EDITORIAL NOTE:

The following are excerpts from a memorandum prepared by Dr. Leo Szilard in March, 1945. This memorandum was to be placed before President Roosevelt, but owing to his sudden death, it did not reach him. Referred by the White House to James F. Byrnes it was placed before him by the author in a personal interview on May 28, 1945 (six weeks before the first bomb was tested in New Mexico). These excerpts contain none of the secret information which may have been embodied in the original document. It is believed that this was the first document which discussed the implications of the atomic bomb with respect to our future relations with Russia and the question of international control of atomic energy. It also contained the original suggestion of denaturing fissionable materials for the puppose of making more difficult their use for the mamufacture of bombs.

ATOMIC BOMBS AND THE POSTWAR POSITION OF

THE UNITED STATES IN THE WORLD

by Leo Szilard

The development of the atomic bomb is mostly considered from the point of view of its possible use in the present war and such bombs are likely to be available in time to be used before the war ends. However, their role in the ... years which will follow can be expected to be far more important and it seems that the position of the United States in the world may be adversely affected by their existence. The following might very well turn out to be the future course of events:

Before the end of the war we shall use atomic bombs against Japan. These bombs will be much less powerful than we know could be made and which in all likelihood will be made within ---- years yet the first bomb that is detonated over Japan will be spectacular enough to start a race in atomic armaments between us and other nations.

In a few months Russia's war with Germany may be over. The work on uranium will then undoubtedly be given a high priority there but it will perhaps still not be carried out on a large industrial scale until we detonate our first atomic bomb and thus demonstrate the success of this development. For a few years after that we shall almost certainly be ahead of Russia. But even if we assume that we could keep ahead of her in this development all the time, this may neither offer us protection from attack nor necessarily give us substantial advantage in case of war ... years from now.

... years from now Russia may have accumulated enough of some of the active elements which may be used for constructing atomic bombs to have an equivalent to -

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Clearly, if such bombs were available, it is not necessary to bomb our cities from the air in order to destroy them. All that is necessary is to place a comparatively small number of such bombs in each of our major cities and to detonate them at some later time.

The United States has a very long coast-line which will make it possible to smuggle in such bombs in peacetime and to carry them by truck into our cities. The long coast-line, the structure of our society, and our very heterogeneous population may make an effective control of such "traffic" virtually impossible. One can easily visualize how a "friendly" power in time of peace may have such bombs placed in all of our major cities under the guidance of agents. This might be done free from aggressive intent. Such a power might know or suspect that we have accumulated a quantity of atomic bombs and fear our defenses are so strong that after the outbreak of hostilities it would be difficult to reach our cities by air. In such circumstances it may be exceedingly difficult for its "government" to refuse to take "precautions" which its "army" considers necessary. . .

So far it has not been possible to devise any methods which would enable us to detect hidden atomic bombs buried in the ground or otherwise efficiently protected against detection.

If there should be great progress in the development of rockets after this war, it is conceivable that it will become possible to drop atomic

bombs on the cities of the United States from very great distances by means of rockets.

The weakness of the position of the United States will largely be due to the very high concentration of its manufacturing capacity and of its population in cities. Thirty million people live here in cities of over 250,000. This concentration is so pronounced that the destruction of the cities may easily mean the end of our ability to resist. Keeping constantly ahead of the Russians in our production of these heavy elements will not restore us to a strong position. No quantity of these "active" materials which we may accumulate will protect us from attack and so far as retaliation is concerned, we might not be able to do more than to destroy the large cities of Russia which are few in number and the economic importance of which is in no way comparable to the economic importance of our own cities. Thus it would appear that we would not gain an overwhelmingly strong position in a war with Russia merely by accumulating an enormous quantity of these elements or by increasing, as we might, the efficiency of our bombs from ----- to a much higher value.

The strong position of the United States in the world in the past thirty years was essentially due to the fact that the United States could outproduce every other country in heavy armaments. It takes a very large number of tanks, airplanes and guns to bring about a decision in a war and as long as tanks, airplanes and guns are the major instruments of war the large production capacity of the United States gives it an advantage which may be considered decisive.

The existence of atomic bombs means the end of the strong position of the United States in this respect. From now on the destructive power which can be accumulated by other countries as well as the United States can easily reach the level at which all the cities of the enemy can

be destroyed in one single sudden attack. The expenditure in money and material which is necessary to reach this level is so small that any of the major powers can easily afford ir provided . . . For us to accumulate active materials in quantities beyond that necessary to destroy the cities of the "enemy" would probably give us some advantage in the war, but it is difficult to say whether the importance of such "excess" amounts of material would be really substantial. Out-producing the "enemy" might therefore not necessarily increase our strength very much.

The greatest danger arising out of a competition between the United States and Russia, which would lead to a rapid accumulation of vast quantities of atomic bombs in both countries, consists in the possibility of the outbreak of a preventive war. Such a war might be the outcome of the fear that the other country might strike first and no amount of good will on the part of both nations might be sufficient to prevent the outbreak of a war if such an explosive situation were allowed to develop.

One of the questions that has to be considered is whether it might be possible to set up some system of controls of the production of these active materials. Such controls would ultimately have to extend to every territory on the earth. Whether it is politically and technically feasible to set up effective controls and what we could do to improve our chances in this respect are questions that urgently require study and decisions. Some further remarks on these questions are made below, but other considerations might be put forward as soon as the question receives the attention of the Government.

A system of controls could be considered successful only if we could count on a period of grace in case the controls were denounced or obstructed by one of the major powers. This means that the system would have to be of such a nature that at least . . . would lapse between the time the nations began to convert their installations for the purpose of manufacturing atomic bombs and the time such bombs became available in quantity.

SYSTEMS OF CONTROL OUGHT TO BE CONSIDERED

From a formal point of view all countries may be considered as potential enemies, but it is perhaps not too optimistic to assume that we may disregard the possibility of a war with Great Britain in the next fifteen years. It appears, however, rather unlikely that jointly with Great Britain we could police the world and thus prevent by force the manufacture of all of the "active materials" anywhere in the world, including Russia.

It might perhaps be possible to set up jointly with Great Britain and Russia some sort of joint control of the manufacture of the active materials everywhere in the world if we could get Russia to agree to such a control which of necessity would have to extend to her territory. The purpose of such a control would be to prevent the active elements from becoming available in a form in which they could be used for the manufacture of atomic bombs. This would not necessarily mean that the development of atomic power has to be suppressed but only that the elements involved must not be prepared in certain forms and degree of purity.

This point raises the following question: What forms of atomic power can we permit to be organized if we want to make sure that the available materials and facilities cannot easily be converted for the manufacture of atomic bombs? Some thought has already been given to this question with the following result.

There are two types of active materials. Materials of the first type can be diluted by the abundant isotope of uranium in such a way as to rule out the possibility of using them for atomic bombs while leaving unimpaired the usefulness of the materials for industrial purposes. A chemical separation from the diluting material would be impossible and a conversion into materials which can be used for atomic bombs would take . . .

Material of the second type which can be used for atomic bombs can be "denatured" by . . . Whether more elaborate methods can be worked out which will permit the detonation of the denatured material is a question which would have to be carefully scrutinized. These lines merely serve to indicate that there might perhaps be a satisfactory solution

to the problem of reconciling the requirements of safety of the United States with the desire not to hamper the development of atomic power for industrial purposes. Unfortunately it is by no means sure that a satisfactory solution of this problem is in fact possible. It would be much easier, safer, and would require a much less tight control to arrest the development of atomic power by scrapping and outlawing the large and easily visible installations which characterize the first stage of this development.

CONTROL OF RAW MATERIALS COULD BE CONSIDERED

If Russia, the United States and other countries were willing to forego the use of atomic power for peacetime purposes, one could have a system of control that would be fairly simple since it would be almost sufficient to control the movements of raw materials. Ores of uranium would have to be mined under control and transported to some "neutral" territory. Whether or not it would be permitted to have in a neutral territory installations belonging to . . . and atomic power plants,is a question of minor importance. It appears likely that if the major powers were willing to forego the use of atomic power, a system of controls could be set up without encountering too great difficulties.

AN ALTERNATIVE SYSTEM OF CONTROLS WOULD HAVE TO BE MUCH TIGHTER

On the other hand, if the United States, Russia, and other countries should have atomic power installations within their territory, a very tight system of control would be needed in order to make sure that the nations would not have to face a sudden attack by atomic bombs. For a control of this sort to be effective, it would be necessary that our agents and the agents of Great Britain move freely around in Russia, be permitted to keep contacts with Russian civilians, secretly employ Russian civilians for the purpose of obtaining information, and have entry into every factory or shop throughout the vast territory of Russia.

That there may be dangerous loopholes in control systems which might be set up is illustrated by events that took place in Germany after the first World War. At that time, there were many Germans who were willing to give information to the Inter-Allied Commission about violations of the control regulations, but those who actually did so were publicly tried under the German Espionage Law and were given heavy sentences. The Treaty of Versailles did not stipulate that the German Espionage Law must be revoked.

Clearly, it would be desirable to create a situation which would permit us to appeal in various ways to physicists and engineers everywhere for information that would uncover violations of the controls. This would give us additional assurance that such violations would be detected but it presupposes that we succeed in creating conditions in which we would guarantee the personal safety of those who volunteer such information and the safety of their families.

Since Russia cannot be expected to agree to such a control unless she obtains the same rights of control in the United States and Great Britain the question whether Congress and the people of the United States are willing to agree to such a control might become of paramount importance.

HOW COULD RUSSIA BEST BE PERSUADED?

As to our chances of persuading the Russians to accept mutual control, much may depend on the proper timing of our approach to Russia. It would appear that such an approach would have to be made immediately after we demonstrated the potency of atomic bombs.

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Events may be expected to move so fast that if it is intended to reach an agreement with Russia and other countries such an agreement would have to be complete before the next presidential elections.

IF THE CONTROL IS INTERFERED WITH

While it may be a great step forward to establish a tight control on the atomic power development by a reciprocal agreement with Great Britain and Russia and extend it to all territories of the world, yet we cannot disregard the possibility that one of the major powers, for instance Russia, after a few years - during which the controls may have operated quite successfully - may begin to place difficulties in the way of an effective control of activities conducted in its own territory. It would be quite essential that the people of this country and the world be brought to understand from the start that any difficulties which any nation may place in the way of the established controls would have to be considered as tantamount to a "declaration of war".

Such a "declaration of war" would have the effect that the United States and other countries involved would at once begin to manufacture atomic bombs. If up to that time the control had been effective, it would take ---- to convert the materials and installations involved in the utilization of atomic power to the manufacture of bombs. In such an "armament race" in which all countries would have to start, so to speak, from scratch, the position of the United States might be quite favorable, provided the development of atomic power had been kept up at a high level.

Clearly if any major power deliberately wants to start a war, there will be a war and all that we can hope to achieve by the reciprocal control which we have discussed is that a war may not break out as a result of an armament race.

Still, it would seem that if the situation were generally understood there might be some hope that having succeeded in setting up a system of reciprocal control and having kept it in operation for a few years,

neither the United States nor Great Britain nor Russia would attempt to interfere with this system of control in such a manner that its acts would be considered by the other partners as a menace. We would then perhaps have a chance of living through this century without having our cities destroyed.

An attempt to manufacture atomic bombs undertaken by any of the smaller countries would be of minor importance since it could be met by immediate armed intervention using ordinary methods of warfare such as tanks and airplanes.

IN THE ABSENCE OF A SYSTEM OF CONTROLS

In discussing our postwar situation the greatest attention was given in this memorandum to the role that Russia might play. This was not done because it was assumed that Russia may have aggressive intentions but rather because it was assumed that if an agreement can be reached with Russia, it will be possible to extend the system of controls to every country in the world.

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ATOMIC BOMBS AND THE POSTWAR POSITION OF THE UNITED STATES IN THE WORLD

Spring 1945

The development of the atomic bomb is mostly considered from the point of view of its possible use in the present war and such bombs are likely to be available in time to be used before the war ends. However, their role in the ten years which will follow can be expected to be far more important and it seems that the position of the United States in the world may be adversely affected by their existence. The following might very well turn out to be the future course of events:

Before the end of the war we shall use atomic bombs against Japan. These bombs will be much less powerful than we now know could be made and which in all likelihood will be made within two or three years; yet the first bomb that is detonated over Japan will be spectacular enough to start a race in atomic armaments between us and other nations.

In a few months Russia's war with Germany may be over. The work on uranium will then undoubtedly be given a high priority there but it will perhaps still not be carried out on a large industrial scale until we detonate our first atomic bomb and thus demonstrate the success of this development. For a few years after that we shall almost certainly be ahead of Russia. But even if we assume that we could keep ahead of her in this development all the time, this may neither offer us protection from attack nor necessarily give us substantial advantage in case of war six years from now.

Six years from now Russia may have accumulated enough of some of the active elements which may be used for constructing atomic bombs to make

atomic bombs which are equivalent to 10 million tons of TNT. Two tons of such active elements, if detonated with an efficiency of 30%, or ten tons of such elements, if detonated with an efficiency of 6%, would correspond to 10 million tons of TNT and this quantity would be sufficient to destroy all of our major cities in a single sudden attack.

Quoting the total amount of TNT to which an average atomic bomb corresponds does not give an adequate picture of the scope of action of such a bomb. A small bomb of this type corresponding to 10,000 tons of TNT detonated for instance at a suitable height above a city can be expected to destroy an area within a radius of one kilometer. A number of such bombs properly distributed over a city will make streets within a city completely impassable, may leave few survivors within the affected area, and can lead to toal destruction by fire of the city.

A bomb containing about 200 lbs. of active material and weighing slightly more than a ton would, if detonated with an efficiency of 6%, correspond to 100,000 tons of TNT and destroy an area of about 4 square miles. The same bomb would, if detonated with 30% efficiency, destroy an area of 10 square miles. Clearly, if such bombs are available, it is not necessary to bomb our cities from the air in order to destroy them. All that is necessary is to place a comparatively small number of such bombs in each of our major cities and to detonate them at some later time.

The United States has a very long coast-line which will make it possible to smuggle in such bombs in peacetime and to carry them by truck into our cities. The long coast-line, the structure of our society, and our very heterogeneous population may make an effective control of such "traffic" virtually impossible. One can easily visualize how a "friendly"

power in time of peace may have such bombs placed in all of our major cities under the guidance of agents. This might be done free from aggressive intent. Such a power might know or suspect that we have accumulated a quantity of atomic bombs and that our defenses are so strong that after the outbreak of hostilities it would be difficult to reach our cities by air. In such circumstances it may be exceedingly difficult for its "government" to refuse to take "precautions" which its "army" considers necessary.

Such bombs may remain hidden in cellars of private houses in our cities for any number of years or they may remain hidden below the ground buried in gardens within our cities or buried in fields on the outskirts of our cities. Orginally these bombs may have been planted merely as a routine precaution, but if later a serious international tension should develop there would be a strong temptation to exert pressure on the United States by virtue of the presence of these bombs. In case of war, all of our major cities might vanish within a few hours.

So far it has not been possible to devise any methods which would enable us to detect hidden atomic bombs buried in the ground or otherwise efficiently protected against detection.

If there should be great progress in the development of rockets after this war it is conceivable that it will become possible to drop atomic bombs on the cities of the United States from very great distances by means of rockets.

The weakness of the position of the United States will largely be due to the very high concentration of its manufacturing capacity and of its <u>population</u> in cities. This concentration is so pronounced that the

destruction of the cities may easily mean the end of our ability to resist. Keeping constantly ahead of the Russians in our production of these heavy elements will not restore us to a strong position. No quantity of these "active" materials which we may accumulate will protect us from attack and as far as retaliation is concerned, we might not be able to do more than to destroy the large cities of Russia which are few in number and the economic importance of which is in no way comparable to the economic importance of our own cities. Thus it would appear that we would not gain an overwhelmingly strong position in a war with Russia merely by accumulating an enormous quantity of these elements or by increasing, as we might, the efficiency of our bombs from 6% to a much higher value.

The strong position of the United States in the world in the past thirty years was essentially due to the fact that the United States could out-produce every other country in heavy armaments. It takes a very large number of tanks, airplanes and guns to bring about a decision in a war and as long as tanks, airplanes and guns are the major instruments of war the large production capacity of the United States gives it an advantage which may be considered decisive.

The existence of atomic bombs means the end of the strong position of the United States in this respect. From now on the destructive power which can be accumulated by other countries as well as the United States can easily reach the level at which all the cities of the "enemy" can be destroyed in one single sudden attack. The expenditure in money and material which is necessary to reach this level is so small that any of the major powers can easily afford it provided they adopt "modern" production methods (see below). For us to accumulate active materials in quantities beyond

that necessary to destroy the cities of the "enemy" would probably give some advantage in the war but it is difficult to say whether the importance of such "excess" amounts of material would be really substantial. Out-producing the "enemy" might therefore not necessarily increase our strength greatly.

The greatest danger arising out of a competition between the United States and Russia, which would lead to a rapid accumulation of vast quantities of atomic bombs in both countries, consists in the possibility of the outbreak of a preventive war. Such a war might be the outcome of the fear that the other country might strike first and no amount of good will on the part of both nations might be sufficient to prevent the outbreak of a war if such an explosive situation were allowed to develop.

One of the questions that has to be considered is whether it might be possible to set up some system of controls of the production of these active materials. Such controls would ultimately have to extend to every territory on the earth. Whether it is politically and technically feasible to set up effective controls and what we could do to improve our chances to bring this about are questions that urgently require study and decisions. Some further remarks on these questions are made below, but other considerations might be put forward as soon as the question receives the attention of the government.

The system of controls could be considered successful only if we could count on a period of grace in case the controls were denounced or obstructed by one of the major powers. This means that the system would have to be of such a nature that at least one or two years would lapse

between the time the nations began to convert their installations for the purpose of manufacturing atomic bombs and the time such bombs became available in quantity.

THE FIRST STAGE

Before going further it is necessary to make a few technical remarks:

The present development of the atomic bombs is based on methods which were devised in 1939 and 1940 and which must be considered as the first stage of the atomic power development. These methods are expensive in money and materials and most of them may be considered as out-dated.

This first stage may be defined by saying that it utilizes directly or indirectly only the energy locked up in the rare isotope of uranium. Naturally found uranium contains less than one per cent of this rare isotope. It is doubtful whether the industrial installations based on this first stage will yield more than one ton of active material in the next couple of years which, taken with an efficiency of 6%, would correspond to about a million tons of TNT.

The first stage of this development is at present, so to speak, "in the bag,". While in 1939 and 1940 the possibility of putting this first stage into operation was merely evidenced by the assertions of the physicists, the development has now reached the stage where the successful operation of this stage can be demonstrated, if need be, to skeptical statesmen.

THE SECOND STAGE

The second stage is characterized by the utilization of the abundant isotope (rather than the rare isotope) of uranium and would yield at a low cost vast quantities of the active materials. With respect to this program

we are today in a position similar to that which we occupied with respect to the first stage in 1940.

If conditions were created in which the physicists could work unhampered, it is estimated that it would take two years to have this second stage in the pilot plant phase. Thirty tons of these active materials could be in production by means of these "modern" methods five years from now and the expenditure involved would be a small fraction of the cost which has so far been expended on the development of the now out-dated methods of the first stage.

It would appear highly desirable to set up at once an organization that is capable of taking care of the development of the second stage. But unless this development is coordinated with political action on the part of the United States Government, it will not materially contribute to the safety of the country; in certain unfavorable circumstances it may even be detrimental to the safety of the country.

SYSTEMS OF CONTROL OUGHT TO BE CONSIDERED

From a formal point of view all countries may be considered as potential enemies, but it is perhaps not too optimistic to assume that we may disregard the possibility of a war with Great Britain in the next fifteen years. It appears, however, rather unlikely that jointly with Great Britain we could police the world and thus prevent by force the manufacture of all of the "active materials" anywhere in the world including Russia.

It might perhaps be possible to set up jointly with Great Britain and Russia some sort of joint control of the manufacture of the active materials everywhere in the world if we could get Russia to agree to such a control

which of necessity would have to extend to her territory. The purpose of such a control would be to prevent the active elements from becoming available in a form in which they could be used for the manufacture of atomic bombs. This does not necessarily mean that the development of atomic power is suppressed but only that the elements involved must not be prepared in certain forms and degree of purity.

This point raises the following question: What forms of atomic power can we permit to be organised if we want to make sure that the available materials and facilities cannot easily be converted for the manufacture of atomic bombs? Some thought has already been given to this question with the following result:

There are two types of active materials. Materials of the first type can be diluted by the abundant isotope of uranium in such a way as to rule out the possibility of using them for atomic bombs while leaving unimpaired the usefulness of the materials for industrial purposes. A chemical separation from the diluting material would be impossible and a conversion into materials which can be used for atomic bombs would take one or two years.

Material of the second type which can be used for atomic bombs can be "denatured" by adding a substance which cannot be separated chemically from it and which will make it impossible to detonate by straightforward methods bombs which one may attempt to make from such mixtures. Whether more elaborate methods can be worked out which will permit the detonation of the denatured material is a question which would have to carefully scrutinized. These lines merely serve to indicate that there might perhaps be a satisfactory solution to the problem of reconciling the requirements of safety of the United States with the desire not to hamper the development of atomic power for industrial purposes.

Unfortunately it is by no means sure that a satisfactory solution of this problem is in fact possible. It would be much easier, safer, and would require a much less tight control to arrest the development of atomic power by scrapping and outlawing the large and easily visible installations which characterize the first stage of this development.

CONTROL OF RAW MATERIALS COULD BE CONSIDERED

If Russia, the United States and other countries were willing to forego the use of atomic power for peacetime purposes one could have a system of control that would be farily simple since it would be sufficient essentially to control the movements of raw materials. Ores of uranium would have to be mined under control and transported to some "neutral" territory. Whether or not it would be permitted to have in a neutral territory installations belonging to the first stage and atomic power plants would be a question of minor importance. It is likely that if the major powers were willing to forego the use of atomic power it would seem that a system of controls could be set up without encountering too great difficulties.

AN ALTERNATIVE SYSTEM OF CONTROLS WOULD HAVE TO BE MUCH TIGHTER

On the other hand, if the United States, Russia, and other countries should have atomic power installations within their own territory, a very tight system of control would be needed in order to make sure that the United States would not have to face a sudden attack by atomic bombs. For a control of this sort to be effective, it would be necessary that our agents and the agents of Great Britain move freely around in Russia, be permitted to keep contacts with Russian civilians, secretly employ Russian civilians for the purpose of obtaining information, and have entry into every factory or shop throughout the vast territory of Russia.

That there may be dangerous loopholes in control systems which might be set up is illustrated by events that took place in Germany after the first World War. At that time there were many Germans who were willing to give

information to the Inter-Allied Commission about violations of the control regulations, but those who actually did so were publicly tried under the German Espionage Law and were given heavy sentences. The Treaty of Versailles did not stipulate that the German Espionage Law must be revoked.

Clearly, it would be desirable to create a situation which would permit us to appeal in various ways to physicists and engineers everywhere for information that would uncover violations of the controls. This would give us additional assurance that such violations would be detected but it presupposes that we succeed in creating conditions that would enable us to guarantee the personal safety of those who volunteer such information and the safety of their families.

Since Russia cannot be expected to agree to such a control unless she obtain the same rights of control in the United States and Great Britain the question whether Congress and the people of the United States are willing to agree to such a control might become of paramount importance.

HOW COULD RUSSIA BEST BE PERSUADED?

As to our chances of persuading the Russians to accept mutual control, much may depend on the proper timing of our approach to Russia. It would appear that such an approach would have to be made immediately after we demonstrate the potency of atomic bombs.

Such a demonstration may take place in the course of the war. However, the psychological advantages of avoiding the use of atomic bombs against Japan and, instead, of staging a demonstration of the atomic bomb at a time which appears most appropriate from the point of view of its effect on the governments concerned might be very great. Therefore this possibility

seems to deserve serious consideration in deciding whether or not to use such a bomb against Japan. If at the time when we demonstrate the atomic bomb to the world we had the second stage of the atomic power development "in the bag", chances of obtaining the consent of Russia to some satisfactory system of controls might be considerably improved. At that time, Russian physicists would probably be quite uncertain as to whether or not they could catch up with us in this development. As far as the first stage is concerned, they may be expected to have a full appreciation of its scope and to be fairly confident that they can duplicate in a fairly short time what we have accomplished so far. Their knowledge of atomic constants, however, is in all probability too inaccurate to enable them to appraise whether or not they can utilize the abundant isotope of uranium or to estimate how long it would take them and how much it would cost. As long as the Russian physicists remain uncertain about this point there might be considerable willingness on the part of the Russian government to set up jointly with us and Great Britain a really effective control of this field. Whether or not we have by that time actually accumulated ten or twenty tons of the active substances appears to be of secondary importance as long as we can demonstrate that we have in manufacture quantities which cannot be derived from the first stage of development with which the Russians may be familiar.

Events may be expected to move so fast that if it is intended to reach an agreement with Russia and other countries such an agreement would have to be complete before the next presidential elections. Thus we have to conclude that if the second stage is to be developed for the purpose of

enabling the Administration to obtain Russian cooperation in the proposed joint control, we have no time to lose in attacking the problems connected with the second stage of the development.

IF THE CONTROL IS INTERFERED WITH

While it may be a great step forward to establish a tight control on the atomic power development by a reciprocal agreement with Great Britain and Russia and extend it to all territories of the world, yet we cannot disregard the possibility that one of the major powers, for instance Russia, after a few years--during which the controls may have operated quite successfully--may begin to place difficulties in the way of an effective control of activities conducted in its own territory. Clearly it would be quite essential that the people of this country and the world be brought to understand from the start that any difficulties which any nation may place in the way of the established controls would have to be considered as tantamount to a "declaration of war".

Such a "declaration of war" would have the effect that the United States and other countries involved would at once begin to manufacture atomic bombs. If up to that time the control had been effective, it would take about two years to convert the materials and installations involved in the utilization of atomic power to the manufacture of bombs. In such an "armament race" in which all countries would have to start, so to speak, from scratch, the position of the United States might be quite favorable, provided the development of atomic power had been kept up at high level.

Clearly if any major power deliberately wants to start a war, there will be a war and all that we can hope to achieve by the reciprocal control

which we have discussed is that a war may not break out as a result of an armament race.

Still, it would seem that if the situation were generally understood there might be some hope that having succeeded in setting up a system of reciprocal control and having kept it in operation for a few years, neither the United States nor Great Britain nor Russia would attempt to interfere with this system of control in such a manner that its acts would be considered by the other partners as a menace to their security. We would then perhaps have a chance of living through this century without having our cities destroyed.

An attempt to manufacture atomic bombs undertaken by any of the smaller countries would, be of minor importance since it could be met by immediate armed intervention using ordinary methods of warfare such as tanks and airplanes.

IN THE ABSENCE OF A SYSTEM OF CONTROLS

In discussing our postwar situation the greatest attention was given in this memorandum to the role that Russia might play. This was not done because it was assumed that Russia may have aggressive intentions but rather because it was assumed that if an agreement can be reached with Russia it will be possible to extend the system of controls to every country in the world.

In the absence of a system of controls, however, a number of countries might, say, ten years from now, be in possession of large quantities of atomic bombs and represent a threat to the cities of the United States.

What policies could be adopted to safeguard the security of the United States in the absence of a reliable system of controls requires

serious consideration particularly since our chances of creating a satisfactory system of controls may be rather small. The situation will probably have some effect on city planning.

In discussing this question one will have to consider a number of possibilities which go far beyond the narrower question of whether or not the second stage of the atomic power development ought to be vigorously pursued, and the discussion of those possibilities goes beyond the scope of the present memorandum. As far as this narrower question is concerned the following remark might, however, be made.

One might consider the advisability of discontinuing now the work on detonating active substances and of immediately scrapping now all installations for the manufacture of active materials. In view of the fact that the Germans have not pushed this development, the scrapping of our own installations coupled with an agreement with Russia and Great Britain which would outlaw the building of such installations might perhaps enhance the security of the United States in the next 25 years. In order to understand this point of view one has to realize that it is necessary to develop the first stage of atomic power before the second stage can be entered upon and that the installations belonging to the first stage are of necessity large and conspicuous structures; consequently it does not require a tight control to detect any structures of this type which might be erected in violation of the law.

Conversely, it might be proposed that we should lose no time in developing the second stage of atomic power and that we should develop within a few years methods for manufacturing overwhelming quantities of the active materials.

While it may be difficult to decide between these two points of view, the present trend to develop atomic bombs and to maintain our installations for the manufacture of active materials but to delay in developing the second stage would appear to lead to the worst possible course of action that we could take.

ATOMIC BOMBS AND THE POSTWAR POSITION OF THE UNITED STATES IN THE WORLD

April 15, 1945

The development of the atomic bomb is nowadays mostly considered from the point of view of its possible use in the present war and some such bombs may still be available in time to be used before the war ends. However, their role in the ten years which will follow can be expected to be far more important and it seems that the position of the United States in the world may be adversely affected by the existence of such bombs. The following might very well turn out to be the future course of events:

Before the end of the war we might use atomic bombs against Japan. These bombs will be much less powerful than we now know could be made and which in all likelihood will be made within two or three years; yet the first bomb that is detonated over Japan will be spectacular enough to start a race in atomic armaments between us and other nations.

In a few months Russia's war with Germany may be over. The work on uranium will then undoubtedly be given a high priority there but it will perhaps still not be carried out on a large industrial scale until we detonate our first atomic bomb and thus demonstrate the success of this development. For a few years after that we shall almost certainly be ahead of Russia. But even if we assume that we could keep ahead of them in this development all the time, this may neither offer us protection from attack nor necessarily give us substantial advantage in case of war six years from now.

Six years from now Russia may have accumulated enough of some of the active elements which may be used for constructing atomic bombs to make atomic

bombs which are equivalent to 10 million tons of TNT. Two tons of such active elements, if detonated with an efficiency of 30%, or ten tons of such elements, if detonated with an efficiency of 6%, would correspond to 10 million tons of TNT and this quantity would be sufficient to destroy all of our major cities in a single sudden attack.

Quoting the total amount of TNT to which an average atomic bomb corresponds does not give an adequate picture of the scope of action of such a bomb. A small bomb of this type corresponding to 10,000 tons of TNT detonated for instance at a suitable height above a city can be expected to destroy an area within a radius of one kilometer. A number of such bombs properly distributed over a city will make streets within a city completely impassable, may leave few survivors within the affected area, and can lead to total destruction by fire of the city.

A bomb containing about 100 kg of active material and weighing slightly more than a ton would, if detonated with an efficiency of 6%, correspond to 100,000 tons of TNT and destroy an area of about 15 square kilometers. The same bomb would, if detonated with 30% efficiency, destroy an area of 45 square kilometers. Clearly, if such bombs are available, it is not necessary to bomb our cities from the air in order to destroy them. All that is necessary is to place a small number of such bombs in one of our cities and to detonate them at some later time.

The United States has a very long coast-line which will make it possible to smuggle in such bombs in peacetime and to carry them by truck into our cities. The long coast-line, the structure of our society, and our very heterogeneous population may make an effective control of such "traffic"

virtually impossible. One can easily visualize how a "friendly" power in time of peace may have such bombs placed in all of our major cities under the guidance of agents. This might be done free from aggressive intent. They might know or think that we have accumulated a quantity of atomic bombs and that our defenses are so strong that after the outbreak of hostilities it would be difficult for them to reach our cities by air. In such circumstances it may be exceedingly difficult for their "government" to refuse to do what their "army" considers a necessary precaution.

Such bombs may remain hidden in cellars of private houses in our cities for any number of years or they may remain hidden below the ground buried in gardens within our cities or buried in fields on the outskirts of our cities. Originally these bombs may have been planted merely as a routine precaution, but if later on a serious international tension should develop there will be a strong temptation to exert pressure on the United States by virtue of the presence of these bombs. In case of war, all of our major cities might vanish within a few hours.

So far it has not been possible to devise any methods which would enable us to detect hidden atomic bombs buried in the ground or otherwise efficiently protected against detection.

If there should be great progress in the development of rockets after this war it is conceivable that it will become possible to drop atomic bombs on the cities of the United States across very great distances by means of rockets.

The weakness of the position of the United States will largely be due to the very high concentration of its manufacturing capacity and of its population in cities. This concentration is so pronounced that the destruc

tion of the cities may easily mean the end of our capacity of resistance. Keeping constantly ahead of the Russians in our production of these heavy elements will not restore us to a strong position. No quantity of these "active" materials which we may accumulate will protect us from attack and as far as retaliation is concerned, we might not be able to do more than to destroy the large cities of Russia which are few in number and the economic importance of which is in no way comparable to the economic importance of our own cities. Thus it would appear that we would not gain an overwhelmingly strong position in a war with Russia merely by accumulating an enormous quantity of these elements or by increasing, as we might, the efficiency of our bombs from 6% to a much higher value.

The strong position of the United States in the world in the past thirty years was essentially due to the fact that the United States could out-produce every other country in heavy armaments. It takes a very large number of tanks, airplanes and guns to bring about a decision in a war and as long as tanks, airplanes and guns are the major instruments of war the large production capacity of the United States gives it an advantage which may be considered decisive.

The existence of atomic bombs means the end of the strong position of the United States in this respect. From now on the destructive power which can be accumulated by other countries as well as the United States can easily reach the level at which all the cities of the "enemy" can be destroyed in one single sudden attack. The expenditure in money and material which is necessary to reach this level is so low that any of the major powers can easily afford it provided that they adopt "modern" production methods (see later). To accumulate active materials in quantities beyond that necessary

to destroy the cities of the "enemy" to to out-produce the "enemy" will probably give some advantage in case of war but the advantage of additional amounts of active material is comparatively low.

The greatest danger arising out of a competition between the United States and Russia, which would lead to a rapid accumulation of vast quantities of atomic bombs in both countries, consists in the possibility of the outbreak of a preventive war. Such a war might be the outcome of the fear that the other country might strike first and no amount of good will on the part of both nations might be sufficient to prevent the outbreak of a war if such an explosive situation were allowed to develop.

One of the questions that has to be considered is whether it might be possible to set up some system of controls of the production of these active materials. Such controls would ultimately have to extend to every territory on the earth. Whether it is politically and technically feasible to set up effective controls and what we could do to improve our chances to bring this about are questions that urgently require study and decisions. Some remarks on these questions are made further below, but other considerations might be put forward as soon as the question will be considered by responsible persons.

The system of controls could be considered successful only if we could count on a period of grace in case the controls were denounced or obstructed by one of the major powers. This means that the system would have to be of such nature that at least one or two years would elapse between the time when nations begin to convert their installations for the purpose of manufacturing atomic bombs and the time such bombs would become available in quantity.

THE FIRST STAGE

Before going further it is necessary to make a few technical remarks:

The present development of the atomic bombs is based on methods which were devised in 1939 and 1940 and which must be considered as the first stage of the atomic power development. These methods are expensive in money and materials and most of them may be considered as out-dated.

This first stage may be defined by saying that it utilizes directly or indirectly only the energy locked up in the rare isotope of uranium. Naturally found uranium contains less than one per cent of this rare isotope. It is doubtful whether the industrial installations based on this first stage will yield more than one ton of active material in the next couple of years which, taken with an efficiency of 6%, would correspond to about a million tons of TNT.

The first stage of this development is at present, so to speak, "in the bag,". While in 1939 and 1940 the possibility of putting this first stage into operation was merely evidenced by the assertions of the physicists, the development has now reached the stage where the successful operation of this stage can be demonstrated, if need be, to skeptical statesmen.

THE SECOND STAGE

The second stage is characterized by the utilization of the abundant isotope (rather than the rare isotope) of uranium and would yield at a low cost vast quantities of the active materials. With respect to this program we are today in a position similar to that which faced us with respect to the first stage in 1940.

If conditions were created in which the physicists can work unhampered,

it is estimated that it would take two years to have this second stage in the pilot plant phase. Thirty tons of these active materials could be in production by means of these "modern" methods five years from now and the expenditure involved would be a small fraction of the cost which has so far been expended on the development of the now out-dated methods of the first stage.

It would appear highly desirable to set up at once an organization that is capable of taking care of the development of the second stage. But unless this development is coordinated with political action on the part of the United States Government, it will not materially contribute to the safety of the country; in certain unfavorable circumstances it may even be detrimental to the safety of the country.

SYSTEMS OF CONTROL OUGHT TO BE CONSIDERED

From a formal point of view all countries may be considered as potential enemies, but it is perhaps not too optimistic to assume that we may disregard the possibility of a war with Great Britain in the next fifteen years. It appears, however, rather unlikely that jointly with Great Britain we could police the world and thus prevent by force the manufacture of all of the "active materials" anywhere in the world including Russia.

It might perhaps be possible to set up jointly with Great Britain and Russia some sort of a joint control of the manufacture of the active materials everywhere in the world if we could get Russia to agree to such a control which of necessity would have to extend to their territory. The purpose of such a control would be to prevent the active elements from becoming available in a form in which they could be used for the manufacture of atomic bombs. This does not necessarily mean that the development of atomic power is suppressed but only that the elements involved must not be prepared in certain forms and degree of purity.

This point raises the following: What forms of atomic power can be permitted to be practised if we want to make sure that the available materials and facilities cannot easily be converted for the manufacture of atomic bombs? Some thought has already been given to this question with the following result:

There are two types of active materials. Materials of the first type can be diluted by the abundant isotope of uranium in such a way as to rule out the possibility of using it for atomic bombs while leaving unimparied the usefulness of the material for industrial purposes. A chemical separation from the diluted material would be impossible and a conversion into materials which can be used for atomic bombs would take one or two years.

Materials of the second type which can be used for atomic bombs can be "denatured" by adding a substance which cannot be separated chemically from it and which will make it impossible to detonate a bomb made from it by simple methods. Whether more elaborate methods can be worked out which will permit the detonation of the denatured material is a question which would have to be carefully scrutinized. These lines merely serve to indicate that there might perhaps be a satisfactory solution to the problem of reconciling the requirements of safety of the United States with the desire not to hamper the development of atomic power for industrial purposes.

Unfortunately it is by no means sure that a satisfactory solution of this problem is in fact possible. It would be much easier, safer, and would require a much less tight control to arrest the development of atomic power by scrapping and outlawing the large and easily visible installations which characterize the first stage of this development.

CONTROL OF RAW MATERIALS COULD BE CONSIDERED

If Russia, the United States and other countries were willing to forego the use of atomic power for peacetime purposes one could have a system of control that would be fairly simple since it would be sufficient to control the movements of raw materials. Ores of uranium would have to be mined under control and transported to some "neutral" territory. Whether or not it would be permitted to have installations belonging to the first stage and atomic power plants in that neutral territory would be a question of minor importance. In any case, if the major powers forego the use of atomic power it would seem that a system of controls could be set up without encountering insurmountable difficulties.

AN ALTERNATIVE SYSTEM OF CONTROLS WOULD HAVE TO BE MUCH TIGHTER

On the other hand, if the United States, Russia, and other countries have atomic power installations within their own territory, a very tight system of control would be needed in order to make sure that the United States doesnot have to face a sudden attack by atomic bombs. For a control of this sort to be effective, it would be necessary that our agents and the agents of Great Britain move freely around in Russia, are permitted to keep contacts with Russian civilians, secretly employ Russian civilians for the purpose of obtaining information and have entry into every factory or shop throughout the vast territory of Russia.

That there may be dangerous loopholes in control systems that might be set up is illustrated by events that took place in Germany after the first World War. At that time there were many Germans who were willing to give information to the Inter-Allied Committee about violations of the control

regulations, but those who actually did so were publicly tried under the German Espionage Law and were given heavy sentences. The Treaty of Versailles did not stipulate that the German Espionage Law must be revoked.

Clearly, it would be desirable to create a situation in which, by offering large rewards to physicists and engineers for information leading to the detection of violations of the controls, we could obtain an assurance that violations of the controls will be detected and means would have to be found to guarantee the personal safety of those who volunteer such information, and the safety of their families.

Since Russia cannot be expected to agree to such a control unless they obtain the same rights of control in the United States and Great Britain the question whether Congress and the people of the United States are willing to agree to such a control may become of paramount importance.

HOW COULD RUSSIA BEST BE PERSUADED?

As to our chances of persuading the Russians to accept mutual control, much may depend on the proper timing of our approach to Russia. It would appear that such an approach would have to be made immediately after we demonstrate the potency of atomic bombs.

Such a demonstration may take place in the course of the war. However, the psychological advantages of avoiding the use of atomic bombs against Japan and rather to stage a demonstration of the atomic bombs at a time which appears most appropriate from the point of view of its effect on the governments concerned would be very great. Therefore this possibility seems to deserve serious consideration in deciding whether or not to use such a bomb against Japan.

If at the time we demonstrate the atomic bomb to the world we could have the second stage of the atomic power development "in the bag," our position with respect to Russia would be rather advantageous from the point of view of successful negotiation. Russian physicists would probably be quite uncertain whether or not they could catch up with us in this development.

As far as the first stage is concerned, the Russian physicists may be expected to have a full appreciation of its scope and to be fairly confident that they can duplicate in a very short time what we have done. Their knowledge of atomic constants, however, is at present not sufficiently accurate to enable them to appraise whether or not they can utilize the abundant isotope of uranium or to estimate how long it would take them and how much it would cost. As long as the Russian physicists remain uncertain about this point there might be considerable willingness on the part of the Russian government to set up jointly with us and Great Britain a really effective control of this field. Whether or not we have by that time actually accumulated ten or twenty tons of the active substances appears to be of secondary importance as long as we can in fact demonstrate that we have in manufacture quantities which cannot be derived from the first stage of development with which the Russians may be familiar.

Events may be expected to move so fast that if it is intended to reach an agreement with Russia and other countries such an agreement would have to be complete before the next presidential elections. Thus we have to conclude that if the second stage is to be developed for the purpose of enabling the Administration to obtain Russian cooperation to the proposed mutual control, we have no time to lose in attacking the problems connected with the second stage of the development.

IF THE CONTROL IS INTERFERED WITH

While it may be a great step forward to establish a tight control on the atomic power development by a mutual agreement with Great Britain and Russia and extend it to all territories of the world, yet we cannot disregard the possibility that one of the major powers, for instance Russia, after a few years during which the controls may have operated quite successfully, may begin to place difficulties in the way of an effective control of activities conducted in its own territory. Clearly it would be quite essential that the people of this country and the world be brought to understand from the start that any difficulties which any nation may place in the way of the established controls would have to be considered as tantamount to a "declaration of war".

Such a "declaration of war" would have the effect that the United States and other countries involved would at once begin to manufacture atomic bombs. If up to that time the control had been effective, it would take about two years to convert the materials and installations involved in the utilization of atomic power to the manufacture of bombs. In such an "armament race" in which all countries would have to start, so to speak, from scratch, the position of the United States might be quite favorable, provided the development of atomic power had been kept up at a high level.

Clearly if any major power deliberately wants to start a war, there will be a war and all that we can hope to achieve by the mutual control which we have discussed is that a war may not break out as a result of an armament race.

Still, it would seem that if the situation were generally understood there might be some hope that having succeeded in setting up a system of mutual control and having kept it in operation for a few years, neither the

United States nor Great Britain nor Russia would attempt to interfere with this system of control in such a manner that its acts should be considered by the other partners as a menace to their security. We would then have a fair chance of living through this century without having our cities destroyed.

An attempt to manufacture atomic bombs undertaken by any of the smaller countries would, of course, be of minor importance since it could be met by immediate armed intervention using ordinary methods of warfare such as tanks and airplanes.

IN THE ABSENCE OF A SYSTEM OF CONTROLS

In discussing our postwar situation the greatest attention was given in this memorandum to the role that Russia might play. This was not done because it was assumed that Russia may have aggressive intentions but rather because it was assumed that if an agreement can be reached with Russia it will be possible to extend the system of controls agreed upon to every country in the world.

In the absence of a system of controls, however, a number of countries might, ten years from now, be in the possession of large quantities of atomic bombs and represent a threat to the cities of the United States.

What policies could be adopted to safeguard the security of the United States in the absence of a reliable system of controls requires serious consideration particularly since our chances of creating a satisfactory system of controls may be rather small. The situation will probably not be without profound effect on city planning.

In discussing this question one will have to consider a number of possibilities which go far beyond the narrower question whether or not the second stage of the atomic power development ought to be vigorously pursued

and their discussion goes beyond the scope of the present memorandum. As far as this narrower question is concerned the following remark might, however, be made.

One might consider the advisability of discontinuing now the work on detonating active substances and of immediately scrapping now all installations for the manufacture of active materials. In view of the fact that the Germans have not pushed this development, the scrapping of our own installations coupled with an agreement with Russia and Great Britain which would outlaw the building of such installations might safeguard the security of the United States in the next 25 years. In order to understand this point of view one has to realize that it is necessary to develop the first stage of atomic power before the second stage can be entered upon and that the installations belonging to the first stage are of necessity large and conspicuous structures; consequently it does not require a tight control to detect any structures of this type which might be erected in violation of the law.

Conversely, it might be proposed that we should lose no time in developing the second stage of atomic power field and that we should develop within a few years methods for manufacturing overwhelming quantities of the active materials.

While it may be difficult to decide between these two points of view, the tendency to develop atomic bombs and to maintain our installations for the manufacture of active materials but to delay in developing the second stage would appear to lead to the worst possible course of action that we could take.