Spokane

ATOMIC ENERGY, A SOURCE OF POWER OR A SOURCE OF TROUBLE

During the war we gave very little attention to the peace-time applications of atomic energy. Mostly we were concerned with its applications for the manufacture of plutonium and for the detonation of the bomb. The transition from war to peace is not easy to make. Many months after the end of the war one of my colleagues remarked to me that we are probably making a mistake by not giving enough thought to the peace-time applications of atomic energy, and when I asked him what particular peace-time application he had in mind, he said he was thinking of the use of atomic energy as a source of power for the driving of warships.

During the months in which the Atomic Energy Committee of the United States Senate held its hearings on the problem of atomic energy, they heard many ~~distinguished~~ scientists and many distinguished men from other walks of life. They all talked about the significance of the bomb. They did not talk about peace-time applications. By the time my turn came to testify before the Committee, eight other men had been heard and none of them spoke of peace-time applications. I, too, shared the feeling of these men that within the next decades the atomic bomb might easily overshadow the peace-time applications of atomic energy, as well as it may overshadow many other things in life; but somehow it offended my sense of proportions that none of those who spoke before me as much as mentioned the significance of atomic energy for the production of electrical power.

None of us who worked in this field during the war feel really free or are in a mood to say anything much about this particular subject at the present time. But while we do not feel free to say all that we know, there is no reason why we should hesitate to quote what has already been said in public. And so today on the subject of the use of atomic energy for the production of electrical power, I feel at least free to quote to you what I myself have said publicly on this subject at the Senate hearings.

There are two substances which you may consider as the key to the peace-time applications of atomic energy and incidentally also to the manufacture of atomic bombs. In many respects these two substances are rather similar. One of them, Uranium 235, which is produced at Oak Ridge, Tennessee, is not so much manufactured as it is merely extracted by means of a rather laborious process from natural uranium. Uranium 235 accounts for less than 1% of natural uranium and accordingly its quantity is severely limited by the quantity of natural uranium which can be made available. In one of the pre-war years, for instance, we imported 400 tons of uranium. If we procured every year such a quantity of uranium and if we managed to extract all the uranium 235 from it which it contains, we would obtain every year about three tons of uranium 235. We would do pretty well however in extracting two-thirds of this quantity and obtaining two tons of uranium 235 every year. If we use up two tons of this uranium 235 per year by allowing it to disintegrate, or let us simply say by burning it, and if we use the heat which is thus liberated for the production of steam and the steam for the production of electrical power, how much power could we generate? By burning two tons per year, we could produce electrical power at the rate of 1 1/4 million kilowatts, and this, as you know, corresponds to the average production rate of the Tennessee Valley Authority in 1944.

Let us switch over now from uranium 235 to the other key substance--plutonium. Plutonium does not occur in nature, but it can be manufactured from natural uranium and it comes from a component of natural uranium which accounts for more than 99% of this substance. In the United States plutonium is manufactured at present by rather old-fashioned methods at Hanford in the State of Washington. If plutonium is allowed to disintegrate, or let us again say if it is burned, heat is produced in much the same way as in the case of uranium 235. Heat is produced however not only when we burn plutonium, but also when we manufacture it. As a matter of fact more heat is produced in the process of making plutonium than in the process of burning it. So if we consider the atomic fuel plutonium for purposes of power production we must keep in mind that we produce heat as a by-product at the time we manufacture plutonium and that we also produce heat again later when we decide to burn a certain quantity of it.

With your permission, I will assume that the quantity of plutonium which can be produced might be expected to increase from year to year in geometrical progression; this might mean for instance that if we start with one ton production per year in 1947, we might produce two tons in 1948, four tons in 1949, eight tons in '50 and sixteen tons in '51. However, the geometrical progression need not be that fast, it might be much slower. For instance it might be that the quantity which we can produce will double only every three years. This would mean that if we produce one ton in 1947, we produce two tons in '50, four tons in '53, eight tons in '56 and sixteen tons in '59. The time in which the production would double might be less than one year and might be more than three years. In any case, the years from 1947 to 1951 or from 1947 to 1959 would then be considered as the building-up period.

After such a building-up period is completed, there is no reason why we should hesitate to burn up some 20 tons of plutonium every year and produce electrical power on this basis at the rate of about 15 million kilowatts. This means that the rate of the electrical power production on the basis of burning 20 tons of plutonium per year is the same as the rate at which electrical power was produced in the United States before the war. An increase in the rate of our electrical power production by this amount obtainable by utilizing atomic energy would obviously have some significance for the economy of the United States in the next fifteen years.

There is no direct way in which atomic power could be transformed into electrical power. Atomic power will yield heat and the heat will have to be used to make steam and the steam to make electricity or else the heat will have to be used for heating up of some inert gas and the hot gas to drive turbines which, in turn, will drive the electrical generators. All this means that even if atomic energy would cost nothing and, as a matter of fact, it might cost very little, electric power produced on this basis would still cost more than hydro-electrical power costs today. You can figure out yourself how things stand in this respect by remembering that even if the coal price were down to nothing the cost of electric power from steam plants would still amount to about 4½ mills per kilowatt hour at the bus bar. It may take some time before the price of electricity produced from atomic power can sell at this low price, and it is doubtful that it will ever be able to compete wherever hydro-electrical power is available. Wherever hydro-electrical power is available, it ought to be utilized, particularly since the interest rate will probably continue its general tendency of becoming lower and lower so that we shall be able to afford the large initial investment of such installations. But hydro-electrical power is not available everywhere, and where it isn't available atomic power will only have to compete with coal. As a fuel coal will probably be more expensive than plutonium in years to come. As our economy is going to approach a happier state of equilibrium, it is likely that the standard of living of the coal miners will approach the standard of living of other categories of skilled workers. In other words, the coal price is more likely than not to go up. Even today coal costs England $10 a ton and, even so, the British Government finds it difficult to induce men to take up coal mining as a profession. With a coal price of $10 per ton the cost of electricity at the bus bar might be about 9½ mills per kilowatt hour and atomic energy should have no difficulty to compete at such a price. Countries like England with her high price of coal and Russia and China with their poor systems of transportation might perhaps be more eager in the near future for atomic power than we shall be. But there is little doubt that the time will come when even in the United States atomic power will displace other fuels in the production of electrical power.

Unfortunately, economic considerations are overshadowed by political considerations. Unfortunately plutonium is not only an important atomic fuel, it is also the chief ingredient of atomic bombs. Can we afford to have atomic power unless we are safe from bombs? And can we be safe from bombs unless we can count on peace?

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But hydro-electrical power is not available everywhere, and where it isn't available atomic power will only have to compete with coal.

As a fuel coal will probably be more expensive than plutonium in years to come.

As our economy is going to approach a happier state of equilibrium, it is likely that the standard of living of the coal miners will approach the standard of living of other categories of skilled workers.

In other words, the coal price is more likely ~~than not~~ to go up than to go down.

Even today coal costs in England $10 a ton and, even so, the British Government finds it difficult to induce men to take up coal mining as a profession.

With a coal price of $10 per ton the cost of electricity at the bus bar might be about $9\frac{1}{2}$ mills per kilowatt hour and atomic energy should have no difficulty to compete at such a price.

Countries like England with her high price of coal and Russia and China with their poor systems of transportation might perhaps be more eager in the near future for atomic ~~power~~ energy than we shall be.

But there is little doubt that the time will come when even in the United States atomic ~~power~~ energy will displace other fuels in the production of electrical power.

Unfortunately these days economic considerations are overshadowed by political considerations. Unfortunately plutonium is not only an important atomic fuel, it is

Most of you know what one bomb did to H. — and if you were to do so you can figure out for yourself what one bomb would do to N.Y. or San Fr. // You may be however

Atomic bombs are cheap to produce in quantity and they will be produced in quantity if they are produced at all. — ~~If~~ To nations which have the industrial equipment the cost of such bombs will be no more than the cost of medium size bombers. — They may cost one or two million dollars a piece. —

Insert this

also the chief ingredient of atomic bombs.

Can we afford to have available atomic ~~power~~ energy unless we are safe from bombs?

And can we be safe from bombs unless we can count on peace?

Thirty million people live in this country in cities of over 250,000 and that means that thirty million people may die in one single sudden attack.

Another thirty million people live in metropolitan areas and will be in danger of their lives in case of war.

If we leave our cities as vulnerable as they are at present, a strong army and a strong navy will not help us much in such a contingency.

It is possible to make the United States much less vulnerable, but in order to do so, we would have to relocate thirty to sixty million people.

We would have to house these people in new cities which would form a sprawling network across an area of about three thousand square miles.

Such a relocation would be difficult to organize, but from a purely economic point of view, it would be possible to carry it out.

At the cost of about twenty billion dollars per year, such a gigantic relocation could be accomplished in ten years.

Moreover, on the basis of such a ten years' plan, it could be carried out without an appreciable drop in the standard of living during the transition period.

With conditions in the world being what they are, some of us would be quite willing seriously to consider this kind of military defense except for the doubt in our minds that by dispersing of our cities we might defend ourselves against the weapons of the past rather than the weapons of the future.

Recently John J. McCloy, now president of the world bank, spoke before the annual convention of the National Association of Life Underwriters.

McCloy, formerly Assistant Secretary of War, had served as a member of the Lilienthal Committee of the State Department.

This is what McCloy said. I quote:

"From firsthand information given to me by the scientists whose prophecies were uncannily accurate during the course of the war, there can be little doubt that within the next ten years, to be conservative, bombs of the power equivalent of one hundred thousand to two hundred and fifty thousand tons of TNT can be made, something over ten times more powerful than the bomb dropped on Hiroshima.

"And if we can move to the other end of the periodic table and utilize hydrogen in the generation of energy, we would have a bomb somewhere around one thousand times as powerful as the Nagasaki bomb.

"I have been told by scientists who are not mere theorists but who actually planned and made the bomb which was exploded in New Mexico that, given the same intensive effort which was employed during the war toward the production of that bomb, we were within two years' time at the close of the war of producing a bomb of the hydrogen-helium type, i.e., a bomb of approximately one thousand times of the power of the present bombs." End of Quote. —

Now bombs of the Nagasaki type act by the blast which they cause.

One single bomb of this type destroys many of the buildings of a city.

Bombs of this type produced in sufficient quantities could very well destroy all of the buildings of all of our major cities.

But clearly if giant bombs could be made and used against us, they would not be used to destroy the buildings of our cities.

They would be dropped off the Pacific coast and be permitted to disperse radioactive materials into the air.

The prevailing winds would then carry these materials clear across the continent.

If such bombs were used against us, the cities would remain undamaged, but the men and women inside of the cities would not remain alive.

From the vantage point of the physicist, the outlines of such a war are gradually becoming visible, and as they do so, they take on more and more the shape of a catastrophe for which there is no precedent in the history of mankind.

The traditional aim of foreign policy is to prolong the peace, that is, to lengthen the interval between two wars.

But we physicists find it very difficult to get enthusiastic about such an objective.

If we accepted the thought that it will be impossible to reach a state of permanent peace without first going through another world war, most of us would pray for an early rather than a late war.

The problem which faces the world today cannot be solved at the level of foreign policy.

It will have to be solved one floor above the level of foreign policy.

What are our chances that we will reach the solution of the problem of peace without going through another world war?

Most of us physicists believe that nothing short of a miracle will achieve this end.

But a miracle was once defined by Enrico Fermi as an event which has a probability of less than ten per cent of occurring.

This is just Fermi's way of saying that we all tend to underestimate the likelihood of improbable events.

And if there is one chance in ten of finding the right road and of moving along it fast enough to escape the approaching catastrophe, then I say let us focus our attention on this narrow margin of hope, for another choice we do not have.

Obviously, the odds are heavily against us.

But we may have one chance in ten of reaching safely the haven of peace.

And maybe God will work a miracle if we don't make it too difficult for Him.