The Week in Science

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When Uranium Splits

In the days when radium was still the wonder of the world and we first heard of the tremendous amounts of energy contained in matter scientists did some curious speculating in the early manner of H. G. Wells. Suppose it were possible to annihilate an atom and suppose the energy that held it together were released. The world might be blown up and gravitational disturbances initiated that might have serious effects on the solar system itself, we were told. Atoms were like so many grains of gunpowder. Set off one and the next would be touched off, until the whole earth would be destroyed in a blaze of light and heat. "Some imbecile has been annihilating matter," some wise Martian astrophysicist would observe as he beheld our dazzling but catastrophic end.

Similar speculations are naturally engendered by the discovery made by Drs. R. B. Roberts, R. C. Meyer, P. Wang, L. R. Hafstad and Dr. M. A. Tuve (Carnegie Institution of Washington) of what is called "delayed neutron emission." A few weeks ago Professor Niels Bohr and Enrico Fermi announced in this country that Drs. O. Hahn and F. Strassman had noted that uranium is disintegrated when it is bombarded by neutrons and that Dr. Lise Meitner and Dr. Frisch had interpreted this reaction as a splitting of the uranium into two new atoms. The Carnegie scientists repeated the experiments, checked the interpretation and found that the atoms which resulted from the splitting in their turn emitted neutrons. In other words, one atom can touch off another. The old possibility of destroying the earth is revived.

The Carnegie Institution of Washington's Department of Terrestrial Magnetism, where Dr. Tuve and his associates are working, assures this department that the earth is quite *safe*. "The heavy elements (radium, thorium, uranium) are not generally distributed in the earth's crust," says Dr. Tuve, "and in the pockets or lodes where they are found they are always highly diluted with oxygen, silicon, etc." These "inert" atoms capture neutrons as readily as uranium or thorium. So the chain reaction would not extend very far. Dr. Tuve informs us that other elements like lead, bismuth, thallium, mercury have been tested and that they show no sign of splitting. Lastly, the bombarding neutrons must have very high energy, which means that very pure uranium or thorium in large amounts would be required. Radioactive elements are rather scarce even in the earth's rocks.

Doubtful Source of Power

When uranium is split energy running to a hundred million volts is released. It looks, then, as if we might at least dream of powerhouses where atoms bombarded by neutrons would take the place of coal. The Carnegie scientists dash this hope, too. "At present exceedingly improbable," is the verdict. On the other hand, Dr. Tuve concedes that if one or more free neutrons are released for each initial neutron a chain reaction and hence the utilization of atomic energy becomes a speculative possibility.

In any event the chain process must be subject to control. But since the neutron can travel from two to twelve inches (mean free path) Dr. Tuve estimates that *at least 100 kilograms (220 pounds)* of raw material are required. Otherwise the neutrons will leak out through the boundary and stop the chain reaction.

Two hundred pounds of any pure radioactive element is something to make a physicist wonder how its emissions can be controlled. At present the room in which powerful X-ray apparatus is housed is lined completely with lead. The treatment of a patient is watched through lead-glass windows. The radiations from 200 pounds of uranium would be millions of times more deadly. Hence thick walls with water running through them might have to be erected. There is no prospect that anybody will collect 200 pounds of pure radioactive material. And in impure material the "inert" atoms would retard the chain reaction—stop it entirely.

The matter of control is clearly important with pure or high concentrated uranium. Suppose control were not adequate. The mass would begin to heat up at the center, Dr. Tuve points out. This means that it would blow up like an overdriven steamboiler that has no safety valve. The neutrons would then escape. Result: No more energy. So we return to our power houses, with their turbines and generators, and view with satisfaction what little smoke floats up from the stacks. It is not so spectacular, such a power house. But it's comfortable and safe.

Cancer and X-Rays

The cancer experts stepped forward last week to tell us of the new compact machines which have been devised to generate X-rays at a voltage running well over a million and what are the prospects of curbing cancer with very penetrating rays. Out of these pronouncements emerged the prospect that small powerful machines will be more generally installed both in physicians' offices and in small hospitals for the treatment of tumors.

In New York Dr. Francis Carter Wood reviewed the work that has been done at the Crocker Institute of Cancer Research (Columbia) with voltages up to 1,000,000; in Chicago R. Robert S. Stone delivered two lectures at the University of Chicago on similar experiences in Boston Dr. John G. Trump described the new powerful 1,250,000-volt machine which is to be installed in the tumor clinic of George White Memorial Building now being constructed for the Massachusetts Institute of Technology.

On the whole these authorities were in substantial agreement. Both Drs. Wood and Stone saw no sense in running voltages up to more than 1,000,000. Below 200,000 volts X-rays are not effective in treating deep tumors. Dr. Wood thought it unnecessary to go above 700,000 volts and that "even 600,000 volts are practically as good as 1,000,000." Dr. Stone put the case in another way by explaining that increases in voltage beyond 200,000 reach a point of diminishing returns. The opportunity for progress lies in devising new techniques rather than in increasing energy.

As the higher voltages are approached a larger proportion of normal tissue is affected. X-rays ionize cells—break them down. Cancer cells do not recover from the attack so readily as normal tissue. At high voltages the rays pass through one side of the body, through the cancer and then through the opposite side. Normal tissue on the far side may be injured. This effect has been increased by cross-firing techniques in which the rays are administered from both sides of the body.

Dr. Wood pointed out that there is no reason for building machines which run at more than 1,000,000 volts because radium gives off penetrating gamma rays at about that point. Mesothorium is even more powerful. To duplicate its rays artificially 3,000,000 volts would be necessary.

Something of the compactness of the new X-ray generators may be gathered from the description that Dr. Trump gave of the 1,250,000-volt machine for the Massachusetts Institute of Technology. It is only a tenth as big as one which runs at 1,000,000 volts in the Huntington Memorial Hospital in Boston. Besides it can be operated to its maximum output at a cost of only 8 cents an hour.

Though radium emits rays more powerful than those which can be generated by any X-ray machines Dr. Trump left no doubt that engineers will strive for higher voltages because radium is so very expensive. On the other hand, radium or, perhaps, some artificially activated substance will always be necessary because it can be buried in a growth, according to Dr. Wood.

Neutron Possibilities

Neutrons also have their possibilities. Dr. Stone speculated on them in Chicago. To him they "may offer the most hopeful technique in cancer therapy" because of their shocking power, which is a hundred times that of super-voltage X-rays. To compare neutrons with X-rays is like comparing cannon balls with rifle bullets.

As yet the experiments which have been made with neutrons in cancer are entirely inconclusive. It remains to be seen whether neutrons will have a significantly greater effect on tumors than on normal tissue. Some experiments made with animals hold out the hope—but it is only a hope.

If neutrons turn out to be effective aids in cancer therapy new engineering problems will have to be solved. Unlike X-rays neutrons are not stopped by a sheet of lead. In the University of California, where the first experiments with neutrons on living tissue were made, water is used as the protective medium. It was found that when neutrons struck the water they generated penetrating gamma rays. To stop the gamma rays the water tube had to be encircled in one of lead.

News Notes

HEIGHT RECORD: From St. Cyr, near Versailles, there rose recently a sounding balloon bearing a radiometeorograph, that is, an instrument which measures temperature, barometric pressure and moisture and radios its findings back to a station on the ground. A height record of 31.465 kilometers was made—19.54 miles. Before this the Germans had sent an unmanned sounding balloon to thirty-four kilometers' (21.114 miles), but it carried the usual instruments of the self-recording type and not a radiometeorograph.

LACQUER FROM MILK: Department of Agriculture chemists have developed a new resin from lactic acid. The resin, in turn, can probably be converted into acrylic acid, a glassy, transparent lacquer. The lactic acid is obtained from whey, which is left after cheese is made and which is now a waste.

EXPLAINING VENUS: Astronomers have known these many years that Venus has a dense atmosphere, which is like a mirror to the sun's rays. Hence the brightness of Venus. But what is the atmosphere composed of? Drs. E. D. Slipher and James B. Edson of Lowell Observatory, Flagstaff, Ariz., have decided that, like our own, the Venusian air must be full of fine dust particles, each a little mirror. If water is ever discovered in the atmosphere this conclusion may have to be modified. Water is a fine reflector.

CRAB SPOORS: Tracks in Pennsylvania rocks 300,000,000 years old are supposed to be those of a land-walking backboned creature. On the strength of these footprints in the hardened sands of time daring paleontologists have pictured something that had forefins and five-toed feet. Along comes Dr. Kenneth E. Caster of the University of Cincinnati and shows that the tracks were probably made by extinct horseshoe crabs, which were not backboned at all. Fossil crabs are found in Ohio rocks, where they left tracks much like those discovered in Pennsylvania. Besides Dr. Caster made experiments with living crabs to see what kind of imprints they left.

ELECTRON BULLETS: Dr. George B. Collins of Notre Dame, assisted by Drs. Eugene Guth, Bernard Waldman and William Poyle, has succeeded in breaking up the beryllium atom into two atoms of helium and one neutron. The achievement is noteworthy because the beryllium was bombarded not by the usual protons (cores of hydrogen atoms) but by electrons. Speed and hitting power are needed to smash an atom. Hence the tendency is to use heavy bullets. The electron, only 1/1847 the weight of the hydrogen atom, must be given high speed to do any atom-smashing. Dr. Collins and his associates gave electrons the necessary momentum in a gigantic X-ray tube, twenty-five feet long. Pushed by 1,750,000 volts they were able to hit beryllium with sufficient force. No mean task, this. When electrons strike anything penetrating X-rays are generated. The Notre Dame physicists had to keep fifty feet away from the tube on account of the rays. Dr. Collins tells about the work in The Physical Review.

GRINDING BY ELECTRIC EAR: Rock and ore grinding mills hum, groan and roar. The louder they are the more inefficient they are. Harlow Hardinge provides them with an electric ear in the form of a microphone, so that they can hear themselves. When the noise becomes microphonically unbearable to the mill more material is automatically fed. When there is little noise the "ear" pricks up as well as its circuit, because quietness is a sign that the supply of raw material should be cut off. So just by listening to itself a crusher or grinder makes rock and ore run more rapidly or more slowly into the hopper.

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