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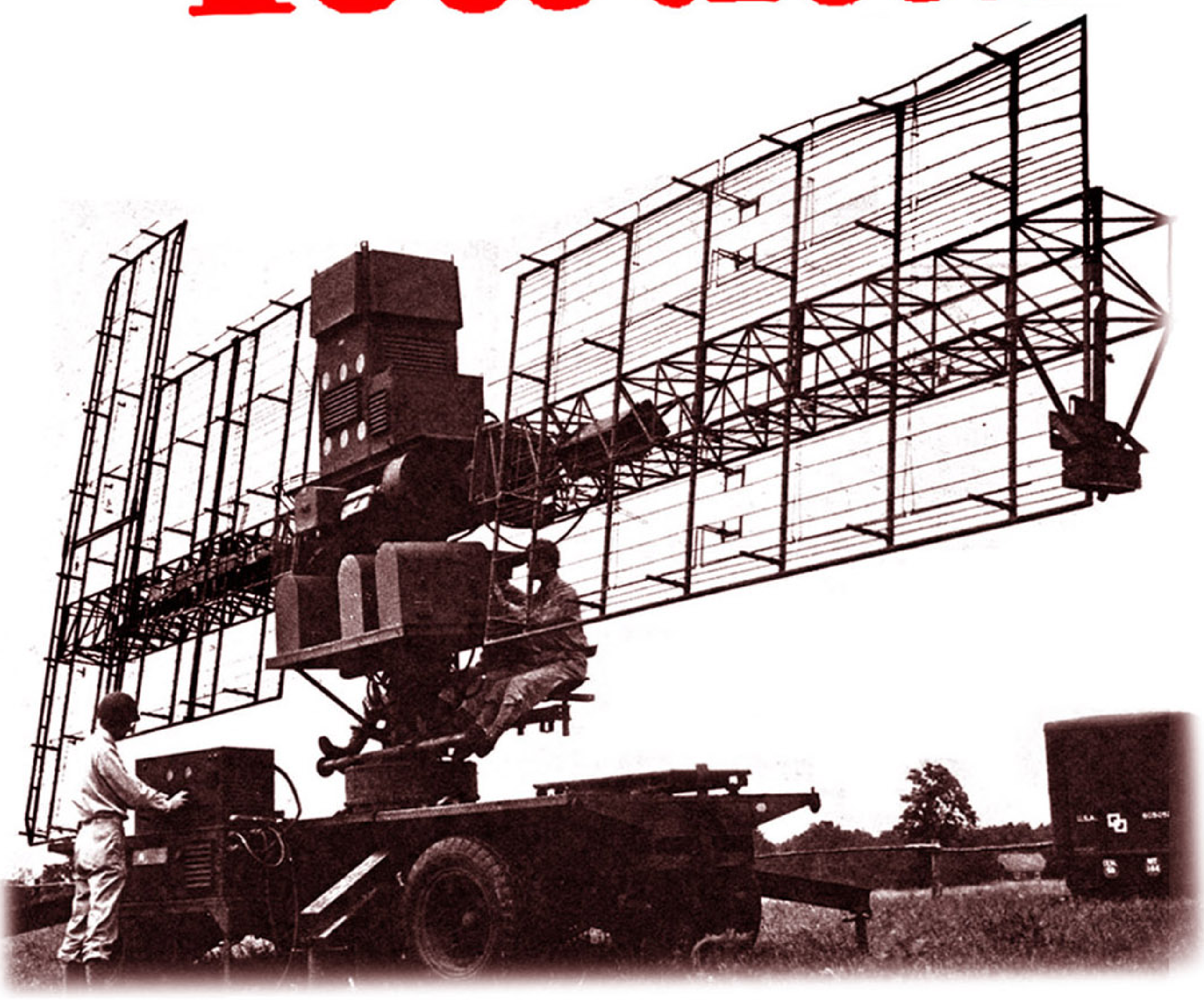
Radar



This anti-aircraft radar set is manned by four soldiers. The standing lator, and the other three, on high elevated seats, operate the ve position scopes and the range scope. The windmill-like structure

In a war which wound up in an atmosphere of scientific marvels, radar ranks high as a stand-out achievement. The Army has taken the wraps off the secret story of what makes radar tick.

By Pfc. ROBERT BENDINER

BOCA RATON ARMY AIR FIELD, FLA.—In the midst of the vast excitement that followed the unleashing of the atomic bomb, the Army for the first time permitted publication of the basic facts about radar. To a lot of people, the radar disclosure seemed pretty small potatoes compared with the news about the atomic bomb. In the opinion of many well-informed analysts, however, radar's place of honor among the scientific marvels which helped win the war is second to none.

"Radar played a greater part in the whole war than the atom bomb itself," according to Sir Stafford Cripps, formerly Britain's Minister of Aircraft Production. In fact, Sir Stafford adds, "it contributed to the winning of the war more than any other single factor." That is a tall claim, but it is supported by a number of our own Army and Navy authorities. And here are a few of the reasons:

1) It was radar that enabled the RAF to save the day when the *Luftwaffe* threatened to bring England to her knees. No matter how thick the fog or black the night, radar's penetrating eye picked up the German planes as they left the Continent, gave the RAF fighters the maximum time and the most accurate information to counter the attack and sighted the ack-ack guns with deadly accuracy. On Sept. 15, 1940, radar-guided ground and aircraft guns combined to down 185 out of 500 attacking planes. Germany's air arm had met its first serious defeat.

2) It was radar that drove the U-boat from the seas. In 1942 the subs were sinking 16,000 tons of Allied shipping a day. Our Atlantic coast was strewn with wreckage; the loss of life was heavy and the loss of supplies grave enough to threaten our ultimate success in the war.

Carried in aircraft that swept the coasts and the major sea lanes, radar spotted the subs 10 miles off when they surfaced at night to charge their batteries and take in fresh air. High-speed planes were notified and guided direct to the targets. In three months of 1943, 100 U-boats went down.

3) It was radar that played a major part in protecting our convoys so well that we lost only 1/10th of one percent of our convoyed ships; it was radar that directed our bombers in paralyzing

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German coast defenses on D-Day; radar that guided our paratroopers to landings in Normandy and Holland; radar that put our bombers over Europe in fog, darkness and rain; and radar that made it possible for our ships to steam closer to enemy shores in the Pacific under the cover of night than would have been thinkable to the most daring commander in the days before the "magic eye."

Until a short time ago radar was among the most hush-hush subjects of the war. Thousands of men in the forces had worked with it, but all were sworn to secrecy. Radar operators and observers were known as "radio operators," and students in American radar schools were forbidden to take their notebooks out of the classroom. In Britain, radar development was carried on in a secluded Suffolk manor over whose entrance was a coat of arms with this misleading motto: *Plutôt mourir que changer.* ("Better death than change.") But now the lid has been lifted, though not yet quite all the way.

To understand the underlying principle of radar, you need only know that certain radio waves, or pulses, traveling with the speed of light (186,000 miles a second), bounce when they hit an object in their path. If the object is squarely facing the source from which the waves have been sent, they will bounce back to the source. If the object is partially directed away from the source, only some of the waves will be returned, the others bouncing off at an angle and losing themselves in space.

The principle is simple enough, but the application of it proves very tricky. It was clear from the start that if a radio wave of sufficiently high frequency could be directed at a given target and an observation made on the time elapsing between the transmission of the wave and its return, the target's distance could readily be calculated. It was clear, too, that if such waves could be beamed out in all directions, they would, by their return impulse, reveal any targets that happened to be in their path. The problems were to devise a sufficiently powerful short-wave transmitter to do the beaming and a receiver to record the returned waves as they bounced back.

Actually the problems did not at first present themselves in such clear terms. Radar (short for "radio detection and ranging") is, like radio itself, the product of evolutionary development in which each major step opens up new vistas. In its crudest form, the radar principle was first noted in 1922 by two scientists employed by the U. S. Navy, Dr. A. Hoyt Taylor and Leo C. Young. Experimenting with radio communication in the fall of that year, Taylor and Young discovered a distortion in received signals due to the reflection from a small wooden steamer on the Potomac. After further experiments, they reported to the Navy that "destroyers located on a line a number of miles apart could be immediately aware of the passage of an enemy vessel between any two destroyers of the line, irrespective of fog, darkness or smoke screen."

Work in this field progressed independently in the U. S., England, France and Germany throughout the 1920s and 1930s. In this country the Signal Corps, the Navy, private industry and, later, the Air Forces all had a hand in overcoming the technical problems involved in developing radar from its crude beginnings into the highly effective instrument it is today. Means had to be developed for generating pulses of the proper length, a receiver had to be devised which would not be blocked by the transmitter pulses, and a cathode-ray tube had to be designed to display the pulses as they were received.

Step by step, all these technical difficulties were overcome. Radar began to take shape. In 1938 a working shipboard model was installed on the U.S.S. *New York* and in the following year it received a workout in battle maneuvers. In 1938, too, the Coast Artillery gave radar a tryout as an anti-aircraft device.

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In addition to locating planes, the new equipment tracked shells in flight and also guided back to a safe landing an Army bomber that had gone astray during a demonstration and had been blown out to sea. In 1939, the AAF, which had been working closely with the Signal Corps, ordered radar equipment in quantity, and the air arm has since come to be the largest user of radar in the service.

In 1940, an agreement was reached with the British to pool the findings of laboratories on both sides of the ocean, and from that point on progress has been made with such rapidity that an industry which was almost non-existent before 1940 has since sold to our own armed forces alone millions of dollars' worth of equipment. Radar has overnight made electronics an industry comparable in size with the automobile industry before the war.

Basically, all radar equipment has just a few major features. It has, first, a modulator, a device for taking power from whatever generating source is used and applying it to turn a radio high-frequency oscillator on and off. It is this oscillator that emits the necessary waves in short bursts, so timed that returning pulses may be recorded between bursts. For this purpose a highly developed vacuum tube has been evolved; it's capable of operating at a power thousands of times greater than was thought possible a few years ago.

Then there is an antenna which concentrates the radio energy into a well-defined beam. The antenna must be capable of being swung from one point in space to another, so that the direction of the rebounding pulse—and consequently of the target—may be determined. Next, there is the indicator, which presents the information in the form best adapted to the particular radar set. The most striking of these indicators is the PPI, or Plan Position Indicator. This, a round, fluorescent glass disc, the face of a cathode-ray tube, is an ever-changing topographical map. Water, which reflects few of the transmitted pulses, appears as black; land, with a number of smooth surfaces facing in the direction of the plane or ship from which the pulses are beamed, shows as gray; while built-up areas, with a great many smooth surfaces directly in the path of the beam, are reflected on the scope as bright patches. Individual objects, such as ships at sea, or airplanes in the vicinity, appear as bright "pips"—"blips," the English call them.

This particular scope is a feature of the amazing BTO set (Bombing Through Overcast). BTO, the peak of electronic development, was kept so secret during the early days of its use that except for the radar operator himself even the crews of planes that carried it were kept in the dark about its details. Crews referred to the BTO mysteriously as "Big Time Operator" and later more widely and more fondly as "Mickey." First used by the British, Mickey was tried out by our Eighth Air Force in the raid on the Wilhelmshaven docks in November 1943. Nine pathfinder planes, each leading a combat wing of 60, were equipped with this marvel, which not only guides a pilot to his target and tells him exactly when to begin his bomb run, but, geared to his bomb sight, also automatically releases the bomb at the strategic moment.

On eight previous raids over Wilhelmshaven our airmen had missed the city's docks entirely. With Mickey, bombing through overcast, they dropped a heavy concentration of bombs on the target area and did considerable damage. Without radar, the Eighth had been compelled to mark time with a force capable of operating 10 to 20 times more often than the target weather would permit. In 1942, our planes were grounded throughout December; in December 1943, using radar, they dropped bombloads that broke the record for any month to that date.

Mickey did a remarkable job in the air offensive that softened Germany for the kill, but it was only one of the many forms in which radar

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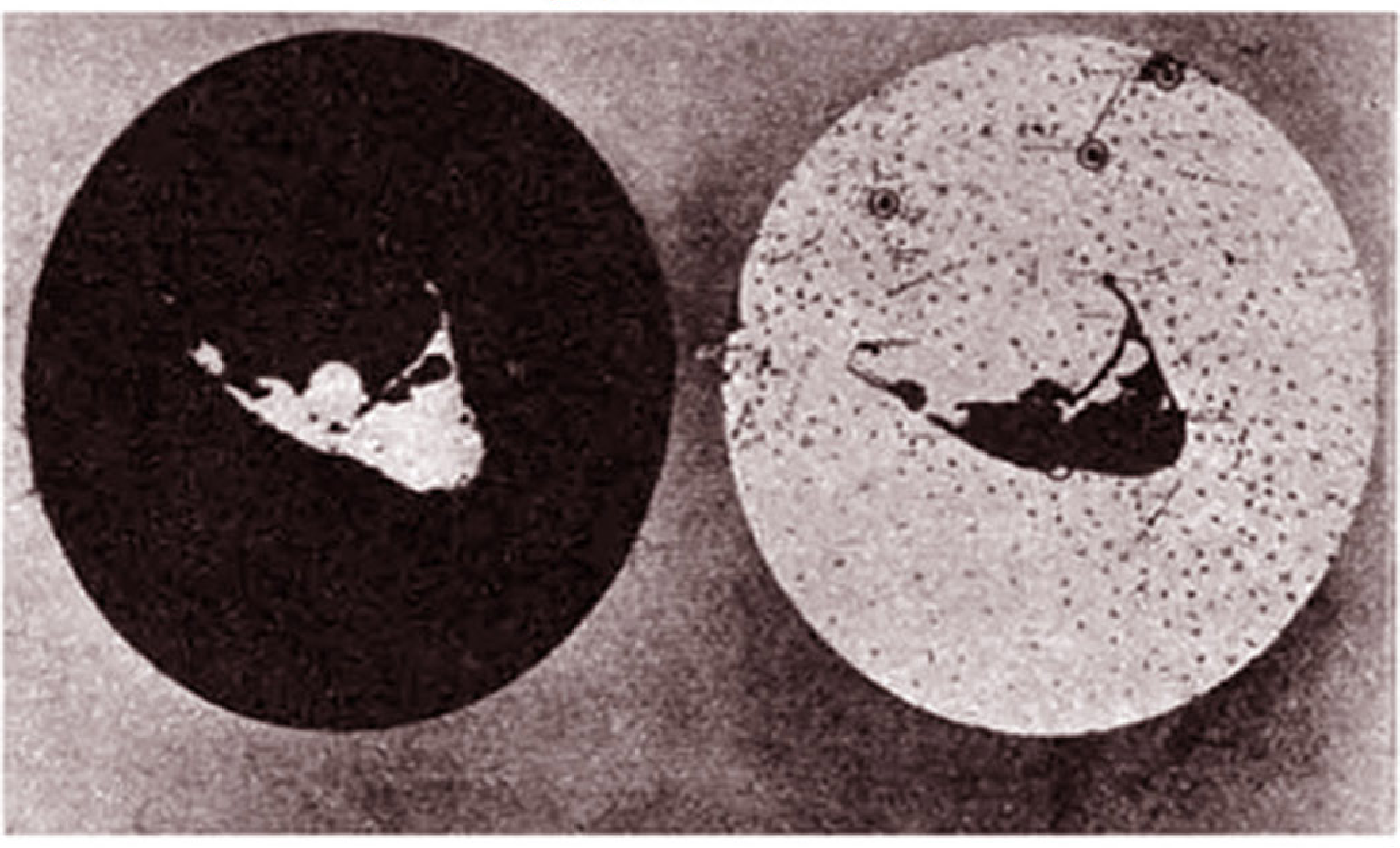
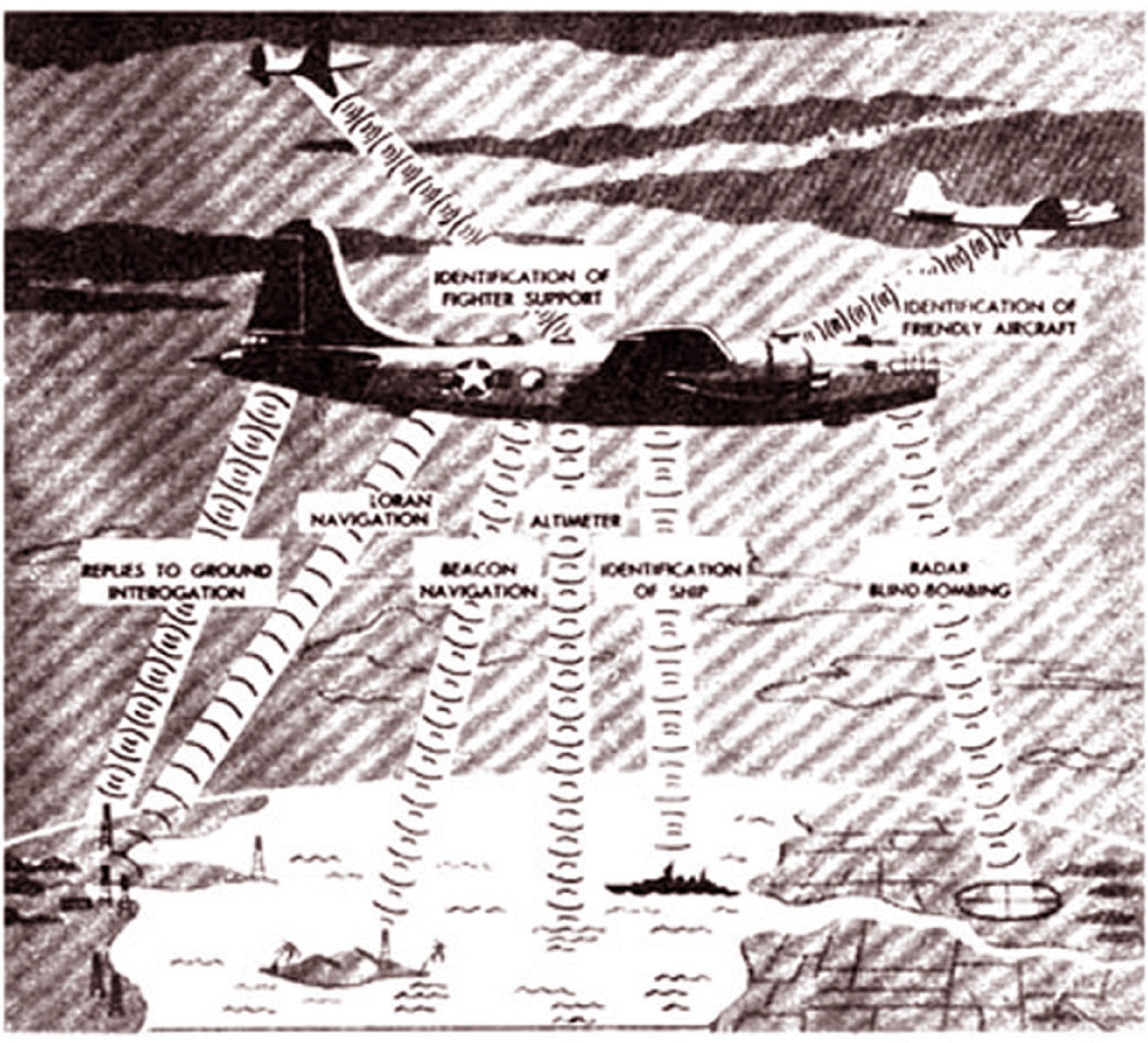


A comparison of an aerial radar photo of the island of Nantucket, Mass., with a chart (right). On the radar screen, land areas appear white and water black. Aircraft or shipping show up as white dots.



The B-29 is sometimes referred to as a flying radar set. This picture shows the functions of five types of radar equipment which are used by the Superforts.

was used against the enemy. Perhaps the simplest and at the same time one of the most useful applications of the principle was in the Tail Warning Set, most commonly used in night fighters. A fighter pilot, concentrating on maneuvering his ship, might be surprised by a sudden attack from the rear—but not if he had this handy gadget. Let an enemy plane approach within 600 feet and the radar-operated Tail Warner would pick the enemy up, flash a red light on the pilot's instrument panel, and also blow a horn or ring a bell, just to make sure.

Many night fighters were also equipped with AI, or Aerial Interception, a compact radar instrument that was used to track down enemy planes at night or in poor visibility. It required such close coordination between radar observer and pilot that pairs, once established, were seldom broken up. The observer, watching his scope, would keep up a running flow of chatter which sounded like nothing so much as a broadcaster giving a blow-by-blow account of the heavyweight battle of the century.

An ingenious radar device is IFF (Identification, Friend or Foe). A ground station located, let's say, with an anti-aircraft battery, picks up an approaching plane on its radar set. Unable to tell, through the overcast or darkness, whether it is an enemy plane or one of its own, the station sends out an interrogating pulse. If the plane is friendly, its IFF transmitter is triggered off by the pulse and proceeds, without human operation, to send out a coded signal. The gunners down below hold their fire and, if necessary, the plane is guided on its way.

Then there is the radar altimeter which, by measuring the time required for a pulse to strike the earth and return, reveals absolute altitude, recording even the smallest ridge or elevation below. This is a great advantage over the barometric altimeter, which shows only altitude above sea level. With the radar altimeter a pilot can avoid such hazards as mountain peaks—or even the Empire State Building. An auxiliary attachment to this altimeter provides a three-light warning board to keep a pilot at a predetermined height. If he gets too high, a green light flashes on, if too low he is given a red signal, while amber informs him that all is well. This device is useful in the dropping of parachute troops.

AMONG the newest applications of radar is GCA, or Ground Control Approach. It is aviation's answer to the eternal threat of bad weather and is expected to put civilian air lines on schedules as reliable as the railroads'. This piece of equipment may be set up on any landing field, where it will proceed to pick up planes approaching the field from a distance of five to 30 miles. A ground operator, having located a plane struggling to come down through a heavy fog, communicates with its pilot by radio and, observing every foot of the plane's progress, "talks it in" to a safe landing.

British "Gee" and American "Loran" (Long Range Navigation) are devices that have already revolutionized both nautical and aerial navigation. Based on the transmission of waves broadcast from several fixed ground positions, Loran enables planes or ships to take fixes more readily than by celestial observation and just as accurately. Unlike astronomical bodies, Loran can be consulted in any weather, and it was a major factor not only in putting thousands of bombers over Europe on the blackest nights but in concentrating them at appointed rendezvous.

Radar sounds complex, and the instrument panel of a completely equipped plane does look like a Hollywood scientist's dream, but in fact the operation of most radar machinery may be learned in a matter of hours. Skilled observation, however, comes only with extensive practice.

In the instruction of radar personnel, the services had a monumental task on their hands. Research, development, production and instruction were all carried on at the same time, and equipment, tested in the field by trial and error, gave way to improved versions as fast as men learned to use it.

The entire program, moreover, had to proceed in such secrecy that even mention of radar off the field was grounds for court martial. "Probably no scientific or industrial development in the history of the world," says a report on the subject recently issued by the Office of War Information, "has expanded in all phases simultaneously, and on such a scale."

Starting with small informal classes carried on by the Signal Corps Laboratories in 1937, radar education has grown to such proportions that Navy schools have put more than 125,000 officers and men through advanced courses, while in the Army the Air Forces alone graduated 23,175 radar men in the first six months of this year, as compared with 818 for the first half of 1942.

The men picked for radar, generally top students at radio schools throughout the service, have tested their gadgets in the clouds over Europe, in the mists of the Atlantic and in the storms of the tropics. They know that the atomic bomb hastened the end of a war whose outcome was no longer in doubt, but they know, too, that radar, the "magic eye," helped tremendously to remove that doubt.