PHYSICS

Precious Waste Products

What is left after the atomic bomb is produced will open up entirely new fields of medicine and in the treatment of disease.

By CALVIN MOORES and MARJORIE VAN DE WATER

➤ SPLITTING the atom is the greatest scientific achievement of our age.

But the greatest immediate contribution of this research to peacetime living is probably in what were the waste by-products of the Army's atomic plants.

The radioactive substances that were merely a troublesome problem of separation and disposal in the process of making an atomic bomb, will open up entirely new fields of medicine and may supersede X-rays for use in industry to look through metals for hidden defects.

The power that is released by the shattering of uranium atoms may also find special uses. Atomic power might be used to run giant power plants—possibly in countries now undeveloped because they do not have common fuels such as coal.

You will not have an atomic furnace in your basement. Nor will you be able to "fill 'er up" with atoms at the corner filling station. Airplanes will not be sent rocketing through space on the backfire of a bomb such as dropped on Hiroshima.

The terrific heat generated by atomic explosion would not only melt, but vaporize the airplane. And if you had an atomic power generator small enough to fit under the hood of your car, when you stepped on the starter you would blow your whole town to atoms. That is because the only small atomic power generator that we know is the atomic bomb.

Power Under Control

Scientists are now producing stupendous amounts of power under control, but this requires huge plants such as the one on the Columbia River at Hanford, Wash.

In this plant, the energy is being considered as a waste by-product and is being thrown away into the Columbia River in the form of heat. This plant, designed for the production of plutonium for use in the atomic bomb, produced the equivalent of 1,500,000 kilowatts in wasted heat for each kilogram of plutonium in the daily output. The ultimate capacity of the hydroelectric plants at the Grand Coulee Dam is expected to be only 2,000,000 kilowatts.

The steps in producing plutonium are roughly these:

1. Raw material in the form of uranium metal is fed in. A small part of this is uranium 235, a larger part is "ordinary" uranium 238.
2. Atoms of uranium 235 are exploded, producing neutrons. Heat and radioactive substances are by-products.
3. Some of the uranium 238 is converted by neutrons into uranium 239.
4. Uranium 239 changes to neptunium 239.
5. Neptunium 239 changes to plutonium 239. Plutonium, in this plant, was the end product and was chemically separated from the unchanged uranium and the radioactive waste products. But since only a small fraction of the original uranium was used up—
6. As a final step the uranium could be recovered and fed in again to repeat the process.

Heat Is By-Product

But in a power plant it is probable that the plutonium would not be removed. Part of the plutonium would explode along with the uranium 235, producing enormous quantities of heat, and the rest would be converted into uranium 235 which makes the process a complete cycle. In this way eventually all the uranium 238 is converted into plutonium and uranium 235 which are burned up and changed to heat.

The atomic power plant of the future can be built using many of the principles of the Hanford plant for making plutonium. But in addition to the apparatus for splitting atoms it must have steam turbines, generators and condensers like those used in a conventional steam generating power plant. Moreover, location on a river, with its cooling water available for the condensers, will still be necessary.

The familiar apparatus is necessary along with power transmission lines, because the heat produced by splitting atoms is of no use to you in your home until it has been converted into electricity and delivered to your light bulb, toaster or washing machine.

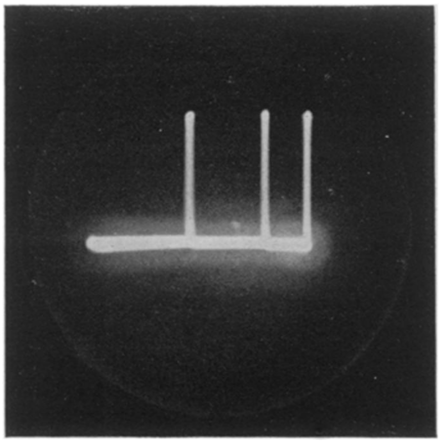
The uranium atoms substitute only for the coal or other fuel, and require a much more complicated furnace to burn them in. But, nevertheless, they might not be more expensive.

Natural uranium may be expected to cost somewhere in the neighborhood of $22 a pound. Coal would not be more than that by the ton at retail. But 140 pounds of natural uranium contain only one pound of U-235. You can get 1,000 times as much electric power from a pound of uranium 235 as you can from a ton of coal.

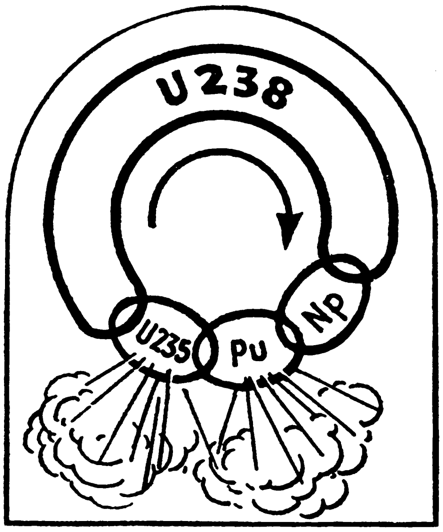
For the present-day consumer this saving would be swallowed up by the great cost of converting the heat to electricity and delivering it to factory and home. In a coal-powered plant, the fuel cost is only one-tenth of the price of the electricity to the consumer. Therefore atoms for fuel could not reduce your bill more than about 10 per cent.

The processes of generating electricity from heat and power transmission are not expected to be changed greatly by the coming of atomic power.

The heart of the atomic power plant, the uranium disintegrator, consists of a sphere built up of graphite blocks. It may be between 20 and 30 feet in diame-



ATOMIC PULSES—In 1939, uranium atoms were first split experimentally, with slow neutrons and much atomic energy released. When the energy is detected and put into an oscillograph, electrical pulses can be seen which closely resemble those shown.



CHAIN REACTION—A small proportion of uranium metal consists of U-235, a larger part is U-238. By splitting the uranium atoms, tremendous power is generated, in an endless chain process.

ter. Graphite is the stuff your "lead" pencil is made of. Into tunnels cut through the graphite sphere are pushed ingots of uranium metal just as it is purified from the ore.

From this point on natural atomic processes, aided by the graphite surroundings, cause some uranium atoms to blow up, releasing power and in turn causing other uranium atoms to blow up in a sort of endless chain.

These atomic explosions cause heat, and this heat can be picked up by circulating a cooling liquid in channels around the uranium ingots. The coolant is then brought out and used to produce steam in a high-pressure boiler. The steam may then be used to operate a conventional turbo-electric generator. Cooling water is then necessary to condense the steam and repeat the cycle.

The astonishing process of apparently spontaneous combustion of the uranium atoms is made understandable by the best present conception of atomic structure and behavior.

Uranium is a hard, heavy, white metal. It is a chemical element and therefore the atom is the smallest unit of it; if you smash the atom you no longer have uranium. All atoms have standard interchangeable parts.

In the heart, or nucleus, of the atom there are protons and neutrons, and it is the number of protons in an atom that determines which element it is. Some uranium atoms have more neutrons than others and are therefore heavier. The two most abundant kinds of uranium have atomic weights of 235 and 238, one type having three more neutrons than the other in the atom. The uranium of weight 238 is 140 times as plentiful as uranium 235.

Ordinarily an atom nucleus is very stable and cannot be broken up except when it is struck with great force by an object smaller than the atom, that is, a part of another atom, for example, a neutron. When the atom bursts, its parts fly out and these may, in turn, strike other atoms.

When the uranium ingots are pushed into the graphite sphere any stray neutron which finds its way to a uranium 235 atom will cause it to blow up and shoot out three new neutrons at high speed. These high-speed neutrons are slowed down by successive collisions with the carbon atoms of the graphite. They collide an average of 200 times and then at low speed find their way back to another uranium 235 atom, producing another explosion.

If the neutron is going neither too fast nor too slow but is slowed down to a medium speed when it strikes a uranium 238 atom, it may not shatter it. It just sticks and makes it uranium 239. This is unstable and turns into neptunium 239, which lasts only a few minutes before it turns into plutonium.

The possible uses of plutonium other than as a super-explosive have not been explored, or at least have not been made public. It is radioactive. It will be difficult to store or transport because except in small amounts it would blow up. It may be that its only usefulness will be in scientific laboratories. It would make possible a small-sized substitute for the giant atom smashers for producing neutrons.

The "waste" by-products of an atomic power plant are the poisonous and intensely radioactive substances, some of which are gases. But it may very well turn out that in the future extremely important uses will be developed for these. Physicians may find that they can be used to treat diseases in new ways or as a substitute for precious radium. They may be used in factories in place of X-rays to detect flaws in large castings.

Nearly all the research leading up to the atomic bomb was focused on the splitting of uranium atoms. There is a possibility, however, that the atoms of other elements may be split with equally spectacular results.

It is not likely that we will be able to explode for power production the atoms of common materials such as water, iron, carbon or even lead. It was not an accident that uranium was first used—the atom of uranium is the heaviest of the elements occurring in nature and therefore could produce lots of energy. Moreover, the uranium atom is comparatively easy to split.

While physicists and the public, especially the Japanese public, are very much impressed with the terrific power of the new atomic weapons, other scientists who deal with such natural phenomena as earthquakes, volcanoes and hurricanes are not so greatly awed because compared to these natural catastrophes an atomic blast does relatively little damage.

That is because these natural phenomena get their energy indirectly from the biggest atomic furnace in our section of the universe—the sun.

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