THE HYDROGEN BOMB

Can it be made? Will it add to our national security? How effective will it be as a military weapon? How much more effective than the atomic bomb? Will the Russians be able to make it? Here are the answers to some of the questions most people ask about the H-Bomb

by ROBERT F. BACHER

THERE HAVE BEEN MANY conflicting statements about hydrogen bombs and what we should do about them. Some of these statements have become distorted in repetition. Others, while clearly stating physical possibilities, concern events which are so improbable as not to warrant serious consideration at the moment. Some of the statements made by scientists, whether intentionally or otherwise, have been very frightening to our citizens. Back of such statements seems to be the idea that if the United States citizen will just become sufficiently frightened, somehow we will not have any more war.

There is no question that the hydrogen bomb has terrifying possibilities. It is our very deep obligation, however, as citizens in a democratic country to consider this whole question objectively, dispassionately and, as carefully as we can under the circumstances, to decide just what our country should be doing. It will not improve the judgement of the citizen to scare him to death first. Our future safety and security depend today on keeping our heads and using wise judgement.

Many people have been able to formulate their opinions of the hydrogen bomb very quickly, on moral grounds alone. They say, and with justice, that it is a weapon of tremendous mass destruction and that accordingly no civilized country should consider its development and use. This is a comfortable position and one very easy to take, but where do we stop? Atomic bombs are also weapons of mass destruction. Are they moral or immoral? Nothing could be more gruesome and immoral than the reports of some of the hand to hand conflicts during the past war.

There is no question about it: War inevitably leads to many acts which are immoral. The relative immorality of various weapons and acts of war becomes difficult to distinguish. The hydrogen bomb, being a weapon of tremendous destruction, is more to be condemned than lesser weapons on these grounds if used for needless mass destruction. Indeed, no one can argue that the moral position of the United States will be improved by the possession or use of this bomb. Immoral as it is, war consumes a large part of the efforts of the people of the world. Situations arise in which war seems to be the lesser of two evils. The real question is: "What should the United States do in order to diminish the probability of world conflict?"

I have no complete answer to this question, but what we do about the hydrogen bomb is directly related to it. One man says that to make the hydrogen bomb starts us on a weapons race which will inevitably lead to war; another, that we can only maintain our security if we make hydrogen bombs and thus are able to hold an aggressor at bay. Which one is right?

Many of our citizens have lost all faith in the United Nations and believe that there are no possibilities for international agreements which will have any meaning. Others feel that we have not made the right approach to the Russians as yet. Certainly there is little reason from our experiences in the United Nations to be very hopeful. If international accord seems so unlikely, we should be interested in whether a vigorous development and production of the hydrogen bomb will increase or diminish the probability of war.

Of course some will argue that any weapon development at all leads to war and that therefore we should make no development of any kind. Though this is in agreement with some of our most deeply rooted Christian ideas, there is no question at all in my mind that for our nation to pursue such a policy would greatly increase the probability of a world holocaust and a national calamity.

Throwing aside such a pacifist view, let us ask the questions: "What weapon development is important to the national security? How important is the hydrogen bomb to national security? Will hydrogen bombs increase our chance of winning a war with minimum loss?"

Technical background of the bomb

Before trying to answer these questions let us look briefly at some of the technical background of the hydrogen bomb. It has been known for a great many years that if one could somehow find a way of putting light atomic nuclei together to make heavier nuclei, it would be possible to extract energy. It has also been known for a long time that if one could take the heaviest nuclei and split them apart one would be able to obtain energy.

The first indication that either of these processes might be important to us as a source of energy came from the suggestion by Hans Bethe that the fusion of the light elements was our fundamental source of energy in the sun and stars. Dr. Bethe worked his ideas out in some detail, and scientists now believe that this fusion is the origin of solar energy. These ideas were well developed before the fission of uranium was discovered. This discovery, in 1938, was immediately recognized as a possible source of energy for man. If it were released gradually, he could use this energy for power. If released suddenly, the energy could provide an explosion.

Two fundamental scientific discoveries which followed soon after the discovery of fission were of far-reaching importance. The first of these was that in the fission of uranium caused by the absorption of low energy neutrons, additional neutrons were released in the process. The importance of this fact is that the fission of uranium could produce neutrons which could then produce another fission, hence the term "chain reaction." These neutrons released in fission could make the reaction self-perpetuating.

The second discovery was that some of these neutrons were emitted some time after the fission took place. It was this fact that made the controlled chain reaction or nuclear reactor a possibility. Without these delayed neutrons we would have no way of controlling a nuclear reactor.

With the fusion of the light elements the situation is entirely different. Here the basic nuclear reactions which lead to the release of relatively large quantities of energy are those which occur when the nuclear particles collide at high velocity or high relative kinetic energy. At the center of the stars the temperature is many millions of degrees Centigrade and the particles of matter are moving at such high speeds that these nuclear reactions may take place. Even then, only a few nuclear reactions are possible. There is no possibility that the energy release from this type of reaction can be controlled on the earth. In the stars the reaction is controlled because of their great size. On the earth these self-sustaining thermonuclear reactions will either give an explosion or nothing at all.

Can it be made?

Whether a hydrogen bomb can be made depends upon whether it is possible to create on earth an assembly of materials which will produce a nuclear reaction if they are heated to a sufficiently high temperature, and then to devise a way to raise these materials to that temperature.

The temperature required is comparable to that reached in the interior of the sun, which is more than 10,000,000 degrees Centigrade. The only way that we know to reach such a temperature today is in an atomic bomb, where the sudden release of energy causes the materials of the bomb to be heated to an extremely high temperature.

The main light element to which I have been referring is, of course, hydrogen. Now ordinary hydrogen just won't work. The scientific evidence for this seems to be quite clear. But hydrogen as it is found in nature has two forms or isotopes. The heavy hydrogen discovered by Urey nearly 20 years ago is a possibility. In recent years heavy hydrogen, as contained in water, has been separated in relatively large quantities.

There is another possibility. For more than 15 years it has been known that a still heavier isotope of hydrogen called tritium—because it has mass three—is produced in nuclear reactions. This material is radioactive and ordinarily does not exist in nature. It has a half life of only 12 years, but its nuclear properties are such that it is of basic interest in the release of energy by fusion.

It has been known for many years that tritium could be produced in a nuclear reaction in which neutrons are absorbed. The big nuclear reactors which are now in operation produce neutrons in large quantity. These neutrons are ordinarily used in the production of plutonium, but they could be used just as well to produce quantities of tritium. Any nuclear physicist can sit down and figure out the theoretical limit of the amount of tritium that can be produced with a given number of neutrons. It would be necessary, of course, to know a great deal about the actual workings of a nuclear reactor in order to say just how much tritium could be produced in that reactor if one were willing to forego the production of a certain amount of plutonium. It sounds as if the production of tritium in quantity is at least a fairly expensive if not formidable process.

That these two isotopes of hydrogen can possibly play a fundamental role in the release of nuclear energy by fusion is well known. Just exactly what relative role they play and how they might play it, is not a subject for open discussion today. These questions are secret. But any nuclear physicist will quickly grasp the basic science requirements, even though the bomb technology is much more complicated.

How do you get it going?

The real problem in developing and constructing a hydrogen bomb is: "How do you get it going?" The heavy hydrogens, deuterium and tritium, are suitable substances if somehow they could be heated hot enough and kept hot. This problem is a little bit like the job of making a fire at 20 degrees below zero in the mountains, with green wood which is covered with ice, and with very little kindling. Today, scientists tell us that such a fire can probably be kindled.

Once you get the fire going, of course, you can pile on the wood and make a very sizeable conflagration. In the same way, with the hydrogen bomb, more heavy hydrogen can be used and a bigger explosion obtained. It has been called an open-ended weapon, meaning that more materials can be added and thus a bigger explosion obtained.

Let us look for a moment at what sort of an explosion is imagined. In 1945 President Truman stated that the atomic bomb was equivalent to 20,000 tons of TNT. In talking about the hydrogen bomb it has commonly been speculated that such a bomb would be 1,000 times as powerful as the bomb dropped on Hiroshima. This would mean that it would have an explosive effect equivalent to about 20,000,000 tons of TNT.

Now it happens that the radius of damage from a big explosion increases as the cube root of the energy is released. With a bomb 1,000 times more powerful than the Hiroshima bomb the radius of damage will be 10 times greater. Since the radius for almost complete destruction from the blast was approximately one mile at Hiroshima, the corresponding radius for a hydrogen bomb 1,000 times as large would be approximately 10 miles—sufficient to cause almost complete destruction of any metropolitan area known today.

There are other damage effects from atomic weapons. At Hiroshima people who were in the open, and exposed directly to the light of the bomb, were seriously burned. With a hydrogen bomb these effects will be much greater and may extend to an even greater radius than that of the blast effects. On the other hand, the radiation which produces these burns is easily absorbed. It is very much like the radiation from the sun, against which a shadow or a blanket of smog is a great protection.

Generally speaking, one would expect the flash burn effects to increase as the square root of the power of the bomb. For a bomb 1,000 times greater than that used at Hiroshima the effects would be expected to extend roughly 30 times as far. At Hiroshima flash burns were severe out to two-thirds of a mile. Similar burns might be expected out to 20 miles for a hydrogen bomb. Such a damage radius would mean that shadows of buildings, trees, bushes, and other objects would be very important in cutting down the direct effect of flash burn. If you couldn't see the bomb directly, you would expect no effect of flash burn.

Both atomic bombs and hydrogen bombs may be expected to release neutrons and penetrating gamma radiation. These particles and rays, however, are absorbed fairly easily in air and will not have an appreciably greater radius of action for a hydrogen bomb than for an ordinary atomic bomb. People who are sufficiently close to be killed by penetrating radiation will very likely be killed by blast effects in any event.

There has been a great deal of speculation about the radioactive products of a hydrogen bomb. The disintegration products of the explosion are themselves not radioactive, as are the fission products of an atomic bomb. But since an atomic bomb would be needed in order to get the conflagration going, some fission products from that bomb would doubtless be present. And large quantities of radioactivity may be produced from the neutrons which are released in the nuclear conflagration.

If the neutrons released in the hydrogen bomb explosion are absorbed in some material which becomes artificially radioactive, then a very large quantity of this radioactive material will be produced in a big explosion. On the other hand, many of these neutrons might be absorbed in material that did not become radioactive. If the neutrons escaped into the air, many of them would be absorbed by nitrogen and, by a nuclear reaction, produce radioactive carbon. This material is most disagreeable as a radioactive contaminant since it has a half life of many thousands of years.

If such a bomb were exploded under water, however, very few of the neutrons would escape. Most of them would be used to produce radioactive sodium, to activate other elements in sea water, or to produce heavy hydrogen by neutron capture in ordinary hydrogen.

Effects of radioactivity

The radioactivity effects of a hydrogen bomb are thus difficult to estimate, since they depend so much on where the bomb is exploded and what material surrounds it. Under conditions in which the largest amount of radioactivity is formed it would be a dangerous hazard. One of the real scare stories about the effects of radioactivity has postulated the complete explosion of 500 tons of deuterium, which, while not impossible as far as anyone can say, is stretching probability a long way.

From this brief analysis of well known scientific information it appears that a hydrogen bomb would require a considerable quantity of heavy hydrogen, both deuterium and tritium perhaps, as well as an atomic bomb to set it off and raise the temperature sufficiently so that a nuclear conflagration could exist. Technically the problem is to figure out how a sizeable fraction of the energy of the heavy hydrogen can be released before the material is cooled too much by emitted radiation or dispersed by the explosion. In the stars the radiation is retained, because the stellar atmosphere is relatively opaque and there is an enormous temperature difference between the center and the outside of the star. In a hydrogen bomb there is no such protective layer, and the central problem is to get a large fraction of the energy released while the temperature is still high enough.

Whether this can be done will of course not be certain until it has been done. There are many opinions as to how difficult it may be. Since the President has directed the Atomic Energy Commission to continue with the development, we can assume that it is regarded as both possible and feasible.

So much for the technical problems which must be solved in order to develop a hydrogen bomb. Assuming that the problems can be solved, let us try to determine whether or not hydrogen bombs will add materially to our national security by considering their effectiveness as military weapons, and comparing them with atomic bombs already in existence.

If we assume that the hydrogen bomb is 1,000 times as powerful as the Hiroshima bomb, it will have a radius for blast damage which is 10 times as great—about 10 miles. For flash burn damage, the radius will be theoretically 30 times as great. But absorption and shadow effects will cut this down so that an effective radius for flash burns for those in the open may be roughly the same as for severe blast damage. Effects of neutrons and hard gamma radiation from the hydrogen bomb would not be expected to extend very much further than they would for an atomic bomb.

The effects of radioactivity would depend very greatly on where and how the bomb was exploded. If the bomb were exploded in the air, the effects of radioactivity from a hydrogen bomb would be quickly dispersed, and for long-lived activity the effects would be almost the same for all parts of the world, unless brought down by rain. It might be possible to enhance these radioactive effects by surrounding the bomb with the proper materials and to arrange it so that the active material would be deposited near the point of explosion. How successful such an unpleasant operation might be would again depend upon where the bomb was exploded and upon the general climatic conditions which existed at the time. In any case, the effectiveness of radioactive contamination from a hydrogen bomb designed and exploded to enhance that effect seems to be somewhat uncertain, and at least in part unpredictable.

Hydrogen bomb and atom bomb

We can easily see that a hydrogen bomb is capable of destroying any major city, with the exception perhaps of some of the outlying districts. How does this prospect compare with what could be done with atomic bombs? We have been comparing the hydrogen bomb with the atomic bombs used at Hiroshima but it has been stated that since the war there have been significant improvements in atomic bombs. These improvements have resulted in more powerful bombs and in a more efficient use of the valuable fissionable material.

Most large metropolitan areas include many districts that are covered by water, or otherwise unsettled, so that the reach of a hydrogen bomb would include many square miles whose destruction would contribute in no way to the effectiveness of the bomb. Atomic bombs could presumably be dropped so as to avoid these areas. Furthermore, it was found in the last war that a saturation raid which greatly hampered fire fighting caused damage far beyond the areas of immediate blast effects. Considering all these factors, it seems likely that there is no metropolitan area which could not be thoroughly destroyed with 25 atomic bombs. It is more likely that less than 10 atomic bombs would be needed to destroy major metropolitan areas, and that two bombs would completely paralyze even large cities.

Except for the psychological effects, and for the most unpleasant and somewhat unpredictable effects of the radioactivity produced, it appears that a hydrogen bomb which is 1,000 times more powerful than an atomic bomb might cause more destruction but would probably not be much more effective than 10 atomic bombs. For smaller industrial targets it would not be much more effective than a single atomic bomb.

One begins to wonder just how powerful a military weapon the hydrogen bomb would be. There does not seem to be very much force to the statement that the hydrogen bomb is such a tremendous new weapon that it can completely revolutionize warfare.

But what about the atomic bomb and the damage which might be inflicted with a sizeable stockpile of these weapons? Suppose, just to take a round number, that the United States possessed 1,000 atomic bombs of the improved variety. If they could be delivered to military objectives at all, they would go a long way at the rate of 10 for a major metropolitan area and perhaps an even smaller number for major cities. There would be a great many for relatively minor military objectives, and I imagine that the military commanders would have a hard time figuring out what to do with the last hundred.

The bigger the better?

It appears that if any nation has as many as a thousand atomic bombs, that the world is already in the position where any nation could be blasted thoroughly and completely. If this is the case, of what additional military use is a hydrogen bomb? For the most part it just seems that everyone is fascinated by the idea of "the bigger the better." There are a few examples in the history of the world that should lead us to question this view. We should not forget the dinosaur or the dodo. We should not forget the battleship, now almost extinct.

Of course it might turn out in a war that it would not be possible to deliver atomic bombs or any big bombs, to the targets which the military commanders might want to destroy. If this is the case, then, from the military standpoint, the solution of this problem is vastly more important than the question as to exactly what kind of bombs would be carried.

If hydrogen bombs would not add very much to the military effectiveness of the United States we might ask whether they would add much to Russia's military potential. Here, of course, one gets involved in even more speculation. One is not able to judge very well whether the Russians have an appreciable chance of delivering the hydrogen bomb by air against the radar defense of this country which is now being constructed. But even if such a defense is reasonably effective, and even if the Russians do not have the same strength of long-range bombers which the United States has, still there is another method of delivery which for the enemy would be perhaps quite effective.

Many of the big metropolitan areas of the United States are located on the seacoast. Into these harbors, or at least reasonably close to them, a hydrogen bomb might easily be brought in the hold of a tramp steamer. While this might not be the most effective place in which to detonate a hydrogen bomb, it would provide a simple method of delivery for a surprise attack. Another variation might involve the use of relatively small unmanned craft which could run ashore with a hydrogen bomb aboard. Practically no Russian cities could be reached in this way. This means that the hydrogen bomb would be a more effective weapon for the Russians than for the United States.

Some people have argued that if we develop the hydrogen bomb and can really keep its details secret, the Russians will never be able to develop it. There is absolutely no reason to believe that this would be the case. Recent experience has shown that the Russians have an atomic energy enterprise adequately developed to make a sizeable atomic explosion. In addition they probably have fairly detailed information on our atomic weapons work, and at least some of the early thoughts on the possibility of a hydrogen bomb—as a result of well known scientific information combined with the blundering indiscretions of some months ago, and also from their espionage activity. Given adequate time, they can most surely make a hydrogen bomb if it is possible at all.

While it is a terrible weapon, the military effectiveness of the hydrogen bomb seems to have been grossly overrated in the mind of the layman. He thinks it can save the country from attack. Pumped full of hysteria produced by Red scares and aggravated by political mud slinging, the average citizen is easily convinced that he can find some security and relief in the hydrogen bomb.

Here we have an instance of what can happen in a democracy when decisions of far-reaching national significance are made without public scrutiny of pertinent information. While most of the pertinent information is not secret at all, some of the information which the citizen should have in order to judge whether a national policy is sound, is secret. One of the most important facts which the citizen should know in order to make a reasonable judgement is the approximate number of bombs in the United States stock pile. It would be quite surprising if the Russians could not figure this out from the information which they obtained. But when Senator Brian McMahon, Chairman of the Joint Congressional Committee on Atomic Energy, raised the question of making the number of atomic weapons available generally, he was vigorously criticized. As of last spring, not even the members of the Joint Committee knew how many atomic bombs the United States had.

In a democracy it is possible to have good government only when the citizens are well informed. It is difficult enough for them to become well informed when the information is easily available. When that information is not available, it is impossible. The hydrogen bomb and its potential usefulness to the United States as a military weapon is a subject of national importance, not only because this is a weapon whose effectiveness has been grossly exaggerated, but also because it is one on which we can place relatively little reliance for the future. Quantities of hydrogen bombs will not contribute very much to the security of the United States. Unfortunately the citizen today believes that they will.

How to increase our national security

If the development of the hydrogen bomb will not do much to increase national security, how else might we do it? There are probably many answers to this question, but let me make one suggestion.

If the Russians should decide to move into Western Europe, we would immediately be faced with the prospect of fighting a war. Presumably, we could use atomic bombs. It would not be long, however, before we would need a big United States army and supplies not only for that army but also for our allies in Europe.

But just how would we get those supplies to Europe? During the past war, on at least two occasions, the Germans came dangerously close to shutting off our supplies to England. This was before the development of the Schnorkel type of submarine, which we are told the Russians now have in quantity. The Schnorkel submarine, while not absolutely impervious to detection by radar, is most difficult to run down. No method of detection has been developed which can locate it at any great distance under water, and it appears that a determined enemy with adequate bases and submarines could go a long way toward preventing us from delivering men and supplies to Europe. We could presumably deliver a certain amount of material by air, but when it comes to delivering millions of tons, our experience with the Berlin air lift should show us that this is not a feasible solution.

Here is a problem whose solution would contribute greatly to our military strength and therefore to our security. Its solution might even deter the Russians from overrunning Western Europe if they planned to do so. On this ground it seems to be much more important than the more spectacular hydrogen bomb development.

Atomic energy for war or peace?

It seems likely that there are many developments related to military strength which may be important for us to pursue. For some of these, as in the case of the development of atomic energy, we may need to choose between weapons and other developments of nuclear power which may have long-range peacetime significance. By adding to our industrial strength, such developments might make a greater contribution to our long-range strength than the more immediate development of weapons.

At the present time it is most difficult to ascertain how our government decides what policies to follow regarding national security. High government officials find themselves advised to pursue this or that development and to construct this or that weapon without being very sure how one weapon compares with another. Where the development of a weapon may compete with a long-range industrial development the problem is still more difficult. The real way to make sure that a reasonable policy is followed is to have all policies, and the information on which they are based, open for public scrutiny.

Furthermore, although the United States is a rich country, we are not in the position of being able to follow every recommendation that anyone believes will increase our national security.

The citizen should have the answers

The citizen must choose in so far as that is possible. Today if he tries to come to some conclusion about what should be done to increase the national security, he runs up against a high wall of secrecy. He can of course take the easy solution and say that these are questions which should be left to the decision of the upper echelons of the military establishments. But these questions are so important today, that to leave them to the military men is for the citizen essentially to abrogate his basic responsibility. If, in time of peace, questions on which the future of our country depends are left to any small group not representative of the people we have gone a long way toward authoritarian government.

The United States has grown to be a strong nation under a constitution which wisely has laid great emphasis upon the importance of free and open discussion. Urged by a large number of people who have fallen for the fallacy that in secrecy there is security and, I regret to say, influenced by many—including eminent scientists who prophesy doom just around the corner —we are dangerously close to abandoning those principles of free speech and open discussion which have made our country great. The democratic system depends on making intelligent decisions by the electorate. Our democratic heritage can only be carried on if the citizen has the information with which to make an intelligent decision.