Creative Use of Atomic Energy

By W. J. Archibald

OUR High School Physics text has taught us that if an object possesses energy, it is capable of doing work. Without attempting to give a precise scientific definition of energy, we may say that an object possesses energy when it has the ability to bring about either creative or destructive ends in the physical world. For example, the atmosphere which surrounds the earth has stored within it enormous amounts of energy which when released can produce creative outcomes, as when it deposits its water vapour on the earth in the form of rain which nourishes all growing things; or this energy can be released destructively as would be the case in a violent wind storm. The energy in the atmosphere is not under the control of man as yet although some day it may be. In a very real sense it can be said that the history of applied science is the history of man's attempt to bring under his control the vast stores of energy that are to be found in the objects of the physical world so that he can release it and use it for either creative or destructive purposes. It is really impressive to think of the great progress that has been made in controlling and harnessing the energy stored in such every-day substances as coal, water, gasoline and oil. The energy has always been there ready to serve faithfully any group of people having sufficient skill and ingenuity to think of a way of exploiting it.

The Nucleus of the Atom

For a very long time it has been known to physicists and chemists that the nuclei of the atoms have stored in them enormous amounts of energy and for a matter of twenty-five years or more it has been possible to release this energy in very small quantities. However the problem of performing the task on a large scale presented great difficulties. No one seemed able to think of a simple "trigger" mechanism that would transform energy from a "latent" to an active state. Consider how easy it is to render active the energy latent in a quantity of gasoline!—it is only necessary to bring a lighted match near it. Nuclear energy could not be released (or so it seemed) by any simple means like this. So formidable was the problem that little consideration was given to it and physicists confined their activities to studying the nucleus merely to satisfy their curiosity, not anticipating any immediate practical outcome. However, the discovery of nuclear fission a few years before the start of the second World War, changed all this because it was soon realized that the splitting of certain nuclei could be brought about on a grand scale by an act almost as simple as that of approaching gasoline with a lighted match. Once this was recognized all possible resources were turned in this direction and the atomic bomb was the outcome—an enormous release of energy admirably suited for purposes of destruction.

Controlling Energy Release

The generation of energy in fissionable material such as uranium is under the complete control of the physicist in the sense that he can turn it on or off at will. He can provide conditions in which the whole act is completed in a few millionths of a second as is the case in a bomb explosion. Or he can arrange to have the evolution of active energy take place at a slow rate as is done in the atomic pile which can be started in the morning and closed down at night by an act as simple in principle as starting or stopping a car. It is this feature of control which is essential if any reservoir of energy is to be tapped for creative purposes, and the nuclear fission process is most cooperative in this respect. If it were only possible to arrange for the instantaneous release of energy then the single peace-

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time application of this principle would be to use it as an explosive, and one can predict quite safely that it will seldom be used for this purpose. There is an interesting difference between a mass of atomic explosive and a stick of dynamite. If a stick of dynamite is too large for the job in hand, it can be cut in pieces and part of a stick used whereas if an atomic "stick" is made too small it cannot be detonated and is useless. The smallest atomic charge that will go off when detonated is equivalent to many thousand tons of T.N.T. and it is difficult to imagine an engineering undertaking that could find a use for explosions of this magnitude.

The Atomic Pile

How does the energy released in the fission process manifest itself? The atomic pile, which is a device that permits the slow, controlled generation of atomic energy merely gets hot, and if the pile is not to be damaged by overheating it is necessary to cool it by running water through and around it. So complete is the control which can be exercised over this evolution of heat that the pile can be prevented from generating even as much heat as a flash light bulb. But the pile may be turned on to full capacity and made to produce heat at a rate of thousands or perhaps even millions of watts depending on its size and design. One has therefore when considering the possible engineering applications of atomic energy, to bear in mind that what one gets from an atomic pile is heat. Hence uranium or plutonium may be legitimately regarded as fuel which upon "combustion" generates heat. In harnessing atomic energy it is only necessary to circulate a liquid or a gas through a pile and then admit it at a high temperature and pressure into the cylinder of a heat engine or force it under pressure through the blades of a turbine. Ordinary steam engines or turbines could be used and the only engineering problem to be faced is how to use a pile efficiently and safely as a boiler for heating the steam or whatever else is used as the working substance.

In principle, such utilization seems quite simple, but in practice there are grave problems to be faced. For example, even a small plant capable of generating 100 H.P. would need to be surrounded by a shield equivalent in weight to at least 3 feet of solid steel. This protective device is required because of the dangerous radiations which are emitted from the pile and which are far more intense than the rays from a large mass of radium. It is therefore hardly to be expected that it will be possible to build atomic-power units for normal use weighing less than about 100 tons. This rules out the possibility of fuelling cars, airplanes and possibly even locomotives by atomic energy. However stationary installations designed to supply power to whole cities are feasible and perhaps will be in used in the not too distant future.

One often hears the statement that since the blast of an atomic bomb is so terrific, there must be great danger in using atomic fuel in the boiler of an engine. This is a misapprehension—the detonation of atomic fuel is governed by different principles and great skill and knowledge is required to bring it about. Otherwise many countries would have atomic bombs. As it is several countries are now operating piles but as yet their scientists have not discovered (or so it is believed) how to release the energy with explosive violence.

Radiation

Important though it may be to have at our disposal a new and inexhaustible fuel yet the really significant outcomes of the discovery of nuclear fission will not be in the field of power engineering. An atomic pile is not only a generator of heat: it is also a source of radiations, (neutrons, gamma rays and other types) produced in quantities never before attainable. The usefulness of these radiations to the researcher can hardly be over-estimated and most of the piles in operation at the present time are regarded as tools probing more deeply into the secrets of the nucleus. Although it has been possible to manufacture a successful atomic bomb, it is obvious to physicists that very little is known about the nucleus. As understanding of its nature deepens, it is quite conceivable that some new mechanism for the release of energy may be found which would render the use of expensive uranium unnecessary. Such a discovery would be of crucial significance scientifically, economically and politically and the hope of arriving at it explains in part the vast programs of research into the properties of the nucleus which have been initiated by the various nations.

Practical Uses

It would be impossible to enumerate, let alone discuss, the many different types of investigations which are concerned with the use of the by-products of the atomic pile. A brief mention of a few may indicate the type of experiment which might be undertaken.

By the proper use of the pile it is possible to provide a radioactive form of nearly any element in the periodic table, i.e., the elements can be induced to emit some type of radiation. Very sensitive radiation detectors have been devised and it is easy to find and identify these radiation emitting elements in a substance even if they are present in exceedingly great dilution. The chemist is thus provided with a method of analysis which is thousands (and in favourable cases, millions) of times more sensitive than any techniques previously known, he may undertake investigations which formerly were impossible. Chemical analyses can be performed in a matter of minutes which by the standard methods would have required weeks and perhaps even months or years of tedious labour. The importance of such a powerful new technique can readily be appreciated. Interesting and significant results have already been achieved in chemistry and biology and one can confidently predict that the future will yield many more.

In medical research there are various techniques by which radioactive atoms can be used. In the first place they can be considered as "tracers" and followed as they move to different parts of the body. They can further be admitted into the body for the purpose of bringing about changes in certain bodily functions. The radiations emitted by these atoms are very energetic; they are capable of breaking up the complicated molecules in the cells and of thus bringing about the death of the cells. This effect is sometimes desirable, for instance if the cells are diseased or multiplying too rapidly. As an example of a medical application, the treatment of leukemia may be mentioned. Leukemia is a disease caused by excessive multiplication of the white blood cells which are produced in the marrow of the bones. If the patient is fed radioactive phosphorus in a very short time it finds its way to the bones where it is deposited. The radiation which it emits is thus able to destroy the white cells at the site of the disease without doing too much damage to the other cells in the body. The results of such treatments are described by E. O. Lawrence, the famous science writer for the New York *Times*, in his book *Molecular Films, the Cyclotron and the New Biology*. He mentions a typical case of "a patient who had a white blood count of some 200,000 who was given successive small doses of radioactive phosphorus over a period of several months, bringing the white count down to normal, after which the disease could no longer be diagnosed in the patient." One of the important functions of the Canadian Research Centre at Chalk River will be to provide the hospitals of Canada with such substances as radioactive phosphorus. Incidentally, our medical schools are now faced with the problem of training a new kind of specialist, a man who is part doctor, part physicist. A new science has appeared called biophysics, the workers in which are trained to pursue such studies as the one described above.

Extensive use of the radioactive by-products of a pile is also made in the field of technical physics. The subject is less interesting to the layman and hence will not be discussed here. Only preliminary investigations have been undertaken as yet and the full range of the possibilities has yet to be disclosed.

If man can be persuaded to act sensibly in his use of the atomic bomb, there is reason to believe that the discovery of the means of releasing atomic energy is merely the prelude to a host of new discoveries which will be put to creative uses. We may expect new mastery over disease, we may be able to do old tasks more easily and effectively, and we may arrive at a more profound and satisfying insight into some of nature's secrets.

Research in Agriculture

By Frank Shefrin

SCIENTIFIC agriculture is replacing rule-of-thumb farming in Canada. Not all farmers have accepted the new way. Oxen as beasts of burden are more than a tourist curio in some sections. But where new techniques and methods are used, the increase in productive capacity is most marked.

Much of this scientific research development, and extension work is undertaken in the laboratories and on experimental farms operated by the Dominion and Provincial Governments. Through this publicly supported program, the position of the family farm in the Canadian economy has been strengthened.

This article deals briefly with the activities of the Dominion Government research agencies in the physical sciences. Reference will be made to provincial activities. A short statement will also be included on economic and social research in agriculture.

Canadian agriculture, through its human and natural resources, aided by research, has shown remarkable growth during the past sixty-five years. The extent of this expansion of agriculture in space is shown by the fact that during the sixty years between 1881 and 1941 the amount of land used for farming, as reported by the Census, increased from a total of 45 million acres to 175 million acres. Farmland was improved. In 1881, 22 million acres of farmland were classified as improved. By 1941, improved land had reached a total of 92 million acres, well over four times the total of 1881. Land sown to grains, such as wheat, oats and barley occupied 15 million acres in 1881. By 1941 grains sprouted on 57 million acres.

The extension of Canadian wheat production has made us one of the biggest breadbaskets in the world. In 1881 only 2.4 million acres were planted to wheat yielding 32 million bushels. By 1940 28.7 million acres were sown to wheat, giving a yield of 540 million bushels. This yield was exceeded only in 1942. Other grains have shown similar though less steep climbs in production.

The livestock industry expanded. In 1881 there were 1.6 million milk cows on Canadian farms. By 1947 the total was 3.7 million. For other cattle, numbers increased from 1.9 million in 1881 to 6.0 million in 1947. Total milk production amounted to 6.9 billion pounds in 1901 and was around 17 billion pounds in 1947.

The average size of the Canadian farm has also expanded. In 1881, the average size was 97.7 acres and by 1941 it was 238.5 acres. The 1946 Prairie Census shows that in Saskatchewan the

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