PHYSICS

X-Rays Speed Defense

From Cancer Hospitals, Million-Volt Compact Machines Go to Factories Where They "Look" Through 5-Inch Steel

By JAMES STOKLEY

See Front Cover

X-RAYS of 1,000,000 volts are helping America's defense.

Great industrial plants, building huge machinery, have installed equipment to produce these penetrating rays. Steel castings five and six inches thick can be examined as if they were made of glass. Holes inside the castings, and other defects which might mean the failure of a vital part in a warship, a tank or airplane, are found and remedied before they can do any harm.

Only a few years ago 1,000,000-volt X-rays were not in existence. Then elaborate equipment was developed to produce them, and installed in a few hospitals for cancer treatment. But the rugged surroundings of a foundry are quite a different matter from the hospital laboratory. X-rays of lower power had already shown their industrial value. Thick metal parts, however, required X-ray exposures of many hours, far too long to permit a routine examination of the product of a foundry working in high gear.

A giant X-ray outfit, with its 1,000,000 volts, does the work of $90,000,000 worth of radium, and costs only $40,000.

The 1,000,000-volt unit was made smaller and simpler. It weighs 1500 pounds, about a third that of its immediate predecessor. This may not seem very portable, but it is nothing in a plant equipped with cranes for hauling 40-ton castings around. The 1,000,000-volt outfit is just as portable, in relation to the material it works on, as the little X-ray equipment in your dentist's office, with which he detects cavities in your teeth.

Two Units for Navy

Two of the new units are going to the U. S. Navy, for the yards at Philadelphia and at Norfolk. The Ford Motor Co., at Dearborn, Mich., Babcock and Wilcox, at Barberton, Ohio, Combustion Engineering Corporation, at Chattanooga, Tenn., American Steel Foundries, General Electric, at Schenectady, N. Y., have installed them, all for inspection of work in the defense program. Another will soon be in place at the plant of the Campbell, Wyant and Cannon Foundry Co., at Muskegon, Mich., to inspect armament and motor castings which it will build for defense. And still other units are planned.

These 1,000,000-volt X-rays represent the latest stage in a series of researches extending back nearly half a century—back to the time that Prof. Wilhelm Konrad Roentgen discovered X-rays in 1895. His discovery came in the course of a research program dealing with electrical discharges in glass tubes from which most of the air had been exhausted.

Caused When Electrons Stop

X-rays, it turned out, are caused when electrons are suddenly stopped by a solid substance. They are like light waves, but many times shorter in length. In early tubes the electrons were torn out of the cold metal surface of one of the electrodes inside—the cathode. The X-rays were very erratic in behavior, because of the difficulty in controlling accurately the minute amounts of remaining gas. Then, in 1913, Dr. William D. Coolidge, at the General Electric Research Laboratory, invented the tube now almost universally used. Gas is almost completely removed. Electrons are supplied, not from a cold cathode, but from a small glowing filament, like that of an electric lamp. High voltage is applied as in the old tube, the electrons are pulled along, and thrown with great speed against a target of metal, usually tungsten, from which the X-rays radiate.

To get more and more penetrating X-rays, voltages were increased, but there proved to be a limit. If the voltage gets too high—up to several hundred thousand or more, much above that needed for ordinary medical X-rays—"field currents" appear in the tube. These are produced by electrons torn out of cold metal. They make the tube erratic, may even cause its destruction.

About a decade ago, Dr. Coolidge found that these field currents could be eliminated if the high voltage was applied in steps. Tubes were built in several sections, perhaps a hundred thousand volts being put in each one. If there are five sections, with this voltage, after the electrons have passed all the way through, they will have as much energy as if 500,000 volts had been applied at once.

Using this principle, about five years ago, Dr. Coolidge and Dr. Ernest E. Charlton developed an outfit using 800,000 volts. It was made for a hospital, to give high-power X-rays for cancer treatment. The tube was 14 feet long and a foot in diameter. With its bulky high voltage generator, a special building had to be erected to house it. Certainly this was no unit for knocking around a factory.

Again research, under the direction of Dr. Charlton, head of the X-ray division of the General Electric Research Laboratory, solved the problem of simplifying the outfit.

The other day Dr. Coolidge, who is now vice-president in charge of research of the General Electric Company, paid tribute to him and his associates.

"The research work involved," said Dr. Coolidge, "occupied the full time of an average of six men for a period of four years, and this, starting of course not from scratch, but with full knowledge of the X-ray generating equipment of the prior art."

Two Developments Responsible

Two developments were mainly responsible for the new unit. Enclosed X-ray equipment had previously used oil in the casing to insulate the parts from the high voltages. Now it was found that Freon gas, developed for use in electric refrigerators and known chemically as dichlordifluormethane, could be pumped in under pressure and was more effective.

Also, a new type of transformer was designed by W. F. Westendorp. This is called the resonance transformer; it eliminates the iron core that normally forms the center of the coils of wire. With the core gone, the multi-section X-ray tube itself, 30 inches long and 3½ inches in diameter, was placed in this central position, an advantageous one making for compactness and shortening the electrical connections.

A metal extension of the tube projects two feet from the cylindrical tank which holds the entire equipment, and from its end emanate the X-rays. Some shoot straight ahead, as from a gun, others are

DEFECTS REVEALED

A million volt X-ray picture through several inches of steel looks like a fogged film but the white spray is due to defects in the steel.

sprayed to the side. Ordinarily the direct rays are used, but sometimes the side ones are convenient. The snout can be placed at the center of a boiler and radiographs, as the X-ray pictures are called, taken with a single exposure on a series of films all around the circumference.

The 1,000,000-volt outfit will photograph through five inches of steel in 2 minutes. A tube operating on 400,000 volts, the next size smaller, requires three and a half hours for the same job. Even then, the lower power picture does not show nearly as much detail in the thicker sections. In this way the new apparatus speeds inspection of parts for vital defense machinery, to be used on land, at sea, and in the air.

When a steel casting is found to have a defect, such as an inclusion of slag, the radiograph shows its position; the casting is sent back to the foundry and the defect is chipped out. Then new metal is welded in and the part is again X-rayed. If satisfactory, the construction of the machine is completed.

Even on smaller parts, high-voltage is a help, as the tube can back way from the job and spray a large area with the rays. Don M. McCutcheon, in charge of the X-ray laboratory at the Ford Motor Company, found, with a heavy part destined for a large bombing plane, that at least six exposures were needed for each casting with 400,000 volts, while the 1,000,000-volt machine completely X-rayed six entire castings at once.

Million-volt X-rays were not developed because of the urgent defense activities, but their application has been speeded. A present-day parallel is seen in the way in which the last war made popular the general use of medical X-rays. Still somewhat of a novelty in 1914, doctors called to military service had to use them. They learned their advantages, and continued to use them in private practice after the war.

Now that many industries are being forced to use X-rays by the requirements of defense, they, too, will learn their value, and will keep on using them after the wartime rush is over.

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GEOLOGY

Idaho for First Time Enters Mercury Mining Picture

One Mine in Large-Scale Production, One Just Opened, Still Others in Prospect; Some Gold Found With It

MERCURY, vital defense metal, is now being mined on a large scale in Idaho, which until three or four years ago did not figure as a mercury-mining state at all, the U. S. Geological Survey states. One mine, in the Weiser deposits 50 miles northwest of Boise, is already in large-scale production. Another has just been opened, in another ore body some distance away, in the eastern part of the state. Still others are in prospect.

The Weiser ore body has been studied in detail by a Cornell University geologist, Prof. Alfred L. Anderson, who made the examination for the U. S. Geological Survey. His report has just been published by the Idaho Bureau of Mines.

This ore body, Prof. Anderson says, "was discovered in 1937. It aroused much interest, both because it is in an area not previously known to contain metallic lodes and because in the last two years of its operation it has brought Idaho into the list of states that contribute notably to the production of quicksilver."

Mercury is one of the vital defense elements, a key in any munitions program, being used in the detonators of all kinds of explosives, in scientific instruments essential to warfare, and also in drugs and antiseptics.

The United States has been a poor third to Spain and Italy in its production and since the beginning of the war has been cut off from a large part of its previous supplies imported from those countries. This curtailment has been reflected in the price of mercury, which has skyrocketed from $1.60 to $2.90 a pound.

The mercury occurs as cinnabar, a sulphide of mercury. This mineral is found impregnating siliceous, opalized rock which resembles red iron ore. The ore is mined from shallow excavations as well as from some subsurface workings and yields 5 to 15 pounds of mercury to the ton. After mining, the ore is ground and heated to drive off the quicksilver as a vapor. The vapor is then condensed by cooling to give the liquid metal.

Dr. Anderson says that the mineralized ground extends over more than 100 acres, but only a fraction of this has been thoroughly explored. He adds that some gold is found in the mercury, but the quantities are too small to be of commercial value.

Other states leading in the production of mercury are: California, Oregon, Texas, Arkansas and Nevada.

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CHEMISTRY—AGRICULTURE

Two New Plants To Make 20 Tons of Starch Daily

CARLOADS of cull white potatoes, a former waste product of farms, will be fed into two new starch plants which started operation in October in Idaho, thereby adding about 20 tons of starch a day to the nation's supplies and bringing $280,000 a year of new wealth to farmers.

The plants, at Blackfoot and Twin Falls, will use about 19,000 tons of cull potatoes apiece in a year, paying a base price of $3 a ton plus a bonus.

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