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## GENERAL CONSIDERATIONS CONCERNING THE ATOMIC BOMB

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by  
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Our discussion in the next two days would perhaps be less confused than it might otherwise be if we could agree today on a set of assumptions to serve as a basis of discussion. Unfortunately, these assumptions cannot be derived from established facts. They have to be derived from a mixture of facts and guesses and I am afraid that the guesses will predominate in the mixture.

Let us, for instance, consider the question of the destructive power of a single bomb. According to newspaper reports, the bomb detonated over Hiroshima destroyed by its blast four square miles; that is, four square miles was the area of total destruction. The bomb detonated over Nagasaki was considerably more powerful and would have destroyed a larger area if it had been detonated over Hiroshima. It is certain that the radius of action of the bomb will increase as time goes on, but it is not certain that this increase will be very important within the next ten years.

In order to see what this question involves we have to remember that as far as the destructive action of the blast goes, the radius of action of a bomb increases only with the third root of the charge which is detonated. Consider, for instance, a quantity of about 10,000 tons of TNT which will destroy, if detonated, buildings within a radius of about one mile. If we

then wish to increase this radius from one mile to ten miles, we would have to increase the amount of TNT by a factor of one thousand, that is, we would have to use an atomic bomb corresponding to 10 million tons of TNT.

It appears likely, therefore, that it will take further inventions before we can have atomic bombs that have a radius of action of ten miles. It is by no means certain that the physicists will actually make these inventions in the next few years. On the other hand, if one of you were to ask me for a positive assurance that ten years from now the radius of action of atomic bombs will not reach ten miles, I would have to decline-- with regret.

We are, however, in a position to assess the danger which faces this country without making any assumptions about the further development of atomic bombs. There is no reason why another country, for instance, Russia, should not have, six years from now, a large number of bombs of the type which we used at Nagasaki. Unless we arrive at some workable arrangement with Russia rather soon, it is more likely than not that she will have, six years from now, a quantity of such bombs corresponding to 10 million tons of TNT. This quantity, I believe, would be sufficient to destroy all of our major cities.

I ought to pause here for a moment in order to say the following: If Russia is singled out by me in this discussion, I do this because it appears likely that if an arrangement were worked out between Russia and the United States it would be fairly easy to extend the arrangement to all other countries.

The first question that we have to examine then is this: Do the Russians know enough to start manufacturing those two active elements which form the basic materials of atomic bombs? Those of you who read the official release of the War Department, namely the Smyth Report, saw that we instructed clearly all those who can read along what road they have to travel in order to reach the goal. It is now possible for other countries to carry out the development in an organized manner and any group which travels along the road which we have pointed out will find, step by step, what we have found and get the results which we have obtained.

By releasing the Smyth report we have given the other countries essentially as much knowledge as we possessed ourselves in the late fall of 1942. Since it took us from then two and one-half years until we had the first atomic bomb, we may say this: If knowledge were the only limiting factor, the Russians could have an atomic bomb two and one-half years from now.

I do not wish to give the impression, however, that we have given away all of our secrets. We still have retained what we may rightly consider important secrets. These secrets which we have kept are, however, of interest only in connection with the work which may take place from here on. They have practically no bearing on the manufacture of the atomic bombs which are at present available.

Coming back to the question of Russia, clearly, knowledge is not the only limiting factor. Another possible limitation may be due to the scarcity of uranium ores in Russia. The only important deposits within easy reach of Russia which are known to us are the Czechoslovakian deposits. Those deposits

yielded 20 tons of uranium oxide per year before the war. They might yield 40 tons of uranium oxide per year if worked under strained conditions. It is my understanding that the total deposits in Czechoslovakia may not be very significant. It seems to me, however, that it would be foolhardy to assume that in the vast territory which is within the grasp of Russia in Europe and in Asia, no significant uranium deposits will be found, once prospecting gets under way with such an extraordinarily high premium on finding uranium.

Still another factor which might slow down the work in Russia might be the lack of technically trained personnel. In the United States this work was carried out with the help of a very large staff of scientists and engineers, but it would be misleading to consider this as a standard by which to gauge the staff which Russia may need for carrying out her development. Many of those who were engaged in this work sometimes wondered whether the work would not have progressed faster if it had been carried out by a smaller staff. But however that may be, we certainly must not take the amount of \$2 billion which we have spent as a measure of the industrial effort which another country would have to make in order to bring about large scale production of atomic bombs. Another country would pick out from among all the processes which we *have* tried the one which proved to be the most successful. Also, some other countries could operate in a much more economical manner than it was possible to operate in this country under cost contracts in a field where large chemical firms had virtual monopoly.

On the strength of these considerations I propose that as a basis of

our discussion we assume the following: It is more likely than not that Russia can have, six years from now, enough atomic bombs to be able to destroy all of our major cities if she so desires.

Perhaps the greatest danger which faces the world at present is the outbreak of a war which would arise more or less automatically out of an armament race in which Russia and the United States would be building up stockpiles of atomic bombs.

It is proposed to consider tomorrow in detail two rather closely related types of alternative arrangements by means of which such an armament race could be avoided. With your permission I shall again assume that if we succeeded in setting up such an arrangement with Russia it would be easy to extend it to other countries. For this reason I shall not mention any other country but Russia.

I am speaking now of arrangements which could be and ought to be set up immediately. To consider these arrangements in detail appears therefore particularly urgent.

For purposes of discussion, I propose that we distinguish between two alternative arrangements. In either case stockpiles of atomic bombs would be outlawed both within the territory of the United States and within the territory of Russia.

In case of the first alternative there would be no industrial installations for the manufacture of active materials permitted within the territories of sovereign states. This restriction might severely limit, or would perhaps

completely suppress, the development of atomic power. Those who are in favor of these restrictions believe that if we accepted these restrictions then at the price of a close supervision of mining activities we could convince ourselves that there was in fact no manufacture of atomic bombs going on in the inspected territory.

The second alternative would permit industrial installations for the manufacture of active materials and also atomic power plants within the territory of sovereign states but it would not permit the manufacture of atomic bombs. In this case it would be necessary to have a rather tight system of inspection and also other related arrangements, which would cut more deeply into the sovereignty of individual nations than mere inspection of mining activities. I personally prefer this second alternative to the first.

We cannot hope to achieve more by means of any such arrangements than to make certain that no atomic bombs will be available for instant use and that violations of these arrangements will become instantly visible and known throughout the world. Such arrangements could prevent the outbreak of a war arising out of an armament race, but they cannot prevent Russia or any other major power from deliberately starting an armament race by revoking or by sabotaging the agreement which provides for inspection. I personally believe that if we succeeded in establishing a satisfactory arrangement providing for inspection in the near future, that after the arrangement had operated satisfactorily for a number of years the chances for keeping the arrangement in force would be fairly good, since neither Russia nor any other major power would want to abrogate it unless they were deliberately out for

starting a war.

Nevertheless it is necessary for us to try to give an answer to the following question: If Russia suddenly revoked an arrangement which provided for inspection, how long would it take for her to have atomic bombs available in quantity?

In order to answer this question we have to make guesses and these are the guesses which I propose to you as a basis of discussion. If there are the guesses which I propose to you as a basis of discussion. If there are no industrial installations for the manufacture of active materials within the territory of Russia, but if Russia has available a large crew of trained scientists and engineers who have full knowledge of the methods of manufacture which could be used, it will take Russia probably two to three years to have as much as 10 million tons of TNT in the form of atomic bombs.

If, on the other hand, industrial installations for the manufacture of active materials and atomic power plants are going full blast in Russia with certain restrictions of a technical nature which I am not free to explain at the present time, then a conversion of these active materials into forms which can be used for the manufacture of atomic bombs might take anywhere from six months to a year and it is more likely than not that within one year Russia could have atomic bombs corresponding to 10 million tons of TNT.

We are living in a world in which there are no generally accepted principles of justice upon which to base a solution of inter-national conflicts. From time to time there are conflicts which have to be settled by the so-called "method of negotiations." Sooner or later such negotiations might lead to strained relations with Russia. If Russia were then to abrogate the existing arrangement providing for mutual inspection, within six months

or two years our cities would be threatened with annihilation. Thirty million people live in this country in cities of over 250,000, and 60 to 70 million people living in metropolitan areas. This vulnerability of the United States represents a temptation to other countries and to remove this temptation would appear advisable.

If it were possible to relocate, on the basis of a ten-year plan, 30 to 70 million people at a cost not exceeding \$20 billion per year, we ought to do so, since it would very considerably decrease the danger to our cities. A cost of \$15 to \$20 billion would be a burden that our economy could very well bear and there need not be more than perhaps a small decrease in the standard of living during the transition period. Perhaps it would be possible to build cities in shapes which are less vulnerable to atomic bombs than our present cities. One might think of cities one mile wide and 50 miles long with a built up area of 50 square miles. Using some such shape we could still have cities between 100,000 and 500,000, so that we need not forego the advantages of urban life and could have, on the whole, better living conditions than ever before.

It is necessary, however, for a scientist to warn against the belief that the relocation of the population can in the long run save us from extermination in a modern war. I have indicated earlier that the development of atomic bombs might catch up with measures taken for the dispersal of the population since it is quite possible that further work will lead to atomic bombs which will destroy everything with a radius of action of ten miles. But atomic bombs are by no means the only serious threat that we have to face.

Thinking along the lines of biochemical and biological warfare has barely started. Thinking along these lines was slow in getting under way and this slowness was due--I personally believe--to the moral inhibitions which were still strong ten or twenty years ago. The experience of this war, however, shows that these moral inhibitions can no longer be counted upon and the way is open now for finding new methods of extermination against which the dispersal of cities will provide no defense.

Some 15 years ago I happened to ask Dr. Langmuir whether he thought that mankind might perish in a major war. He replied that seeing how difficult it was to get rid of insect pests there was hope for the survival of man. This was the most reassuring argument that I have ever heard, but today, after the discovery of DDT, the argument is no longer valid.

Considering all these things on a time scale extending over more than one generation, we are led to say that we shall not be able to have peace at a lesser cost than at the cost of a world Government. Since we obviously cannot have world government just by asking for it, we ought to examine the question whether world government could perhaps be created step by step within a fixed time interval of perhaps 20 to 30 years. It is my understanding that there will be an opportunity to discuss such questions on Friday and that it is not proposed to discuss them this afternoon

I have omitted mentioning two points which I hope will both be covered in the discussion today. One is the difficulty of defense against atomic bombs--I mean, defense in the narrow military sense of the word. The other

point is the following: This country enjoyed in the past a unique position due to the fact that its industrial capacity made it possible for her to out-produce in tanks, guns, and airplanes every other country or combination of countries in the world. This unique position might now be gone due to the fact that atomic bombs are primarily a weapon against cities and once we have enough of them to destroy all cities of the enemy, the value of additional bombs may be rather small. Outproducing other countries in the sense of building enormous stockpiles of atomic bombs may therefore not help the United States to recover her former favorable position.