effort of educators, industry, and where necessary, governmental agencies.

13.6. EDUCATION

It has not been the purpose of the panel to examine the basic educational problems of the Nation, but our inquiries have brought home to us a realization that the specialized requirements for all levels of training and skill called for by the development of peaceful uses of atomic energy can be met only in the context of our society's overall program for educating scientists and engineers in all specialties. It is widely recognized that this Nation faces serious educational problems at all levels. Foremost among them are:

1. modernization of basic scientific courses and, where necessary, the reintroduction of these courses and of courses in mathematics in elementary and secondary schools throughout the country;
2. motivation of those substantial numbers of competent high-school students not now planning to enter college to want college and postgraduate training;
3. making certain that lack of financial means does not prevent able and interested students from being trained expeditiously to the limites of their capabilities.

13.7. COMPETING REQUIREMENTS OF MILITARY AND PEACEFUL ATOMIC PROGRAMS

Available evidence indicates that serious shortages of qualified scientific, engineering, and technical manpower do exist today in the atomic-energy field. We have observed, however, that these shortages to date result more from the competition of large and continually expanding atomic military programs than from activities in the peaceful uses.

Our Nation must be prepared to expand the number of competent engineers and scientific personnel to meet both the requirements associated with national security and military applications of atomic energy and the peaceful pursuits in this field; and only if we have an adequate supply can we avoid one program's stealing from the other.

In our concern with this problem of manpower shortages, we must recognize that military atomic undertakings are now branching out far beyond weapons. Possible programs of some size include conversion of the Navy to atomic propulsion, creation of airfleets propelled by atomic power, and manufacture of atomic powerplants for remote bases. Such programs, if started on substantial and urgent time scales could intensify the problem; indeed they would cause continued scientific and engineering shortages for years to come, despite vigorous efforts to increase the numbers of qualified people in these fields.

13.8. THE AEC AS A SOURCE OF PERSONNEL

Commission, military, and Government-contractor activities produce number of engineers and scientists having special capabilities in atomic energy. Some of these people leave Government-financed work and become available to industry for development and application of peaceful uses. The Commission estimates that about 3,500 scientists and engineers, who have gained atomic experience with the Commission and its contractors, are now in private industry. Though such shifts in employment ease industry's manpower situation somewhat, they are not a real answer to the long-term problem.

13.9. CONCLUSIONS AND RECOMMENDATIONS

Whatever limitations are imposed by present secrecy rules on other aspects of the development of the peaceful uses of atomic energy, there can be no doubt that sufficient information now exists in unclassified form to serve as texts for the most advanced college courses in nuclear science and engineering.

Having noted the need for more nuclear scientists and engineers, and having noted that present college programs are not adequate to supply them, the consideration of various alternate solutions is in order.

An all too normal tendency is to "view with alarm," to consider every problem in every field a crisis, and to call for crash program solutions.

America's multitudinous forums of public opinion are now at work on the important task of searching for an answer to the problems of higher education in a free society. We believe the Nation will find the answer in a variety of ways, not in any single master plan.

We feel that nuclear scientists and engineers will be important to the Nation in the years ahead. It will also be important to train scientists and engineers in many other specialties as well. Further, scientists and engineers are an important element, but only one of the elements of a free society. Our social sciences and cultural arts need equal emphasis to aid us in adapting to conditions and tensions of the atomic age—both military and peaceful.

The balanced society is the society which serves all its members best and uses all their talents.

Our recommendation here, as on other subjects, is: Balance. Specifically we recommend:

1. the encouragement of orderly and determined efforts on the part of all concerned to increase the output and improve the quality of scientists and engineers capable of contributing to the development of peacetime atomic uses;

2. that the Commission continue support of university research and graduate study; we urge that private enterprise likewise give them support;

3. that the facilities of the national nuclear laboratories be made more widely available to support college training programs; and

4. that recognition be given to the need for additional research reactors and other facilities; in addition to facilities required for use on college campuses, we would consider it wise to design, locate, and operate future research facilities, and especially reactors, in such way that they can be of the greatest use to the greatest number of college and graduate students.

CHAPTER 14—HAZARDS, PROTECTION AND INSURANCE

14.1. INTRODUCTION AND SUMMARY

Potential hazards entailed in the peaceful uses of atomic energy have been mentioned in other chapters. Government action and policy relevant to hazards, protection, and insurance will undoubtedly have retarding or accelerating effect on the expansion—and therefore on the impact—of atomic applications.

The Commission has a basic and urgent obligation to sponsor and foster research into the causes, effects, and control of atomic hazards. If adequate protection is to be afforded all those who might be exposed to harmful levels of radiation, we must know exactly what it is that we are protecting against. Overcautious safety standards applied without adequate knowledge could be so costly as to deter development and application. On the other hand, if hazards are unreasonably high, the world must know it promptly so as to determine the character and scale of peaceful applications which can be undertaken safely.

Insurance problems are currently out of perspective because of the inadequacy of knowledge and experience. No substantial hazards from private plants seem to be involved until 1958 or 1959 when the first large private atomic powerplant will begin to operate. The intervening years might better be spent speeding development of the needed data than in debating prematurely the necessity for Government relief of the present private insurance problem.

14.2. ORIGINS OF ATOMIC HAZARDS FROM PEACEFUL USES

Radioisotopes are being used as tracers in research in many fields and seem likely to be employed on an increasing scale: in plant growth studies; checking wear in automotive parts; studying processes of living organisms; improving the manufacture of steel; and many others. Radiation emanating from reactors or from radioisotopes produced in reactors is being used increasingly for such application as diagnosis and treatment in medicine; thickness gages in industry; preservation of foods; "tailoring" food crops to meet the threats of climate, soils, pests or diseases; or catalysing chemical reaction so as to make new materials.

The use of atomic energy for power and propulsion holds broad promise for economic growth. In many of the applications in use today or conceived as feasible for use tomorrow, potential hazards exist. Radiation, in addition to its beneficial applications, can injure human tissue. It can, in doses beyond tolerance levels, change body processes, thus leading to deterioration. In large doses, it can be lethal. Radioactive particles allowed to enter the human body may be deposited there, and, if present in sufficient quantity, can produce injury and even eventual death.

Improper shielding of sources of radiation; rupture of containers in which radioactive substances are being used, shipped, or stored; or careless handling—these are a few of the many ways radiation accidents can occur. Inattention to proper dose levels by those working with or near radiation may have more insidious results. A nuclear reactor's getting out of control may, under special conditions, cause widespread injury to people and loss of use of property because of radioactive contamination. These events should not occur if design and operating standards are propertly established and effectively enforced. Yet, men make mistakes and accidents happen.

Various methods of disposing of radioactive wastes are being explored, including discharge into abandoned oil and gas domes using deep wells, burial in the ground, and disposal at sea. These and many other proposals which have been made have complicating factors which must be thoroughly investigated. For example, disposal at sea may result in radiation uptake by marine life and possible impairment of a major source of the world's food supplies.

These are only examples to accent our discussion; the hazards involved are varied, the risks involved not yet fully known.

14.3. CONTROL OF HAZARDS FROM PEACEFUL USES

The basic fact of radiation is that it cannot be seen, felt, tasted, or detected in any way by humans, without the assistance of special equipment or instruments. Thus it is, to many people, an unknown which gives rise to fear and misunderstanding.

Much has actually been done in the way of devising radiation safety precautions. The use of radiation first became widespread with the development of X-ray equipment and the availability of naturally radioactive substances such as radium. Benchmarks in the study of radiation damage were established at an early date by radiation injuries to X-ray workers, by the incidence of bone cancer in luminous watch dial painters and of lung cancer in European uranium miners.

Radiation and radioactive materials, however, are now used in amounts all out of proportion to preatomic experience. Information available up to 1939 was of course not adequate. Full scale research on hazards began during World War II, and safety measures were instituted.

To the hundreds of thousands who have had experience with radiation in the atomic-energy program, radiation or radioactive materials command respect. For the uninitiated laymen, the first requirement is to learn what radiation is, and what can be done to protect against it.

Many procedures for the safe handling of radioactive materials have been worked out. These range from the design of simple handling equipment—such as lightweight containers and shipping cartons for small diagnostic and therapeutic amounts of radioisotopes—to the complex, almost human, remote control devices for working with more dangerous quantities. Research has resulted in a firmer basis for limits on radiation dosage levels. Detection and measurement instruments have been developed to assure safe working conditions.

Much research still remains to be done, especially on the long-term effects of radiation. While the Commission and its contractors appear to have a remarkably outstanding safety record in dealing with, or in using radiation and radioisotopes, expanding the peaceful uses of atomic energy increases the proportion of the population that could be exposed. Tolerance doses satisfactory when small fractions of the population were exposed must, therefore, be reexamined continuously.

The known hazards involved in the handling of radiation or radioactive materials in research, in medical diagnosis and therapy, and in industry are apparently measurable, controllable, and in other ways comparable to other hazardous industrial activities.

The National Committee on Radiation Protection under the auspices of the National Bureau of Standards has set up guides as to permissible doses from external sources of ionizing radiation, as to permissible amounts of radioisotopes in the human body, and related subjects. These guides have been important steps in bringing together available information. Whether they are conservative enough is beyond the competence of lay groups such as the present panel. (See vol. 2, ch. 14.) The Commission has an advisory Reactor Safeguards Committee, composed of experts in various fields, as well as a small permanent staff to review proposals involving reactor construction and to advise on the adequacy of safety provisions and precautions in proposed licensed facilities. An inspection service is authorized by the 1954 act and is being set up by the Commission to enforce safety provisions agreed to by licensees. Yet the inspection and enforcement task will require the cooperation of State and local authorities as well as those of Government agencies other than the Commission. Conferences to begin such coordination have already been held and more are in prospect. State public-health services are already engaged in the education, training, inspection, and other public-health protection functions which stem from the expansion of industrial participation in the peaceful uses of atomic energy.

At the present time, however, the most significant control is that exercised by the Commission in compliance with the 1954 act. No one can possess or use radioactive materials or special nuclear materials except under license. Demonstrated ability to maintain approved safety standards is a condition to getting a license.

The role of licensees in meeting the waste disposal problem is less clear. Certainly Government must regulate such disposal to protect public health. Our studies of this particular problem have been fragmentary. However, we feel it important to note the importance of the problem and to suggest that—in addition to continued current and planned studies of waste disposal procedures—organizations making power reactor proposals involving private processing of spent fuels, and organizations desiring to operate licensed fuel reprocessing plants be required to submit plans covering waste disposal. There is an expectancy that such "wastes" may prove to be valuable assets, but much research on uses of such materials remains to be done by the Commission and by industry.

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14.4. INSURANCE AGAINST DAMAGES RESULTING FROM PEACEFUL USES

The 1954 act requires all licensees of the Commission to hold the Government free from any liability arising from damage to persons or property as a result of any licensed peaceful uses of atomic energy. This means that the licensees must pay for all damages, even though the special nuclear materials which they may be using under license belong to the Federal Government and even though all Commission and local regulations are fully obeyed. The risks incurred run from minor health hazards risked by direct employees to the extremes of potential damage resulting from runaway atomic powerplants. These upper damage limits could theoretically include the severe radioactive contamination of expensive urban and industrial areas and radiation injury to millions of persons—injury which might not be able to be evaluated completely for decades or even generations. This is the most extreme view and is the one which is commonly used to "prove" that the risks are too great for private enterprise to assume. It is in the light of these risks that the respective obligations of private enterprise and Government must be balanced.

Sufficient experience in the atomic-energy program to date has permitted private insurance companies to provide coverage of the risks to employees within a reasonable rate structure. This accomplishment is in contrast with the practice that prevailed during World War II when personnel engaged in atomic energy work were insured against job-incurred injuries by complete Government assumption of the insurance risk.

Many States have already modified their workmen's compensation laws and regulations to permit coverage for radiation injuries. Care must be exercised by all those connected with these programs to make sure that all real injuries are properly covered, but that at the same time imagined or tenuously related injuries continue to be dealt with in reasonable balance.

There is real urgency in getting more and better knowledge about the effects of radiation and continuously reviewing standards in the light of the best knowledge available. The Commission has a heavy obligation to sponsor such research in every possible way. Yet, at the same time, the public must be given better understanding of the fact that development of scientifically complete knowledge in these areas is a never-ending task and that a great deal of such research requires a step-wise process which dollars alone cannot speed.

The more widely discussed insurance problem, however, is that relating to the liability of licensees operating atomic powerplants which might theoretically go out of control and shower nearby cities or the countryside with radioactive materials.

No 100 percent safe power reactor has as yet been conceived; 99.99 percent safe may not be enough. While every precaution has been taken in reactor and component designs to assure safety, man-made devices and controls are involved. Unforeseen malfunctions may occur, leading to reactor or plant destruction. Just as perverse ingenuity of punch-press operators has on occasion counteracted safety devices designed for their own protection, reactor safety and control equipment and procedures may be circumvented. Consequences may be serious.

Experience on reactor accidents is meager. Research on this problem is barely started. Important background data has been obtained as a result of an accident involving a research reactor in Canada, and from a deliberate "runaway" reactor experiment conducted by the Commission. From this limited base, it has been concluded that damage may range from local contamination of the reactor structure to contamination of an area of several square miles or more if weather conditions contribute to dispersal and fallout of radioactive particles. The results seem to range from the rough equivalent of partial or complete destruction of a plant by fire to events on the scale of the Texas City disaster. The maximum effects on high industrial or population concentration may be far-reaching in terms of radioactive contamination and radiation exposure. Destructive shock waves of overpressures, however, are unlikely to accompany a "runaway" reactor and nothing like the effects of atomic bombs seems likely or even possible.

If, in spite of all the safety precautions taken, injuries or property damage should still take place, what can be done to insure against ruinous financial loss?

The number of claims for injury or damage resulting from an accident may reach extremely large proportions. Those involved from the liability standpoint include not only the designers and fabricators of equipment, but the operators, corporate licensees, and all of the businesses servicing licensees. The assets of many companies might thus be available to cover such liabilities. Yet no company seems likely to be able to assume liabilities so great as to threaten its solvency.

The insurance industry can cover the atomic powerplant risks involved to the same extent that it normally does in hazardous industries. Several competent studies are in progress, and these should be permitted to determine whether current efforts to form special funds to cover atomic-energy risks will be successful. The obstacle of insurance seems quite likely to be overcome for at least the present development phases of the atomic-power industry.

Those proposing to build and operate atomic facilities and the insurance industry are naturally trying to minimize the possibility of extreme financial losses to their organizations by seeking to have the Government reconsider its position and underwrite losses which are purported to be beyond the capacity of industry.

It is still difficult to judge how necessary it may be to encouragement of development of peaceful uses of atomic energy for the Government to go into the atomic catastrophe insurance business.

Several things must be considered:

Assumption of insurance risks by Government will not now speed "demonstration" of economic feasibility appreciably. Research and development in reactor technology are going forward in Commission laboratories. Construction of the Commission's first large-scale "demonstration" plant is underway. As we have said, several additional "demonstration" plants privately sponsored are now to operate in 1958 or 1959. Should private sponsors withdraw from these projects, we believe that the Commission should proceed with the construction of one "demonstration" plant of each promising major type.

There is, accordingly, no sound basis for attempting to devise now on a "crash" basis a Government insurance program.

We recognize that the present power reactor "demonstration" program is directed at "proving" part of the Nation's energy reserves for the future. Risks in this stage of the development tend to be high. It seems to us, however, to be much too early for private enterprise to concede defeat on the insurance problem. To do so is to prejudge the research efforts still underway and to jeopardize unnecessarily the national attempt to carry atomic power forward to widespread application by private enterprise.

14.5 CONCLUSIONS AND RECOMMENDATIONS

The possible hazards from peaceful uses of atomic energy range from minor to catastrophic. Hundreds of applications in the fields of medicine, agriculture, and industry can apparently go forward under present regulations and standards with no serious risks.

There is urgent need for better data, however, and every effort to expedite its development should be made by the Commission and all other responsible public and private groups involved in development of peaceful uses. Every argument for changes in standards should be explored fully in competent forums to insure that no lead is left unexplored and that real doubts are resolved for maximum public safety.

Federal, State, and local authorities must continue to cooperate closely in the establishment and enforcement of the best uniform radiation health standards which can be developed. There must be balance between the conceivable and the actual hazards, however, and for some years to come the Federal Government will certainly have the responsibility of establishing this balance. This is not the sole responsibility of the Commission, but a joint responsibility of all Federal agencies involved or affected.

We are not satisfied that the time has yet arrived to reconsider the need for a Federal atomic insurance program covering peaceful uses. We have noted with interest recent plans of private insurance companies to deal with these problems. Such efforts should be encouraged. At least 2 and possibly 3 years remain in which to conduct research and accumulate knowledge and experience before any substantial private activity can be delayed or stopped because of inability to obtain adequate insurance. In fact, implications that the Government is prepared now to take on the insurance burden might stifle vigorous private efforts to meet the problem. We look on a Federal atomic insurance program as a threat to private atomic enterprise, not a benefit. It is a last resort not yet called for and one which may not be needed.

Therefore, we recommend:

1. that the Commission be encouraged to step up its program of research into the causes, effects, and control of atomic hazards; the 2 or 3 years remaining before any full-scale "demonstration" atomic powerplant comes into operation must be used to obtain the maximum amount of information in order that both those concerned with protection against harmful levels of radiation and those concerned with providing insurance to cover such damage as may occur can have the most advanced knowledge possible at the earliest time; and

2. that the Joint Committee and the Commission continue to encourage the insurance industry to develop ways of meeting atomic insurance problems entirely within the concepts of private enterprise.

CHAPTER 15—OWNERSHIP OF SPECIAL NUCLEAR MATERIALS, LICENSING AND REGULATION

15.1. INTRODUCTION AND SUMMARY

The 1954 act directs the Commission to establish certain licensing procedures and regulations to govern peaceful uses of atomic energy. There is not as yet sufficient experience to permit full evaluation of the net effect of these provisions.

The policy of exclusive Federal ownership of all special nuclear materials, in the meantime, provides a means for protecting both the public safety and national security. Therefore, delays in issuing regulations imposes no unwarranted risks to safety or security. If Federal ownership is eventually abandoned, then the existence of the licensing and regulatory structure in workable form will make smooth transition possible.

One of the consequences of regulatory systems is a tendency toward overregulation. This is particularly true where all initiative for making determinations rests with the regulatory body. Giving private citizens the right to initiate proceedings for new determinations or for review of existing ones can provide a counterbalancing influence. This is particularly pertinent in consideration of section 102 of the 1954 act which gives the Commission exclusive authority to determine "practical value" of peaceful uses of atomic energy for "commercial or industrial purposes," and permits Commission definition of the criteria to be applied.

Establishment and enforcement of uniform standards to protect the public health and safety are important elements in the rapid development and application of atomic energy in industry, medicine, and research. These are tasks which demand the attention and cooperation of Federal, State, and local authorities. Failure in these areas can retard progress by endangering public safety or by imposing excess costs on manufacturers or users.

While foreign business activities are not licensed, prior authorization must be obtained from the Commission. Powers beyond those involving control of information are available to the Commission in section 57 a (3) of the 1954 act for influencing the role of American businessmen in advancing international peaceful uses of atomic energy.

15.2. PRESENT STATUS OF OWNERSHIP, LICENSING, AND REGULATION

The 1954 act provides for Federal ownership of all special nuclear material. It provides for Federal licensing and regulation of all facilities using or involved in peaceful uses of atomic energy, as well as of all activities involving special nuclear material.

Examination of the progress made by the Commission in discharging its responsibilities under these provisions suggests that the Commission has moved slowly. There is no evidence, however, that any potential private domestic activity has been delayed by the failure of the Commission to publish regulations or establish licensing procedures.

The Commission has selected a complex and time-consuming technique for developing its regulations. It has conducted conferences with representatives of diverse organizations on each aspect of regulations. This practice has the advantage of drawing on many viewpoints and judgments. While some points of view may not be fully reflected by this technique, opportunity for comment is also afforded after publication of proposed regulations in the Federal Register. The logic of this course of Commission action appears sound and is not being vigorously opposed by any interests or groups so far as can be observed.

Four principal elements are involved in discussion of the effects of Government policies and actions on ownership and licensing:

1. The principle of Federal ownership of special nuclear materials;
2. the rights of responsible private individuals and organizations to engage in atomic activities with private funds and to determine competitive economics for themselves rather than having the Federal Government do so;
3. the relationship of State and Federal regulatory and enforcement roles; and
4. the extent of the freedom to be allowed to American businessmen in atomic activities in foreign countries.

There are other aspects which will be of increasing importance in the future. These include operators' licenses, various facilities licenses, license appeal procedures, and inspection enforcement techniques. Nevertheless, these are all straightforward problems for which there are precedents in other hazardous industries. The fundamental difference at this time between these regulated activities and others, for which experience exists, lies in the fact that the foundation for control measures over peaceful uses of atomic energy is Federal ownership of all special nuclear materials.

15.2.1. Federal Ownership

Section 2 h of the 1954 act finds that "It is essential to the common defense and security that title to all special nuclear material be in the United States while such special nuclear material is within the United States." Retention of title to this material which could be used for atomic weapons permits the Federal Government to have more absolute control. Federal jurisdiction is made secure against State interference, recovery of material in wartime or emergency is expedited, and the United States is able to continue working toward international atomic controls with greater flexibility.

Federal ownership does create some problems which may tend to grow with the growth of a private atomic industry. The most critical of these is the role of the Federal Government in the pricing of special nuclear materials, hence its role in the economics of private licensed operations. The provisions of the 1954 act mean that there is only one buyer for any special nuclear material—the Commission. Technically, the Commission pays for the production of the material rather than for the material itself, but this is commonly being called the "buy back" price, referring to plutonium and uranium 233 produced in nuclear reactors.

In most prospective near-term commercial atomic power reactors, the "buy back" price could make or break the economics of the plant. By law, the Commission can only guarantee "buy back" prices for 7 years, while plants able to produce such material must run for 25 to 40 years to amortize their costs. Thus, private investors have no way of forecasting when they may suddenly be thrown into a losing operation as a result of changes in future Commission-guaranteed prices. It is true that all licensees receive the same prices, but all licensees will not have the same types of plants and may have differing economic break-even points.

During the period when there are relatively few atomic powerplants in operation, there are advantages to the principle of Federal ownership. The byproduct materials produced in such plants will have essentially no other potential buyer except the Federal Government, even without the law. In such a limited market place, private operators could scarcely survive wide price fluctuations such as occur in other metal markets like copper. Thus, early atomic powerplant licensees will undoubtedly need the stability which Federal ownership and, hence, Commission-guaranteed prices, can provide.

As the number of atomic powerplants increases, a market for the byproduct plutonium or uranium 233 for use as reactor fuel will undoubtedly develop, thus a degree of inherent market stabilization will come into existence. (See the discussions of growth of installed nuclear power capacity in ch. 2 for time estimates as to when such a period may be reached.) When that time does arrive, the policy of Federal ownership should be reexamined.

Perhaps the strongest reason for Federal ownership is the need for flexibility in dealing with the subject of international atomic controls. The United States can enjoy an advantage by being able to state categorically that it owns and absolutely controls all special nuclear materials in the United States. The entire subject of international controls is one which will change in character with the passage of time. Either a control system will be devised, in which case the Federal ownership policy will have served one of its purposes, or it will become clear that international control is not going to be achieved, in which case Federal ownership is no longer of particular significance.

Another factor which must be considered in any reexamination of the policy of Federal ownership is the possible need for recovery of nuclear materials promptly for military use in an emergency. Here again, the motivation will undoubtedly change with the passage of time. As military atomic stockpiles grow, at some point there will certainly be as much on hand as can be used effectively. If a future war is short, there would not be time to recover the materials and fabricate them into weapons. If a future war is long and any substantial amount of the Nation's electricity is being generated from atomic energy, it seems unrealistic to suppose that such electricity could be sacrificed from the production capability of the Nation by withdrawal of the atomic fuel.

Finally, there is the relationship of State and Federal regulatory and enforcement roles. If the Commission proceeds, as it is now doing, to establish minimum safety criteria and assist State and local governments in developing the capability to enforce these criteria, it must follow that State and local governments will develop increasing knowledge which, together with a realistic sense of responsibility, will permit them to bear a greater share of the burden of public protection. Although the Federal minimum standards will form a foundation of protection, no Federal statute or regulation can prevent any State or local government from imposing regulations on private activities which are more stringent than those imposed by the Federal Government. Therefore, Federal regulations will only tend to establish the reasonable minimum standards for industry. Thus the significance of this factor in the policy of Federal Government ownership also changes in character with the passage of time.

15.2.2. PRIVATE RIGHTS

Under section 104 of the 1954 act, private individuals and organizations may apply for licenses to build, own, and operate research and demonstration facilities using special nuclear materials. Even though the applicants and their proposals are qualified in every way, the final decision as to granting the license is within the discretion of the Commission. The basis for exercise of this discretionary authority lies in considerations of "the amount of special nuclear material available for such purposes" and in Commission evaluation of "activities which will * * * lead to major advances * * *".

Section 103 of the 1954 act requires the Commission to issue licenses to all qualified applicants for commercial peaceful facilities using special nuclear materials, but licenses cannot be granted under this section until the Commission, under the provisions of section 103, "has made a finding in writing" that the type of facility to be licensed "has been sufficiently developed to be of practical value for industrial or commercial purposes." Thus, in effect, a barrier of Commission discretionary authority can deny licenses to applicants under section 103 just as effectively as under section 104.

There have been no denials of licenses to applicants filing under the provisions of either section 103 or 104. Nevertheless, it is worth noting that the 1954 act which ostensibly opens up development and application of peaceful uses to responsible private investors does not, in fact, give anyone the uncontrolled right to engage in such activities even if the applicant meets all established criteria. The effect of these provisions appears to be contrary to the stated objectives of the act. They constitute an interference by the Federal Government in the right of a private investor to risk his own money, even to go broke, if he chooses to do so.

The Commission's interpretation of section 102, which requires the "finding of practical value," particularly strains our concepts of private enterprise. As yet undefined tests of economic feasibility are to be applied by the Commission in arriving at such findings. While the Federal Government does frequently require applicants for other licensed activities to prove economic feasibility of proposed activities, this is the first time, so far as can be determined, that the Federal Government has set itself up to decide on its own initiative when private licensees can profitably embark on regulated activities, denying private investors the right to proceed before that time. Private investors are not given the right under this act to initiate determination of such findings, bearing the burden of proof at their own expense.

15.2.3. Federal and State Regulatory Authority

Throughout the licensing and regulatory provisions of the 1954 act, it is implied that the Federal Government is to exercise the regulatory authority under which licensed activities go forward. There is no question but that some regulation of these activities is required in the interest of national security and the public health and safety. The only basic questions are: Who should set the regulations? Who should enforce them?

At this relatively early stage of private investment in peaceful uses of atomic energy, there are few activities requiring regulation on any intensive scale. As wider application of peaceful uses of atomic energy come into existence, the burden of regulation, inspection, and enforcement will increase. All peaceful uses of atomic energy have in common the presence of radiation and the resultant hazards to workers and public health. Some uses are likely to be in interstate commerce, others confined to specific localities. Some hazards will be of a continuing nature; others will depend entirely upon the standards and design criteria imposed by regulation on manufacturers of equipment. Many activities already regulated by various Federal, State, and local agencies seem likely to be involved. Meatpacking plants, medical clinics, and electric utilities are just a few random examples.

It would seem unnecessarily cumbersome and expensive to have a separate Federal agency—the Commission—invade all of these affected industries and regulate, inspect, and enforce. The Commission has already indicated an intention of letting other Federal, State, and local authorities take on the detailed regulation and enforcement in those areas and activities which are their normal province. For example, conferences of State officials have been held on health and safety and other regulatory problems.

The Federal Government is in a more informed and better position to establish minimum standards. The responsibility for adapting these standards to local conditions and enforcing them could be within the purview of State and local authorities. It should be kept in mind that State and local bodies have the right to impose regulations more stringent than those required by the Federal Government.

15.2.4. Authorization to Conduct Foreign Business

Section 57a(3) of the 1954 act allows American businessmen to sell atomic equipment, advise potential foreign purchasers, and conduct other foreign atomic activities only on Commission approval. Authorization for such activities must be based either on the terms of existing bilateral agreements for cooperation with foreign countries, or on Commission determinations that the activities "will not be inimical to the interests of the United States."

The Commission has recently given a general authorization for conduct of business in foreign countries relating to peaceful uses of atomic energy, not including, however, any general authority to convey restricted data. Atomic power equipment manufacturers have noted that this situation prevents them from discussing the probable cost of electricity from atomic powerplants, arrangements for supplying and reprocessing fuel, and most significant details of plant design. These are matters discussed under control of information. (See ch. 11.)

The foreign business problem can be resolved only in the context of United States policy relating to promotion of international use of atomic energy for peaceful purposes. (See ch. 9.) It should be noted here in connection with licensing and regulation that business profits cannot come ahead of sound national interest in the area of foreign policy. The delays in developing a workable control scheme for international application of peaceful uses of atomic energy are unfortunate, but the interrelationship of this problem with international military control is undeniable.

15.3. CONCLUSIONS AND RECOMMENDATIONS

Ownership of all special nuclear materials by the Federal Government is now desirable and useful, but at some future time the factors motivating such Federal ownership may change. We would expect that continuing review of this statutory finding would result in its abandonment at some future date.

We have noted that while it is desirable to construct a sound licensing system as rapidly as possible, contracts for private possession and use of Government-owned special nuclear materials could provide, in addition to financial terms, all of the conditions necessary for protection of public safety and national security. The emphasis in the 1954 act on licensing is sound as a means of establishing equality of treatment of private participants, only if it is recognized that licensing rather than Federal ownership is to be the future course.

Despite recognition of the fact that there is no evidence of anyone now being injured by the licensing provisions of sections 103 and 104, the principles involved in these sections, in our opinion, conflict with the principles of private enterprise which the 1954 act has been represented as advancing.

As the peaceful uses of atomic energy expand, public safety requires establishment of minimum Federal standards on radiation dosage and equipment design. Enforcement on a uniform basis should be shared with State and local authorities as rapidly as possible. (Assignment of responsibility for various aspects of standards and enforcement is discussed in chs. 14 and 18.)

Delays in clarifying for American businessmen what they can do or what they can discuss with potential foreign customers with respect to peaceful atomic applications further impair incentive for development of industrial atomic manufacturing potential at home, and the leadership of the United States in these fields abroad.

We therefore recommend:

1. that the Joint Committee on Atomic Energy create statutory devices to insure a continuing review of the present policy of Federal ownership of all special nuclear materials in anticipation of the establishment of private ownership;

2. that the 1954 act be amended to permit initiation of proceedings for the determination of "practical value," as required in section 102, by private citizens as well as by the Commission, limiting the definition of "practical value" to technical considerations;

3. that the Commission, and other appropriate Federal departments and agencies, work with State and local authorities to establish uniform safety and health regulations and enforcement relating to peaceful uses of atomic energy; and

4. that the Joint Committee on Atomic Energy reevaluate now the propriety of the controls on the activities of American business in foreign countries imposed by section 57a (3) of the 1954 act, over and above those controls established by other provisions of the act relating to control of information.

CHAPTER 16—FINANCIAL ENVIRONMENT

16.1. INTRODUCTION AND SUMMARY

The Atomic Energy Act of 1954 opened peaceful uses for wider industrial development; it also established elements for a financial environment conducive of growth of private enterprise.

The 1954 act authorizes and directs the Commission to carry on the base load of research and development of peaceful uses. In so doing, however, the Commission is also directed to conduct these activities so as to encourage the growth of an industrial research and development capability. There are various direct and indirect financial devices available to the Commission for providing encouragement and assistance to non-Commission research efforts. The use of these is largely at the discretion of the Commission.

Private and other investors can be encouraged to experiment with unproven ideas, rather than to follow such technological trails as may already have been blazed. In extending such encouragements, the Commission has the delicate and difficult task of extending Government aid equitably without impairing private initiative and willingness to take risk.

16.2. FINANCIAL DEVICES UNDER COMMISSION CONTROL

There are four principal categories of financial devices available to the Commission for improving the financial environment within which the new peaceful atomic industry can develop: (1) Commission research and services for industry; (2) procurement of research and service from industry and others; (3) guaranteed prices and waiver of charges; and (4) training and patents. Not all of these are explicit in the 1954 act. How the Commission exercises its authority in these areas could influence the rate of development.

16.2.1. Commission Research and Services for Industry

The Comisssion is directed by law to conduct or make arrangements for the conduct of research and development, including peaceful uses of atomic energy. The 1954 act gives the Commission wide discretion in selecting the character and direction of research and development activities. Ideally, all activities would be devoted to exploration of the frontiers of national atomic resources. This would require an industrial capability prepared to carry on the technological development of the ideas explored. Until this industrial capability comes into being, the Commission can and must adjust its research programs to expedite and assist in development work which is the national interest and would not otherwise be performed.

Where the Commission finds that research of interest to private industry is not of sufficient national interest to justify a Commission program, the 1954 act also authorizes the Commission to conduct such research for others in its own facilities, making charges as the Commission finds "desirable." There are no standards to guide the Commission in establishing when or how to make charges. Section 161 of the act, which defines standards for charges for certain services which the Commission may perform for others, does not relate to this research authorization.

Since the authority to conduct such research is limited to situations in which the Commission "finds private facilities or laboratories are inadequate to the purpose," the willingness of the Commission to perform such research and the charges it makes have a substantial influence on the financial environment.

Section 161 m. of the 1954 act authorizes the Commission to process, fabricate, separate, or refine in its own facilities source, byproduct and special nuclear material owned by or made available to licensees. Nondiscriminatory prices must be charged for such services. The charges must cover cost to the Commission and at the same time "not discourage the development of sources of supply independent of the Commission." This could mean that the Commission cannot set such charges below prices which private service facilities would have to charge for the same work. The Commission Manual for its employees and contractors seeks to provide some guidance on how such charges are to be set and when services are to be performed. (See Commission letter of December 16, vol. 2, ch. 18.)

Exercise of this authority presents difficulties because only the Commission has certain types of facilities now and these are fully occupied with Commission civilian or military work. Private work will not be done in Commission service facilities unless it gets priority over this other work. No basis for establishing such priorities is set forth in the law. In one of the most critical service areas thus far, the Commission has established a coordinating committee which is attempting to work out priority problems.

16.2.2. Procurement of Research and Services From Industry

Section 31 of the 1954 act authorizes the Commission to pay for research and development done outside its own plants and laboratories. Section 169, though it is entitled "No subsidy," makes it clear that such research work can be performed in connection with licensed plants, whether experimental or commercial. These provisions as interpreted by the Commission, have proved to be the key to making it possible to put Commission research money into large private projects. Three of the five proposed full-scale private atomic powerplant "demonstrations" are being negotiated on the basis of indications from the Commission that it is prepared to give multi-million-dollar research and development contracts to their sponsors.

This is a useful but hazardous financial device. Its origins were in controversy during the Joint Committee hearings in February and March 1955. One thing is clear. The device as it is now being used by the Commission is so powerful that it completely overshadows all of the details of the complex licensing structure of the 1954 act. The organizational problems involved are touched upon in chapter 18, but, in addition, it should be noted here that the real demand today is not for licenses. The key to stimulation has been Commission research and development money.

In order to assist in determining now to allocate the funds available for the exploration of atomic power through the construction of "demonstration" plants, the Commission invited and received proposals for large plants in 1955 and has announced a second round on small "demonstration" plants for 1956. Although the five private proposals in the first round differed substantially in the amounts of Commission money they required, the Commission found itself without funds to accept all proposals. No one got a flat turndown. The allocation of Commission funds is still being negotiated in some cases.

Just as the Commission can have research performed in non-Commission laboratories and plants under contract, it can also contract for other services and materials. Private organizations can and do own uranium ore refineries, for example. They can also own ore-processing plants in which the feed material for both reactors and gaseous diffusion plants are prepared. The Commission has invited private proposals for furnishing up to 5,000 tons of uranium oxide per year from private plants. Such initial sales contracts could permit private investors to go into business with assurance of the marketability of a substantial portion of their product for a definite number of years. The number of years ahead for which the Commission may contract for such services or products, however, is not clear in present law.

If industry is encouraged by such contracts to build plants either larger than private users may require, or plants not technically adaptable at reasonable cost to the sort of demands created by a future civilian market, the Commission may be forced to continue purchases from these plants longer and in excess of Commission needs. Such force may be political rather than contractual, but would, nevertheless, be real.

We have noted the Commission's statement of new policy "to rely on industry to provide any required additional production capacity to the greatest feasible extent." (See ch. 18, vol. 2.)

The Commission and the military services have occasion to procure tremendous quantities of atomic materials and services. Commission orders, for example, have already built a sizable radiation instrument industry. Plans for atomic propulsion of future naval vessels and for processing the fuel from such atomic powerplants could obviously bring an entire array of industrial organizations into the atomic energy business.

The disadvantages of using this technique for speeding industrial participation appears to be in the injection of the pattern of Commission needs into the future pattern of private industry. A chemical processing plant, for example, designed to process fuel from a naval propulsion reactor may not be well-adapted to handling the fuel from private atomic powerplants.

16.2.3. Guaranteed Prices and Waiver of Charges

Section 53d. of the 1954 act gives the Commission discretionary authority to exempt experimental, medical, and research facility licensees from charges for the fuel consumed or any inventory charges on fuel. This authorization does not extend to the treatment of commercial facilities. Such waivers could obviously reduce the financial burdens faced by licensees conducting research and development activities, thus encouraging investment in experimental, medical, and research facilities. Licensees might also be able to afford to introduce more radical elements in design.

On the other hand, if the Commission can be persuaded that a particular atomic facility is experimental rather than commercial, and that no fuel inventory or burn-up charges are to be levied, greater profitability could result. This is an attractive target for prospective private powerplant operators to aim for.

The Commission is required by the act to "establish criteria in writing for the determination of whether a charge will be made for the use of special nuclear material" under section 53 c.; no such criteria as yet exist. Waivers of burn-up charges are being considered. In addition to authority to waive atomic fuel inventory charges, the Commission is authorized to establish guaranteed prices for domestic production of source materials, i. e., uranium and thorium in section 66 of the 1954 act, and for the production of special nuclear materials, i. e., plutonium, uranium 233 and 235, in section 52.

Such guaranties for source materials now extend to 1962 in the United States. Such guaranties are intended to assure the profitability of mining operations, and in fact provide the only economic basis for the uranium mining industry which has developed in the United States. Guaranteed prices are based on the concept that the Government requirements for source materials will not be met unless a guaranteed market exists far enough into the future to permit exploration for and development of resources as well as a period of production sufficient to recoup investment by prospectors and miners.

The stable ore prices which thus result incidentally benefit those looking toward putting the same materials to work for peaceful purposes.

While the guaranteed ore price system was initiated to assure meeting military requirements, the present system for stabilizing the market, however, has no basic element within it which makes it the only way to meet the needs of future industrial uses.

At least one alternative is available. It might be possible to satisfy military requirements by giving guaranties of the minimum quantities of uranium needed from domestic sources in some selected number of subsequent years. In this way, uranium ore producers would begin to have a free market, with the assurance that the Government would be active in that market as a buyer to some definite and predetermined extent. This approach might result in some changes in ore prices, but such changes, however, are not likely to have a significant effect on growth of peaceful uses, because the basic ore price is only one factor in establishing the reactor fuel costs. Fabrication and fuel reprocessing under present technology together appear to exert much greater influence. The security considerations of this course of action, however, lie beyond the purview of our study.

The 1954 act limits the period for which the Commission can guarantee prices to be paid for production of special nuclear materials in licensed facilities to 7 years. This is the practice known as "buy back." The same price applies to all licensees—experimental, medical, research, or commercial. This provision is required in order to compensate licensees for the fact that materials which may be produced cannot be privately owned.

In setting the prices it pays for such production, the Commission has an opportunity to influence the financial prospects for licensed reactor designs and operations. A high price would encourage new reactor operators to produce much special nuclear material. A low price forces the operators to obtain their revenue from other sources, such as electricity, heat, fission byproducts, and radiation capacity.

A price schedule has been established. It is classified confidential restricted data on the grounds that the prices bear a relationship to production costs of similar materials produced in Commission plants, hence would provide a potential enemy with an added tool for computation of United States military stockpiling.

The importance of these prices can be so great in setting the economics of atomic power that the proof of the wisdom of keeping these prices classified and thus out of the realm of public examination should be substantial. In a statement to the panel by the Department of Defense giving its viewpoint on control of information, the classification of guaranteed prices was used as an example of the establishment of a lower classification than was warranted. We are not expert in such matters, but we believe the national interest would be advanced by publication of these price schedules.

The remaining device for direct financial assistance through pricing of materials is contained in section 81 of the 1954 act which authorizes the Commission to distribute byproduct materials, such as radioisotopes and fission products, with or without charge. If a charge is made, it must be set so as to cover costs and not undersell independent sources of supply. The Commission has never proposed giving radioisotopes, radioactively labeled compounds, and the like without any charge. It is interesting to note that this could be done.

We have observed that many substantial contributions can be made by diverse peaceful uses of atomic energy other than atomic power. In most cases, the cost of the radioactive materials is not significant in the total cost. In such applications as medical therapy devices, medical diagnostic and clinical uses, and agricultural research, the cost of the radioactive materials can be a substantial portion of the total cost. The Commission has a policy of selling radioisotopes for all medical research at 20 percent of cost. Apparently this has stimulated use of such materials.

16.2.4. Training, Patents, and Other Indirect Financial Devices

The Commission has already and will inevitably continue to assist private enterprise through the training of skilled and professional manpower both on-the-job in Commission plants and through semiformal programs. People leave the Commission and its contractors every day. While turnover rates do not appear excessive, the new employers to whom these people go get employees already trained in some aspects of atomic energy. This training was paid for by the Commission incident to getting Commission work done. Each person thus trained is one more person for whose training industry does not have to pay.

Patents are also related to financial environment. This subject is discussed in chapter 17. The extent to which the Commission allows private licensees to hold patent rights can have very substantial bearing on the attractiveness of private investment in peaceful uses of atomic energy.

Finally, to the extent that American private enterprise is dependent on foreign markets for early profitability, United States foreign atomic aid may prove very important. Many of the countries interested in acquiring the benefits of peaceful uses of atomic energy do not have the capital available. The United States may very possibly have to provide financing as well as technical assistance if the interest which has been stimulated in foreign countries is to be matched by achievement. (See ch. 9.)

16.3. OTHER INDIRECT FINANCIAL AIDS

We have examined the principal techniques for financial assistance to private enterprise available to the Commission. There are other techniques less obvious but equally significant. These do not involve action by the Commission. The diversity of these is indicated in the following listing:

(*a*) Accelerated tax amortization.
(*b*) Liberalized depreciation allowances.
(*c*) Loss on sale or abandonment of depreciable property used in trade or business.
(*d*) Research and development expense writeoffs.
(*e*) Moderation of double taxation of dividends.
(*f*) Capital gains tax of investors and their financiers.
(*g*) Business-loss offsets.
(*h*) Venture-capital company advantages.
(*i*) Corporation surtax exemptions.

Other financing techniques which have been used by the Federal Government from time to time which could be reviewed for stimulation of atomic development include:

(*a*) Loan guaranties.
(*b*) Direct loans.
(*c*) Small-business aid.
(*d*) Public-facility loans.

These techniques are described in a special study report prepared for the panel by the Department of the Treasury which appears in chapter 16, volume 2.

16.4. CONCLUSIONS AND RECOMMENDATIONS

The selection by the Commission of research and development projects is significant in affecting the financial environment surrounding development of peaceful uses of atomic energy. Research performed by the Commission and access granted to the results can take the place of work which otherwise would have to be performed by private investors.

Guidance related to research conducted in Commission laboratories for itself and for others should be given by the Congress on three points: The priority to be accorded civilian versus military research tasks; the desirability of creating additional Commission facilities to conduct peaceful research as an alternative to other devices, such as direct Government financial aid to private industry to develop such research facilities; and priorities as between potential private applicants for research in Commission facilities.

Without such guidance, the Commission is placed in a position to exercise influence over the economics of private ventures which may lead to charges of favoritism, partiality, and mismanagement of Government resources. This is an excessive responsibility to place on the Commission. It is almost certain to lead to an overly cautious attitude on the part of Commission personnel.

The establishment of priorities for making available Commission facilities for processing, fabricating, separating, or refining source, byproduct, and special nuclear materials appears to follow the standards of urgency applied to peaceful uses requiring these services. Conflicts between Commission and private requirements for such services should also be considered in the context of the organizational problems discussed in chapter 18.

With respect to Commission support of research and development in licensed facilities, we have concluded that only in this way can the Commission assure that exploration of the frontiers of peaceful atomic uses will move forward with sufficient impetus. Investment of Commission research and development money in both small and large private "demonstration" atomic powerplants seems to us to be sound national policy.

The Commission can seek to meet its own requirements for products and services of a military nature by contracting with industry. There may be some question, however, as to how useful this form of financial encouragement can be to peaceful uses development, except for the value resulting from the training of skilled personnel.

Waiver by the Commission of charges for fuel inventories and consumption could be of substantial financial assistance in the development, construction, and operation of experimental, medical, research, and "demonstration" facilities. This device now has limited effect because the Commission is considering the exercise of its discretionary authority only in relation to fuel consumption.

Military requirements for uranium are the present reason for ore-price guaranties. A free market should be the objective for the era of expanded peaceful uses without guaranties.

As an alternative to price guaranties in accomplishing the transition to a free market, tonnage guaranties based upon military requirements should be considered. Any guaranties should be reviewed annually and extended on a 5-year moving basis only if justified by military requirements.

Commission authority to establish guaranteed prices for production of special nuclear materials in licensed facilities is a powerful financial device which has a material bearing on the economics of atomic power. The Commission has exercised its pricing authority in a conservative manner so as not to lay the foundations for a long-term subsidy to the atomic-power industry. The wisdom of this cannot be examined publicly unless the entire supply and demand picture can be declassified. We are not critical of the Commission's prices, but we think it undesirable for a financial device of such far-reaching significance to be hidden from public examination.

The authority of the Commission granted by section 81 of the 1954 act to distribute radioisotopes and fission products with or without charge has been exercised with beneficial effects in the sale of radioisotopes at 20 percent of cost for medical research. We can think of no better way to increase the rate of development of many peaceful uses of atomic energy in the years immediately ahead than by extending this same policy to all research in the fields of general science, agriculture, and industry, as well as to diagnostic and clinical uses in the field of medicine. This may be an ideal way for Government to speed exploration of potential new resources and to aid humanity at modest cost.

Other financial devices, direct and indirect, controlled both by the Commission and by other Government agencies, can be used as necessary to improve the financial environment and speed development of peaceful uses of atomic energy.

We recommend that:

1. the Joint Committee review the 1954 act, in light of the priorities for development of various peaceful uses set forth in our report, with a view to providing clear guidance to the Commission on the relative priorities of military and peaceful uses and between various peaceful uses;

2. the Commission provide financial assistance under section 31 of the 1954 act for the conduct of research involved in one "demonstration" of each major type of utilization facility insofar as such assistance proves essential to private participation in such projects;

3. the Joint Committee, in considering future Commission requests for long-term contract authority for the procurement of materials and services from industry as an alternate to building additional Government facilities, bear in mind that in some cases it may be unsound to encourage private enterprise to focus its attention on Commission military needs not compatible with the ultimate direction of peaceful uses;

4. the Commission waive all charges for fuel used in experimental, medical, research, and "demonstration" facilities where such facilities are owned by nonprofit institutions and used substantially for educational or medical purposes;

5. the Commission recognize that military requirements for uranium are the present reason for ore-price guaranties and that a free market should be the objective for the era of expanded peaceful uses without guaranties; that the Commission, as an alternative to price guaranties in accomplishing the transition to a free market, consider tonnage guaranties based upon military requirements; any guaranties should be reviewed annually and extended on a 5-year moving basis only if justified by military requirements;

6. the guaranteed price schedules for the production of special nuclear materials should be declassified to make possible public examination of this important financial device.

7. the Commission sell radioisotopes at 20 percent of cost for use in all research in the fields of general science, agriculture, and industry, as well as in diagnosis and clinical use in the field of medicine; and

8. the study prepared by the Department of the Treasury be examined as a valuable exposition of important and often-misunderstood financial techniques.

CHAPTER 17—PATENTS

17.1. INTRODUCTION AND SUMMARY

Patents are relevant to the present study to the extent that pertinent provisions of the Atomic Energy Act of 1954—and administration of these provisions—result in stimulation or retardation to development of the peaceful uses of atomic energy.

The patent concepts developed in chapter 13 in the 1954 act reflect issues other than patents themselves. Fears of both public power and private monopoly found expression here. Nevertheless, the law is not clear. The emphasis lies on protecting established or anticipated interests, both public and private, rather than on fostering vigorous scientific and engineering exploration. To the new peaceful atomic industry seeking to get established, the patent provisions of the 1954 act leaves something to be desired, but need not be fatal. The issues involved are discussed below.

17.2. CLARIFICATION OF PATENT PROVISIONS BY ADMINISTRATIVE VERSUS CONGRESSIONAL ACTION

Developments in the peaceful applications of atomic energy are expected to come more rapidly with increased private participation. Historically, one of the stimulants which could encourage such participation has been a strong patent system. The Government grant of exclusive rights under a patent has motivated or justified private investment in research. Unwillingness to grant exclusive right or the imposition of significant limitations can have a stifling effect on the availability of money to support research. Furthermore, patents in industry are important not only because of the exclusive right granted to practice an invention for a specific number of years, but also for the tangible property which patents have come to represent in industrial negotiation.

It has been noted that the peaceful applications of atomic energy are, at the present time, in a period of transition from complete Commission control to substantial private participation. In this transitional period, those who are considering entering the field naturally seek to remove any obstacle to conducting their business in a manner which they consider normal. Each potential entrant, of course, seeks every possible justification for investment, as well as the most advantageous patent arrangements. On the other hand, the Commission—long accustomed to maintaining strict patent control—finds it difficult to divest itself of control in the absence of clear direction in the law.

This transition period from no private patents to some private patents is characterized by maneuver and negotiation on the part of

Government and industry in which the patent provisions themselves in the 1954 act are only one element. Realistic, rather than purely legalistic, Commission interpretation of the somewhat contradictory statutory directives can permit such negotiations to take the place of clarifying amendments.

If the period of negotiation is too protracted, or if the ultimate objective provides less incentive than is held out by the operation of the traditional patent system, development of peaceful applications of atomic energy might conceivably be retarded in ways difficult to appraise. Private individuals and organizations must be assured promptly of the extent of their rights to patents developed from privately financed work wherever it is performed. The reserve power compulsory licensing provisions of the 1954 act guard against the possibility that individuals or groups with prior experience gained as Commission employees or contractors can obtain an excessive advantage contrary to the best interests of the public or in conflict with sound principles of free competition.

The dangers of extended negotiation on patent provision interpretation are revealed in two developments which have already occurred: patent rights of licensees and access permit holders; and private patent rights in foreign countries.

The Commission has tentatively interpreted the statutory provisions so that mere access to certain types of information does not bar private individuals or organizations from receiving patents on subsequent privately financed developments relating to peaceful uses of atomic energy. This policy still has not been officially promulgated but is contained only in proposed regulations. It certainly has not been widely publicized. Many potential private or industrial participants still do not realize that they can now apply for licenses and obtain access to confidential restricted data without impairment of their future patent rights. The following excerpt from a Commission communication (see full text in vol. 2, ch. 17), may therefore be useful:

> With respect to actions taken by the Commission to interpret the meaning of the language in section 152, the Commission has taken the position that a license does not constitute a "relationship with the Commission." In addition, the Commission has stated that it will retain no rights in inventions or discoveries resulting from the sale or distribution of radioisotopes, the sale of irradiation services and the dissemination of information pursuant to an access permit (with the exception of the retention of a royalty-free, nonexclusive license in inventions resulting from access to "secret restricted data").

Further clarification by the Commission of its position would be helpful. The more clearly all Commission patent policy is stated, the more opportunity will be afforded for intelligent debate and review of that policy.

The second development which deserves mention is related to the establishment of a strong United States patent position abroad. In the sense that patents represent tangible property, useful in industrial negotiation, it is advantageous to industry that foreign patents be obtained on inventions made by citizens of the United States. Neither the 1946 nor the 1954 act gave any encouragement to the Commission to acquire patent rights in foreign countries for the purpose of giving the Federal Government international bargaining advantages and therefore the Commission has no strong incentive to obtain such rights. The filing of applications for foreign patents on an atomic-energy invention, to which title in the United States is held by the

Commission, is discretionary with the Commission. The policy has been to file such applications (secrecy requirements permitting) when and where the Commission judges that the best interests of the Government would be served by doing so.

The best interest of Government and industry may not always be coextensive. A mechanism is therefore required which assures that while the Government interests continue to be protected, the interests of industry are not overlooked.

One presently minor but potentially important item has also been called to our attention. The language of section 152 of the 1954 act requires the filing of a statement of the origin of the invention with the Commissioner of Patents either with the patent application or on request. This opens the possibility that the Commission may be barred from obtaining a patent on inventions conceived at Commission expense if it cannot obtain the required statement from the inventor within the 30-day period following request for the statement from the Commissioner of Patents. A perfecting amendment appears desirable to correct this situation.

The expiration date set in section 153h beyond which the compulsory patent licensing features of the 1954 act cease to be effective will automatically shift atomic patents nearer the normal patent system. Although the Joint Committee has indicated its intention to review the entire atomic patent provisions of the 1954 act, it would appear desirable to wait until the September 1, 1959, date is nearer at hand.

17.3. CONCLUSIONS AND RECOMMENDATIONS

Patents can stimulate private investment in the development of peaceful uses of atomic energy. The absence of clear patent policies or ambiguity in administration can seriously retard. The 1954 act for the most part accomplishes the same objectives as the normal patents system and at the same time protects the public against unwarranted abuse or monoploy. Return of patents on peaceful atomic applications to the normal system must be the objective. In the meantime, prompt and definitive statements of Commission patent policy are currently more essential than revision of the patent provisions of the 1954 act.

We recommend:

1. that the Commission announce its complete interpretation of patent provisions relating to private development of peaceful uses promptly, not on a piecemeal or case-by-case basis;
2. that the Commission notify inventors promptly as to the intentions of the Government with regard to the filing of applications for patent rights in foreign countries on inventions to which title in the United States rests with the Commission and authorize the inventors to file applications for patent rights in foreign countries where the Commission chooses not to do so; and
3. that the complete review of the patent provisions of the 1954 act by the Joint Committee be set aside until the expiration date relating to the reserve power compulsory licensing provisions in section 153h—September 1, 1959—is closer at hand. There are many other important policy issues which require more prompt attention.

CHAPTER 18—GOVERNMENT ORGANIZATION

18.1. INTRODUCTION AND SUMMARY

Until passage of the 1954 act, the Atomic Energy Commission and the Joint Congressional Committee on Atomic Energy were the points in the executive and legislative branches of our Government in which were centered or reflected all the responsibilities for policy and for administration of the development and application of all uses of atomic energy. Today, activities connected with the encouragement and regulation of peaceful uses of atomic energy concern almost every executive department and agency, as well as many committees of the Congress.

With the coming of atomic electric power, the Federal Power Commission will clearly be involved. The Department of the Interior is concerned with conservation and exploitation of our natural energy resources. The Department of Labor is responsible for helping meet the requirements for higher worker skills stimulated by atomic precision. The Pure Food and Drug Administration has jurisdiction over the public safety aspects of radiation food preservation. The Public Health Service is concerned with radiation safety. The State Department must suggest and administer foreign atomic policy relating to peaceful uses. The Maritime Administration, the Navy Department, the Army Quartermaster General, the entire Department of Agriculture, and even taxing authorities of the Treasury Department, must deal with special problems related to peaceful uses. The atomic activities of these and the many other executive departments and agencies must all be reflected in congressional committee deliberations.

This change from centralization to dispersed functional interest has resulted from the decision to get on now with widespread application of peaceful uses of atomic energy—uses which encompass almost every aspect of our national life, and affect many broad domestic and international policies. The Nation is moving toward the termination of the era of giving atomic energy special treatment. The widespread benefits now sought require the experience and managerial talents not only of American industry, but also of all elements of our governmental structure.

Integration of Federal atomic policy was relatively straightforward when centralization was the order of the day. It required principal coordination between the Commission and the Departments of State and Defense. Now the problem is vastly different. There is no overall mechanism as yet to accomplish the integration so essential to insure clarity of policy and maximum benefits.

The Commission itself is still in the process of adjusting to its new role. The precise military requirements to which it has been geared since its inception must now accommodate far less precisely stated requirements for development and application of peaceful uses. Appropriately, the 1954 act gave the Commission the breadth of discretionary authority necessary to permit it to meet the varying peaceful requirements which will be imposed during the present transitional period. The pattern and direction of exercise of this discretionary authority, however, has not yet been established.

18.2. ELEMENTS OF COMMISSION ORGANIZATION WHICH AFFECT THE RATE OF DEVELOPMENT OF PEACEFUL USES OF ATOMIC ENERGY

The responsibility for encouragement and regulation of the development of peaceful uses of atomic energy is dispersed throughout almost the entire organizational structure of the Commission. The Washington headquarters, all field offices, and contractor-operated facilities are involved. We have considered primarily the headquarters organizational structure of the Atomic Energy Commission. We believe that the assignment of responsibilities to the other parts of the organization must flow from this source.

The Assistant General Manager for Research and Industrial Development provides the managerial focal point within the Commission for the coordination and the direction of all activities of the Commission relating to: (1) stimulation; (2) development, and (3) application of the peaceful uses of atomic energy.

Actual regulation of the activities of private industry is the responsibility of the Division of Civilian Application which reports directly to the General Manager. The divisions of the Commission most directly affecting or concerned with the encouragement of peaceful uses are those involving information, research, licenses and regulations, and special nuclear materials, and are discussed below:

18.2.1. Information

Control of all classified atomic energy information rests with the Division of Classification. Declassification, downgrading, and all review are conducted under the direction of this Division by employees of the Commission and its contractors at various installations throughout the country. A "classification guide" is provided for their assistance. A part-time Committee of Senior Reviewers, composed of six scientists, advises on classification policy. Until recently, no effective current liaison was maintained by the reviewers with divisions of the Commission or other executive agencies and departments concerned with foreign developments. Responsibility for initiation and selection of documents for classification review rests with employees of the Commission's field offices and contractors. The Division of Classification reports to an Assistant General Manager whose other responsibilities include security, intelligence, information services, organization and personnel, and materials accountability.

Dissemination of unclassified and declassified information is the responsibility of the Division of Information Services. The compilation of publishable technical information recently initiated (see ch. 11) is assigned to the Technical Information Branch of this Division.

Classified information, on the other hand, is made available to authorized non-Commission individuals and organizations through the "access permit" program administered by the Division of Civilian Application. Authorization is obtained for individuals only after appropriate security investigations which are under the control of the Division of Security. The actual information is located at various Commission facilities throughout the country (which are operated by university and industrial contractors to the Commission), as well as at the Commission's field offices and headquarters.

18.2.2. Research

Research relevant to the peaceful uses of atomic energy is supported by the Commission both at its own contractor-operated facilities and on the outside in industrial and university laboratories.

The Division of Biology and Medicine is responsible for research programs in the life sciences. The Division of Research is responsible for research in the physical sciences. The Division of Reactor Development is responsible for the planning and direction of all activities related to reactor development for peaceful and military applications. All three of these Divisions report to and are under the direction of the Assistant General Manager for Research and Industrial Development.

The actual research is performed, however, at various laboratories and other facilities. The Brookhaven National Laboratory, where medical and agricultural research, power reactor development, and basic research are conducted along with other activities, is under the administrative supervision of the New York Operations Office and reports to the Division of Research. The Argonne National Laboratory, a center for reactor development, physical and medical research as well as other research, is under the administrative direction of the Chicago Operations Office which reports to the Division of Reactor Development. The Oak Ridge National Laboratory operated by the Union Carbide Nuclear Co. is a center for radioisotope production, training of nuclear scientists and engineers, reactor development, and chemical processing research. This laboratory is under the administrative jurisdiction of the Oak Ridge Operations Office which reports to the Division of Production. Other research activities are administered by various offices, some of which report to Divisions not otherwise involved in peaceful applications. In addition, many research activities are conducted at the laboratories by inter-divisional arrangements. For example, some research on controlled thermonuclear systems is performed for the Division of Research by the Los Alamos Scientific Laboratory which is controlled by the Division of Military Application.

The peaceful uses research programs of the Commission are integrated primarily through the device of budget formulation and fund control. The actual details of the programs are based for the most part on proposals for projects submitted by the laboratories themselves. The Commission receives overall research policy guidance from the statutory General Advisory Committee, composed of scientists and engineers appointed by the President.

Non-Commission organizations seeking to have research performed in Commission laboratories with or without expense to themselves now deal directly with the field offices and laboratories. Reference to headquarters is reserved for special cases. On the other hand, applications for grants of Commission research funds for work to be performed at non-Commission facilities must be submitted directly to the division having responsibiliy for the type of research proposed. For example, basic negotiations of Commission financial support of research in connection with privately-proposed power reactor "demonstrations" must be conducted with the Division of Reactor Development.

18.2.3. Licenses and Regulations

The full authority for the promulgation of licensing procedures and regulations, and the issuance of licenses resides in the Division of Civilian Application. Enforcement of regulations is entrusted to the Division of Inspection.

18.2.4. Special Nuclear Materials

Special nuclear material—uranium 233, uranium 235 and plutonium—is owned exclusively by the Commission. (See ch. 15.) These are the fuels for prospective economically competitive atomic powerplants. Policies as to assignment of responsibility for allocations of such materials to licensees, prices to be charged for materials allocated, and prices to be paid for materials produced are in a state of transition within the Commission. The functions of the Division of Civilian Application with respect to pricing are being revised. Currently, to procure these fuels, atomic powerplant operators are required to apply to the Division of Civilian Application, to which division is assigned responsibility for developing requirements for, and authorizing distribution of special nuclear materials for licensed use. Actual distribution of such materials is made by the Division of Production. The prices charged—both charges for interest on inventory and charges for materials consumed—are set by the Commission. The Division of Civilian Application currently bears responsibility for development of pricing schedules based on costs determined by the Commission Controller and on the factors required to be considered by the 1954 act. Waivers of charges authorized by law appear to be part of pricing policy, responsibility for which is not yet clearly established. Assuring the preparation of pricing schedules for special nuclear materials produced in licensed facilities is also now a function of the Division of Civilian Application. The Division of International Affairs is responsible for discharging or coordinating all Commission obligations related to the international commitments of the United States. (See ch. 9 for further comments on this subject.)

18.3. OBSERVATIONS ON COMMISSION ORGANIZATION

Prior to the 1954 act, when all development of atomic energy was essentially a Commission monopoly, the organizational structure of the Commission permitted the expressions of free inquiry needed to offset the narrowing influence of monopoly. This structure now appears to us, however, to be too complex and too time consuming to be consistent with the new environment which the 1954 act sought to provide the Nation. The present structure does not provide the straightforward and effective mechanism such as is provided for military applications for defining the integrated objectives of Commission programs: (1) for peaceful uses research; (2) for developing precise requirements with definite time schedules for accomplishment, or (3) for assuring expeditious execution of the necessary programs and projects. We appreciate the enormous problems of transition with which the Commission and its employees are confronted. There is a positive approach in many parts of the Commission organization toward solving these problems within the existing structure. The success of these efforts will not be measured in intentions alone, however, but in overall understanding of these problems and in establishment of a focal point of responsibility for pressing forward with exploration of peaceful uses.

We have noted in chapter 9 the great importance which attaches to the international aspects of the peaceful uses. There is inadequate provision in the Commission's organization for defining and pressing forward with developments so essential for the maintenance of our technical leadership on the international scene. We attribute the absence of any technical program specifically related to foreign needs to this gap.

18.4. EXECUTIVE BRANCH ORGANIZATION FOR PEACEFUL USES OF ATOMIC ENERGY

In the course of our study we have found it necessary to seek information, advice, and assistance from most departments and agencies of the executive branch of the Federal Government. In most cases, interest in the impact of peaceful uses of atomic energy on their functions was evident. Though the data which we requested frequently did not exist in prepared form, the task of providing the information requested was undertaken willingly because it afforded an opportunity—in some cases the first such opportunity—for expressions of functional interests.

If peaceful uses of atomic energy are integrated into the total fabric of our Nation—a prerequisite to the achievement of maximum benefits—The Federal departments and agencies must now begin to organize their own related activities. In addition, there must be mechanisms for coordinating governmentwide domestic and international programs. For some years to come, the Commission will be obliged to stimulate these activities, to render research service, and to serve as technical adviser to assure early competence without intruding on the responsibilities which properly belong to others.

18.5. THE ROLE OF CONGRESS

We have noted at many points in our report instances in which the 1954 act provides less than clear guidance to the executive branch. Problems involving financial assistance to private industry, availability of information, and activities of American businessmen abroad are examples of areas in which the burden is placed on the Commission to ascertain the specific intent of public policy. In many cases, it seems to us that the Commission is certain to be faced with criticisms no matter how it acts, or even if it fails to act.

The transition prescribed in the 1954 act will probably take years, not months, to accomplish. It can be speeded if the required adjustments and clarifications in law are recognized and made promptly within the basic concept of separation of powers of the executive and legislative branches. Recognition depends, nevertheless, upon sympathetic consultation as well as continuous critical but constructive evaluation. Obviously, if this is to be accomplished, the Commission and other agencies and departments of the executive branch must assure that the appropriate committees of the Congress are fully informed not only of their decisions and actions relating to peaceful uses of atomic energy, but of their problems as well.

There are committees of the Congress which must obviously be concerned with various aspects of peaceful uses of atomic energy. Other committees equally clearly have very serious responsibilities with regard to military applications. It will continue to be the Joint Committee on Atomic Energy, however, on which the Congress must rely for the establishment of balance and development of integrated legislative expressions of policy on both peaceful and military uses of atomic energy at home and abroad.

18.6. CONCLUSIONS AND RECOMMENDATIONS

The peaceful uses of atomic energy affect the functions of almost every department and agency of the executive branch and all of the corresponding committees of the Congress. Organization of both branches of our Government must be directed toward acceptance of the fact that the era of atomic centralization in the Government in general and the Commission in particular ended with the decision to press forward with peaceful uses.

There is no actual focal point in the Commission for the integration of policies and programs related to peaceful uses comparable to the focus and impetus provided for military applications. Yet the urgency for exploration of both is rapidly approaching equality as a matter of national policy.

In the transition from primarily military orientation to dual emphasis, the speed with which the Congress recognizes problems and adjusts legislative policy will be of great importance in determining the rate and continuity of progress. The need for a mutuality of understanding between the Joint Committee on Atomic Energy and the Atomic Energy Commission and for leadership on the part of both to a common end is of greater importance today than ever before.

We therefore recommend:

1. that the Commission provide a real focal point within its organization at which are concentrated authority and responsibility for defining the integrated objectives for research and development of the peaceful uses of atomic energy, both at home and abroad, for establishing definite requirements with time scales for accomplishment of these objectives, and for assuring expeditious execution of the necessary programs and projects;

2. that other departments and agencies of the executive branch be encouraged to develop their own organizations for dealing with their functional interests in peaceful uses of atomic energy, drawing upon the Commission for advice and services rather

than leaning on the Commission or delegating their functions to it;

3. that the Joint Committee on Atomic Energy continue to serve the Congress as a mechanism for balancing the interests of the Nation in both peaceful and military atomic pursuits and for providing the Congress and the Nation, through hearings, reports, and by other means, with a constantly expanding but realistic understanding of the import of peaceful uses of atomic energy to the American way of life, economy, industry, employment, and natural resources, and to our international leadership; and

4. that the Joint Committee on Atomic Energy recognize deficiencies in law, act expeditiously to make appropriate adjustments and clarification in law, and provide the Commission, and other agencies and departments of the executive branch concerned with peaceful uses of atomic energy, with opportunity for sympathetic consultation, as well as conducting continuous critical but constructive evaluations.

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