THE DEPARTMENT OF RECONSTRUCTION

CANADA

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CANADA'S ROLE IN ATOMIC BOMB DRAMA

Bursting of Atom Opens New Realms to Science, Says Government Statement.

OTTAWA -- "Enquiries received from all parts of the world indicate the widespread interest in the work carried on in Canada in making possible the production of the atomic bomb," said the Hon. C.D. Howe, Minister of Munitions and Supply and Reconstruction, here today.

"The dropping of the first atomic bombs is, however, the culmination of the work of scientists from many nations, the pooling of the scientific and natural resources of the United States, Britain and Canada and the expenditure of hundreds of millions of dollars in the United States and smaller, but substantial, sums in Canada on plant and equipment in the most extensive scientific effort ever directed towards the attainment of a new weapon.

"Having ample supplies of basic materials, good water supplies, and isolated sites well suited to the work, Canada, with foresight and enterprise and the organization of the National Research Council, has been able to enter as a pioneer into an important new field of technology. The future will disclose the full peacetime potentialities of this remarkable new source of energy.

"Interest in the scientific aspects of the achievement is such that after consultation with Dr. C.J. Mackenzie, President of the National Research Council, it has been decided to make public the following details:

LARGE LABORATORY ESTABLISHED IN MONTREAL

Canada has been associated with scientific development in this field since the time when Rutherford began his investigations on Radioactivity in McGill University in 1899. Investigations were, however, confined to university laboratories until the outbreak of war in 1939. From that time, the interests of scientists working on this subject in Britain, the United States, Canada and France were directed to the possibility of a practical application. On the fall of France, French scientists working on the problem were sent by Professor Joliet to join the British scientists. In October, 1940, information on this and other war research was interchanged between Britain, the United States and Canada. Towards the end of 1942, the British proposed that an important section of the work should be carried on in Canada as a joint enterprise. Accordingly a joint laboratory of United Kingdom and Canadian staff was established in Montreal under the administration of the National Research Council. This laboratory has now grown to a staff of over 340, by far the largest organization ever created in this country to carry out a single research project.

PLANT AT PETAWAWA

As a result of agreements reached between the three partner governments, the work of this laboratory was closely co-ordinated with the tremendous research activity in this field in the United States. Its work led to the design of a pilot plant for the production of atomic bomb materials, now under construction at Petawawa, Ontario, by Defence Industries Limited, as a part of the combined United Kingdom - United States-Canadian program. A branch of the National Research Council will be established there in close association with the pilot plant to carry out research on the application of atomic energy in war and in industry, and on the use of its products in research and medicine.

The primary material required for the operation of this pilot plant and for its production of materials for atomic bombs is uranium. One of the world's two most important deposits of this substance was discovered by Gilbert Labine near Great Bear Lake in Canada. To preserve this important asset for the people of Canada and to protect the supply for the United Nations, the Dominion Government took over the ownership of the mines and the extraction plant.

BURSTING THE URANIUM ATOM

The possibilities of the release of atomic energy have been known to physicists for some time. The first indications came shortly after the discovery of radium, when Curie found that it generates heat and maintains itself at a temperature some degrees above its surroundings. The source of this heat energy was investigated by Rutherford during his researches at McGill University in the early years of this century when he showed that new kinds of rays were emitted from radium and a few other similar materials. These rays come from the innermost part of the radium atom which is called its nucleus.

In 1919, Rutherford went further and showed that the nucleus of an atom could be made to emit rays by artificial means, releasing energy in the process. In this process, the atomic nucleus expels a small part of itself as a projectile of very high velocity. This is called the artificial transmutation of an atom, because the loss of the small part changes its nature.

During succeeding years, many new methods of disrupting the nucleus were discovered. Among the most powerful was the use of neutrons, a projectile discovered by Chadwick in 1932. A neutron is actually a part of the nucleus of an atom which may be ejected when the atom is transmuted. A neutron expelled from one atom eventually collides with and enters the nucleus of another atom, often producing a transmutation of the second atom.

In these early experiments, the atomic energy was released from single atoms at a time and required special and delicate apparatus for its detection. It was not until 1939 that the discovery of "fission," or bursting of uranium atoms, gave the first hope that it might be possible to release atomic energy on a large scale capable of military and industrial applications. Physicists and chemists in various laboratories throughout the world had been trying to understand the behaviour of the heavy element uranium when it is exposed to neutron rays. Gradually, bit by bit, with careful experimenting they found the explanation. They discovered that the rays caused the uranium atom to split in two. They found that this bursting, or "fission" as it is called, of a uranium atom was over ten million times more violent than the bursting of a molecule of a modern high explosive.

The bursting of a molecule of high explosive is a chemical process -- one of the many chemical processes that are familiar to us, like the rusting of iron and the burning of coal. These processes are brought about by the forces between atoms which are called chemical forces. The bursting of the uranium atom, on the other hand, is caused by forces inside the atomic nucleus, forces enormously stronger than the chemical forces between atoms.

NEUTRON PROVIDES "TRIGGER"

The fission of uranium differs from ordinary atomic transmutation processes. Transmutation involves the ejection of a relatively small part of the atomic nucleus, such as a neutron or an electron. The loss of this part alters the properties of the atom, including its chemical behaviour. In the case of fission, however, the uranium atom splits into two large parts which become two new atoms of chemically different elements, a discovery so surprising that the scientists feared that no one would believe it. In addition, the fission of a uranium atom is accompanied by the expulsion of neutrons. The number of neutrons emitted varies, but lies between one and three. This is a fact of the greatest importance, for it opens up the possibility that the same process of fission can be propagated in neighbouring atoms of uranium. Another important respect in which fission differs from transmutation is that the energy released in the process is many times greater.

The entry of a neutron into the nucleus of the uranium atom is the trigger which sets off the fission process. Since neutrons are also emitted in fission, they are available to act as the triggers for the fission of still other uranium atoms, and thus under favourable conditions, whole chains of fissions can be produced, each fission being caused by a neutron released in a previous fission. In this way the process can be made self-propagating and self-increasing so that what starts as an action affecting only one or two atoms may, in a short time, affect a large proportion of the atoms in a block of material. In other words, a "chain reaction" is set up. These are the conditions which must be realized if the energy released in these nuclear processes is to be made available on a large scale. If the chain reaction builds up very quickly the energy will be released in a violent explosion as in a bomb; when the chain reaction is controlled the energy may be set free at a steady rate.

MANY DIFFICULTIES OVERCOME

The large-scale release of atomic energy depends entirely on the conservation of the neutrons produced, in other that they can cause still further fissions. If the supply of neutrons is dissipated by losses, the combustion of uranium atoms will die out like a fire that lacks air. Losses of neturons can occur in many ways. Some of them merely escape from the uranium to the outside; others may be absorbed in the uranium itself or in foreign substances. All materials absorb neutrons. Any substance which is present with the uranium competes with it for the available supply of those particles.

Even in uranium itself not all the neutrons absorbed produce fission. in ordinary uranium, as it occurs in nature, there are three kinds of uranium atom which are distinguished by the names U238, U235 and U234 atoms. They have been so named because they are respectively 238, 235 and 234 times as heavy as the lightest kind of atom,hydrogen. Almost all of the fission occurs in the U235 atoms but these are only 7/10 per cent of the mixture. The number of U234 atoms is negligibly small. The U238 atoms absorb neutrons freely without producing fission (except to a slight extent when they are struck by neutrons of very high velocity), and unfortunately U238 atoms greatly predominate in natural uranium. In order, therefore, that the reaction shall multiply itself at the greatest possible rate it is necessary to use U235 alone or at least fairly free from admixture with 238.

In a mass of U235, neutrons will be lost mainly by escape into the outer air. The importance of this effect can be reduced by increasing the size of the mass, since the production of neutrons, which is a volume effect, will increase more rapidly with size than the loss by escape, which is a surface effect. It follows that if the explosion is possible it will require at least a minimum mass of material, which is called the critical size. Thus the explosion is very different in its mechanism from the ordinary chemical explosion for it can occur only if the quantity of material is greater than this critical amount. Quantities of the material less than the critical amount are stable and perfectly safe. On the other hand, if the amount of material exceeds the critical value, it is unstable and a reaction will develop and multiply itself with enormous rapidity resulting in an explosion of unprecedented violence. Thus all that is necessary to detonate the bomb is to bring together two pieces of the active material, each less than the critical size, but which when in contact form a mass exceeding it.

The separation of the U235 atoms, which are most useful for fission, from the comparatively inert U238 atoms is extremely difficult. Both kinds are uranium atoms. They have identical chemical properties and therefore no chemical procedure can distinguish between them. Physical methods which depend on the very slight difference in weight must be used for their separation, and very great technical difficulties had to be overcome to develop a method which was satisfactory even on a laboratory scale. To do this on the scale required for production of the amounts of material necessary for an atomic bomb was a most formidable task and demanded a great industrial effort. The separation of the U235 has however been accomplished in the United States.

PLUTONIUM NEW SUBSTANCE

Uranium is not the only substance that is capable of fission. Another fissile material is plutonium. This substance does not occur naturally, but must be prepared by exposing uranium to neutrons. The U238 atoms, which contribute very little to the fission of ordinary uranium, are the ones that are transmuted to become eventually atoms of plutonium. Plutonium, like U235, is very fissile, and it has the important advantage that it is chemically different from uranium and is therefore easily separated from it by chemical methods.

NEW PLANT PRODUCES PLUTONIUM

The plant which is being built near Petawawa to produce materials for release of atomic energy, will contain uranium and heavy water. When these materials are brought together in certain proportions and in sufficient quantity chains of fissions are set up and large quantities of energy are released from the uranium in a controlled and non-explosive way.

The basic process in the Petawawa plant is the production of fission in uranium 235 by a slow neutron. The fission of a U235 atom releases high speed neutrons; these collide with the heavy water molecules without being absorbed and so they lose speed until they in turn produce fission. In this way a slow neutron "chain reaction" is set up. This results in very large numbers of neutrons being set free. Some of these neutrons are absorbed in the U238 atoms to produce plutonium. Later the uranium can be removed from the plant and the plutonium extracted chemically.

AID IN RESEARCH AND MEDICINE

Other neutrons can be absorbed in materials placed round the reacting uranium. By this means interesting new radioactive materials can be produced in large quantities. The plant will therefore be a source of supply of such materials for the study of chemical and biological processes and for application in medicine.

Some of the energy of fission is released in the form of fast neutrons and energetic gamma radiation. The reacting uranium must therefore be surrounded with a great thickness of material to absorb the neutrons in order to protect the working personnel from injurious effects. The intensity of the fast neutron radiations is much greater than any previously available to physicists and presents great possibilities for scientific research.

INDUSTRIAL POWER SOURCE

The greater part of the energy of fission appears in the form of heat generated in the uranium metal. This heat has to be removed by rapidly flowing water or gas. The metal surface temperatures are too low at present for this heat to be used effectively for the generation of power, but there is a possibility that this limitation may be removed by further work.

RESEARCH COUNCIL DESIGNS PLANT

The design of uranium fission plants presents technical problems entirely different from anything previously encountered in industrial and engineering experience. It requires the combined knowledge and training of experimental and mathematical physicists, chemists and engineers and experts in other sciences. Every important feature of design has been based on difficult calculation, measurement and experiment.

This work has been carried out for the Canadian plant by the Montreal Laboratory, aided by such experience and information from the U.S. project as was authorized by agreement. The laboratory presented the basic data to Defence Industries Limited who have prepared detailed designs for the construction by the Fraser Brace Company.