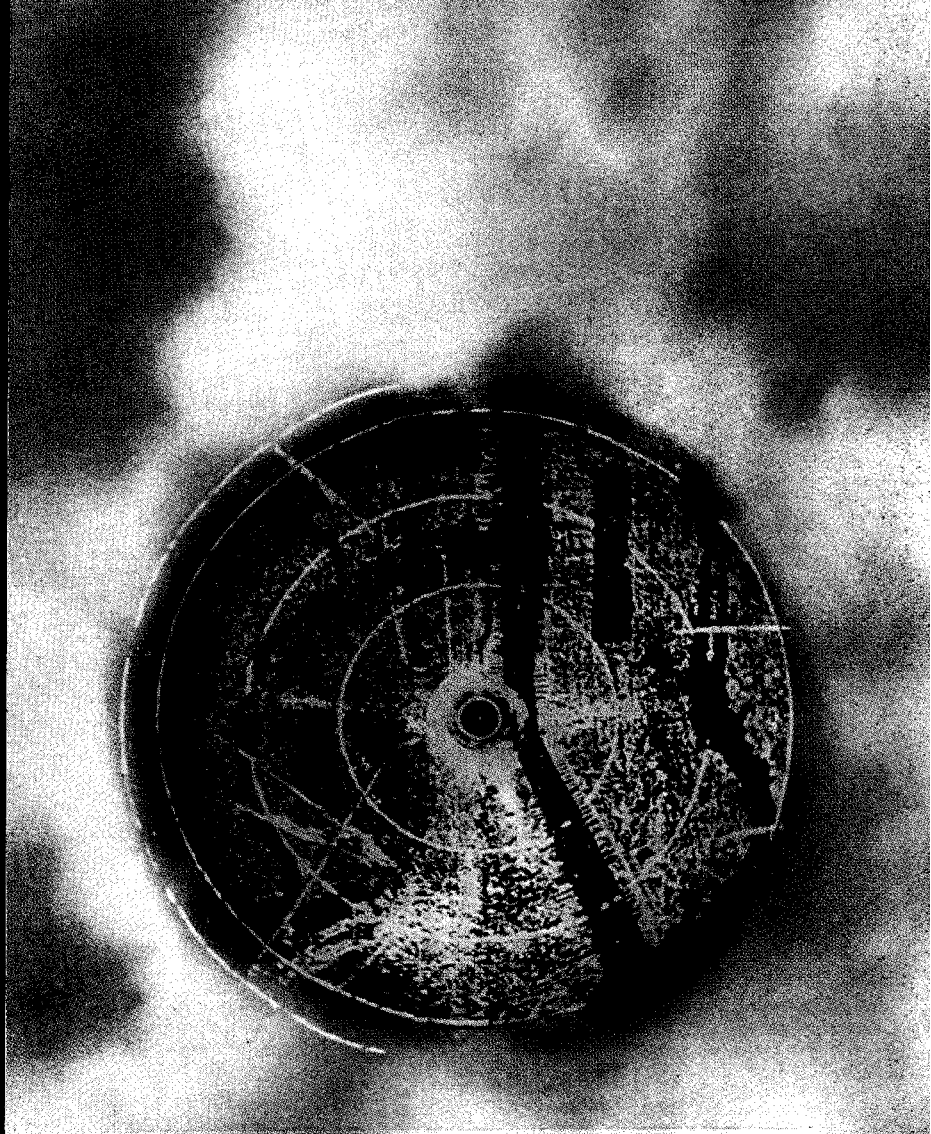
The Great Detective



Radar Scope photograph of New York City, taken from a B-17 by Radiation Laboratory staff members. This photograph was taken with high definition apparatus which provides radar identification of important military objectives. The outline of Manhattan Island clearly shows the Hudson river with its shipping docks. The Metropolitan Museum can be seen jutting out into Central Park. On the New Jersey side the Hackensack river is clearly visible. At the time the photograph was taken the plane was directly over the spot in the center of the circle. Distance is indicated by the concentric circles used for navigation and bombing.

The Great Detective

by

Wesley W. Stout

Chrysler Corporation
Detroit, Michigan
1946

AN investor has a natural interest in how well his savings have been put to work by the managers of a corporation in which he has invested.

Here is a report of another kind: of how the investor's money, plus his taxes, was put to work in the defense of his country in a time of great peril.

This book deals with only one such instance of many within Chrysler Corporation, one of many thousands in American industry generally, but there were few more dramatic or more decisive.

Foreword

In radar the Allies were engaged in a deadly race with the enemy for technical supremacy from the first year of the war, a race in which they continuously and increasingly bested German science and manufacture for all Germany's acknowledged prowess in these fields.

"We fell behind technically," said Grand Admiral Doenitz, when captured. "We were unable to build short wave radar to compete with the Anglo-American improved radio location equipment."

Dr. DuBridge, Director of the Radiation Laboratory, has written generously of Chrysler's part in short wave radar. If he and his fellow physicists found it worth while to work with our engineers and production men, we found it exciting to work with these magicians of electronics. Working as a team on radar and other strange new weapons, American Science and American Industry discovered a mutual respect which, if it is carried over into peace, will not have been the least gain of the war.

K. T. KELLER
President

Chrysler Engineering Division building where a fundamental problem of gun-laying radar was solved. (below) the Dodge Main plant where the SCR-584 radar mount was made.

The Great Detective

When the Japs struck Pearl Harbor on that Sunday morning of December, 1941, the public was told that a detecting device had flushed their carrier-based planes when these still were half an hour away. This was radar, though the name was not spoken then or until long after.

The public was puzzled. It was familiar with the nest of horns of the old sound-listening post, photographs of which it had seen often. But as any high school boy knows, sound travels only 700 miles an hour, little faster than a 1946 jet plane, and dissipates so quickly that it is lost within a few miles.

What was this legerdemain, then? The public learned for the first time on April 24, 1943, through a guarded Army-Navy joint press release. Censorship was restored after this fragmentary mention and not lifted again until Japan had sued for peace.

Radar is a Navy-coined word for radio detection and range finding.

It was radar which enabled the RAF to break the back of the German air blitz of England in 1940, thereby stopping Hitler from invading the island.

It was radar which took most of the sting out of the V-1 buzz bomb.

Herman L. Weckler
Vice President and General Manager of Chrysler Corporation

K. T. Keller
President of Chrysler Corporation

It was radar which defeated the German's new U-boat technic.

It was radar, more than any other one factor, which disrupted Jap shipping and destroyed the Jap Navy.

It was radar which made possible the accurate bombing of Germany through the nearly constant winter overcast.

It was the intervention of microwave radar, specifically the SCR-584 set for which Chrysler made the fundamental component, which saved the day for us at the Anzio beachhead.

It was the SCR-584, again, which drove the Luftwaffe away from the Normandy beachheads.

It was radar which won the war, according to Sir Stafford Cripps, who was chairman of the British

F. W. Slack in charge Radar work at Chrysler Engineering

F. J. Lamborn Vice President and General Manager, Dodge Division

C. W. Hirsch Superintendent Radar Division at Dodge

Radio Board during the most critical period. "If radar had not prevented the enemy from getting by surprise over England," he said, after the war had ended, "I don't know where we would have been. It played a greater part in the war's outcome than did the atomic bomb itself. It contributed to the winning of the war more than any other single factor."

Beginning as a purely defensive weapon, radar changed the face of war more than any single development since the airplane, for one of war's great weapons is surprise, and it defeated most tactical concealment. Yet it had become by 1944 a superlative weapon of offense.

More was spent on radar by the United States Government than on the atomic bomb. Up to July, 1945, $2,700,000,000 of radar equipment had been delivered to the Army and Navy.

Long before radar was named publicly in 1943,

Chrysler Corporation had been asked by the Radiation Laboratory of the National Defense Research Committee and by the Army to design the antenna mount, a then unsolved basic element of a revolutionary short-wave radar set, and to manufacture it in secret. The design of the instrument was assigned to the Company's Engineering Division, and the Dodge Division was told to prepare to manufacture it. By early 1944, Dodge had turned out 2,092 of these mysterious mechanisms.

War means haste and Chrysler was required to make its price estimate without an opportunity of breaking down the instrument into its component parts, studying each detail, as would be done in normal manufacturing. As the mount had yet to be designed, this was impossible.

At the request of the War Department, the Corporation submitted an estimate of $16,451 apiece, pleasantly surprising the Radiation Laboratory, the Signal Corps and the General Electric Company, the prime contractor, who had, they said, expected any figure up to $50,000. Yet on a cost and fee contract such as often has been misunderstood as neither rewarding economies nor penalizing waste, Chrysler's actual price to the Government was $9,386 each, a saving to the taxpayer of nearly $15,000,000 or approximately 43% of the estimated cost.

The antenna mount made by Chrysler sends out 2,000 microwave (10 centimeters) radio pulses a second, each pulse traveling at the speed of light and

Signal Corps officer attaching the plastic-enclosed radar antenna to the spinner motor.

Recording van on right made records of radar operations for the study of anti-aircraft research groups.

beamed as a searchlight is focused. This radio beam searches the sky and whenever it intercepts any object, such as an airplane or a ship, it bounces or echoes back from it into the antenna.

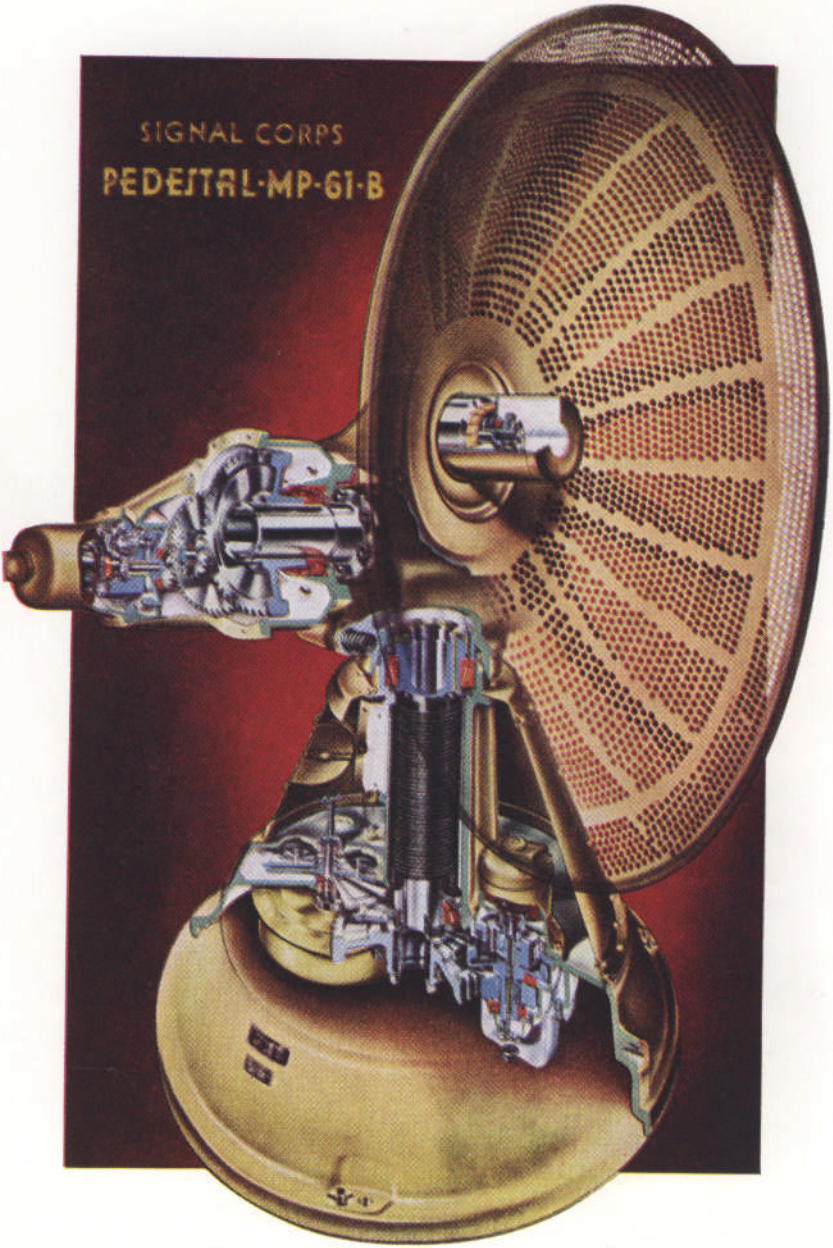
Such is the uncanny cunning of the radar unit that from this faint sigh it computes instantly and automatically the direction, distance, speed, altitude and course of the object. An auxiliary instrument distinguishes the object automatically as friend or foe. If the latter, the radar fastens its electronic teeth into the target and follows it thenceforth, however the plane may twist or dodge, with the tenacity of a bulldog.

There are many types of radar, large and small.

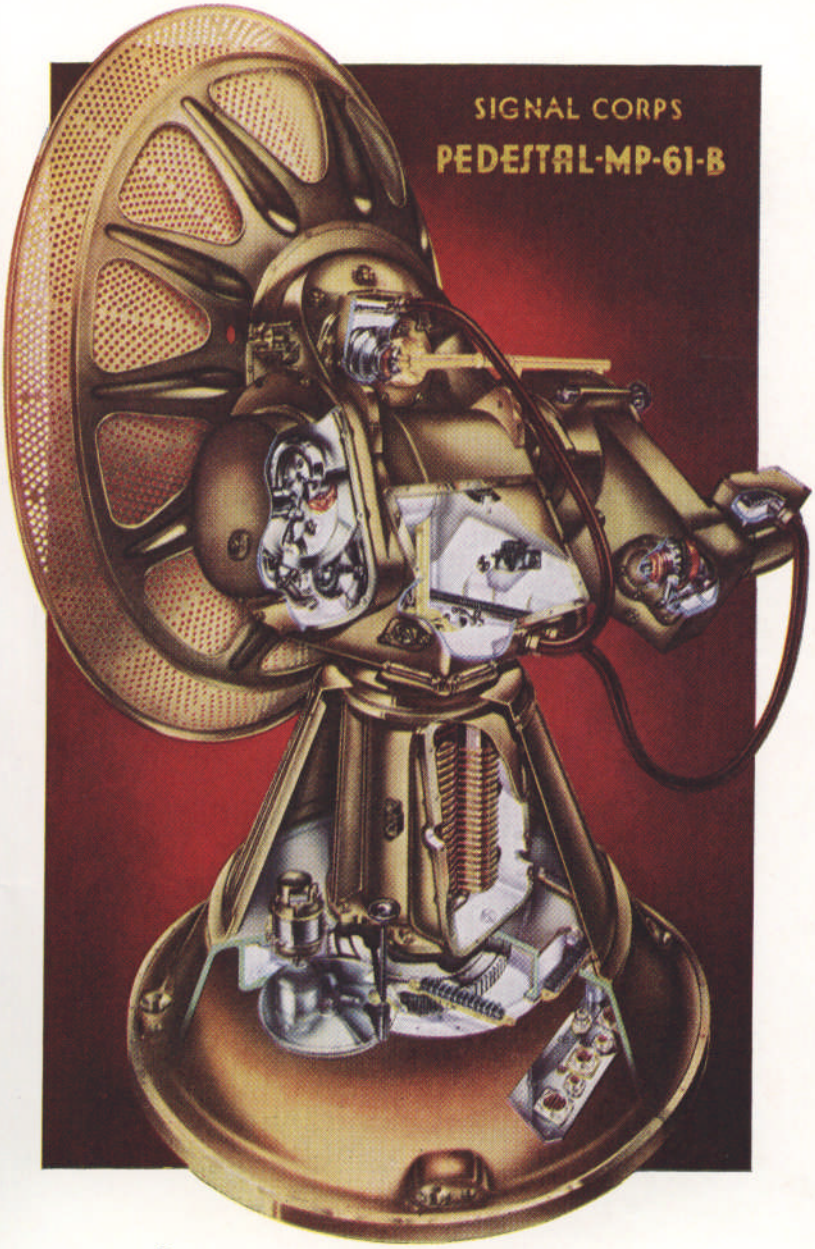
That for which Chrysler designed and manufactured the antenna mount is the anti-aircraft set known as the SCR-584, the most complex mobile weapon known to modern war. It was the standard radar issued for each heavy anti-aircraft gun battery, housed in a 10-ton semi-trailer. Each battery consisted of four 90mm guns, an IFF (identification, friend or foe) unit; a power plant; an M-9 gun director or computer which is a robot brain; and the scanning pedestal made by Chrysler upon the minute accuracy of which the performance of the entire battery depends.

This antenna mount is a large and intricately geared, wired and motored mechanism crowned by what looks like a big colander or sieve, familiarly called the "dish" by the G.I. Six feet in diameter, it contains 6,440 equal holes, meaningless as far as the function of the instrument goes. In its center is a plastic enclosed and exquisitely accurate antenna rotated by a motor at 1,750 revolutions a minute.

From this antenna are beamed into the heavens short wave radio pulses one-millionth of a second in duration at intervals of only one two-thousandth of a second. A modulator stores up power and shoots it out in bursts ten times more powerful than the strongest American commercial radio station uses. A cavity magnetron, a million times more powerful than any previous magnetron, oscillates violently 3,000 times in that one-millionth of a second, or at the incredible rate of three billion times a second.



Front cutaway view of the complete radar mechanism as Chrysler built it.



Rear cutaway view of the complete radar mechanism as Chrysler built it.

Traveling with the speed of light, this echo will return to the radar antenna in a hundred one-millionths of a second from a plane ten miles away. Within one one-millionth of a second after the transmitter has completed its signal, the receiver connected to the same antenna must be at full sensitivity in order that it respond to the faint energy of the returning echo.

A special vacuum tube devised for the SCR-584 radar performs this all but instantaneous switch, repeating it a thousand times a second. Since the outgoing burst is a powerful blast, its power must be kept out of the ultra-sensitive receiver where it would destroy the tubes and circuits set up to catch and

Chrysler radar teamed with 90-mm battery at Camp Davis, North Carolina, Army anti-aircraft proving ground.

amplify the weak echo. The tube insures this by providing a short-circuit path for the transmitter's power, a tiny gap between two needle-like copper conductors that are enclosed in an atmosphere of gas of controlled pressure. An excellent insulator, this gap will stop the flow of current of ordinary voltage, but the high voltage of the transmitter leaps the gap and so by-passes the receiver. When the echo returns a few millionths of a second later, its feeble few millionths of a watt current is blocked away from the transmitter by the gap and so passes undissipated into the receiver.

A very small fraction of the energy beamed out by the antenna reaches the target. As most of this glances off the target haphazardly and is lost in space, a still tinier fraction of that power echoes back to be amplified by the receiver just as your radio amplifies what it hears, but to an infinitely greater degree. If you can conceive of a million times a million, that is the amplification produced by the SCR-584's receiver tubes.

In commercial radio an electronic tube takes the broadcast from the antenna, rectifies it, changes its frequency to one that is audible to the human ear and transmits it to an amplifier. Even though electrons may travel across such a tube at speeds up to three million feet a second, it would be far too slow for the billion-cycle frequencies of microwave radar. A special detector had to be contrived for the

SCR-584, a tiny silicon crystal and a cat-whisker probe of fine tungsten wire in a porcelain cartridge. Entering the receiver, the radar echo impresses its minute voltage on the crystal causing electrons to flow from the crystal to the cat-whisker probe instantly.

The great dish, officially known as a paraboloid because of its parabolic contour, and driven by two gear trains, swings laterally around the horizon (azimuth) and up and down the heavens (elevation) as it scans or probes. Radar waves behave much as light waves do except that the microwave penetrates the densest fog or storm front. The parabolic surface of the dish focuses the radar beam just as a searchlight reflector focuses light waves.

Your radio news and entertainment is reflected from the outer atmosphere and so follows the curve of the earth indefinitely. But like television, all radar sets can see only in a straight line. If the view is not obstructed by mountains, buildings or other physical objects, the SCR-584 radar will pick up a plane at a distance of 45 miles. Other radars function up to 200 miles, depending upon the elevation of the set and the elevation of the target, but lack the accuracy necessary to directing gun fire.

As the antenna mount rotates, a cathode ray tube operating on the principle of television and known as the PPI or Plan Position Indicator translates the returning echoes into a visual map for the radar

Chrysler-built radar directing strategic aircraft in "close support" at Eupen, Belgium—November, 1944.

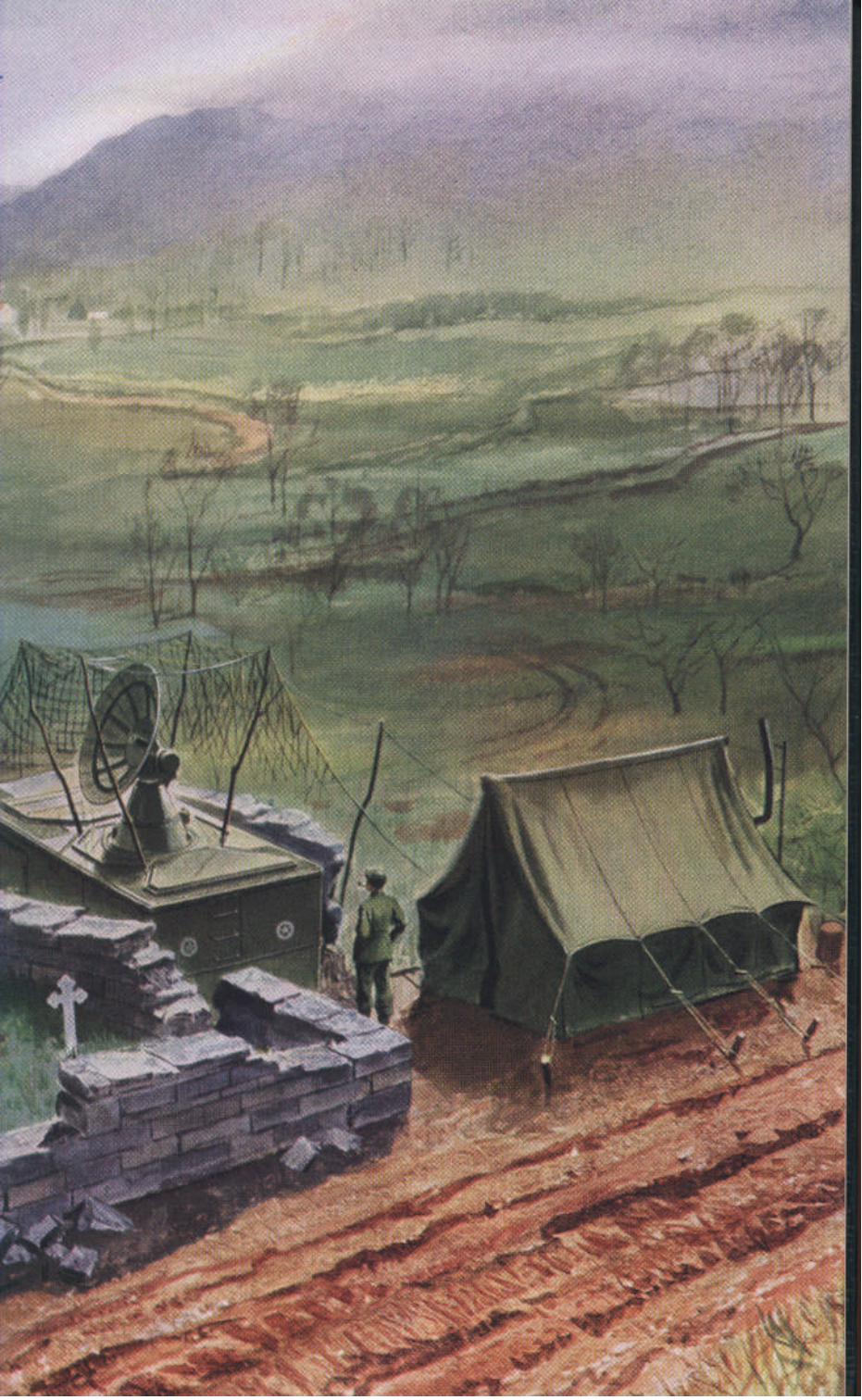
crew. When the scope watcher begins his vigil he spends his first ten minutes in studying the ground images, such as hills, which appear on the glass, to familiarize himself with the normal—what he should see. If the same images show up in the same positions on each sweep of the antenna they may be presumed to be fixed objects.

But when a strange blob of light appears it is suspected of being an intruder, and if it changes position with each sweep of the antenna the scope operator reports an unidentified aircraft echo to his fellow, the IFF operator and to the nearest anti-aircraft operations room, giving the range and bearing of the object, these being visible on the graduated glass. The blobs of light, unlike televised images, are not photographic, but they are easily interpretable to a trained man, and the scope is specially treated to hold its images for 20 to 25 seconds on each sweep.

If the plane continues to approach, the interrupted beam echoing back into the antenna becomes stronger and stronger. By the time the plane has come within 20 miles both the IFF unit and the operations room will have identified it as friend or foe. The operations room can report only whether friendly aircraft are in the vicinity, but the IFF, a British development, answers the $64 question surely.

Its coded signal is returned auto-

Camouflaged radar trap for enemy planes set up alongside a graveyard in Italian hills. 90-mm batteries are nearby.



Heavily camouflaged radars set up across the river from Cologne as we battled for the Rhine in late winter of 1945.

matically from the plane if it is one of our own, returned without the knowledge or aid of the plane crew. There is no response from an enemy plane. Every American and British plane or vessel carried a small auxiliary radio set, the sole purpose of which was to answer this challenge. Each set contained an explosive charge and a detonator. Pilots were under order to destroy it in any emergency involving capture. In the event of a crack-up severe enough to knock out the crew, the force of the landing was counted upon to explode the charge.

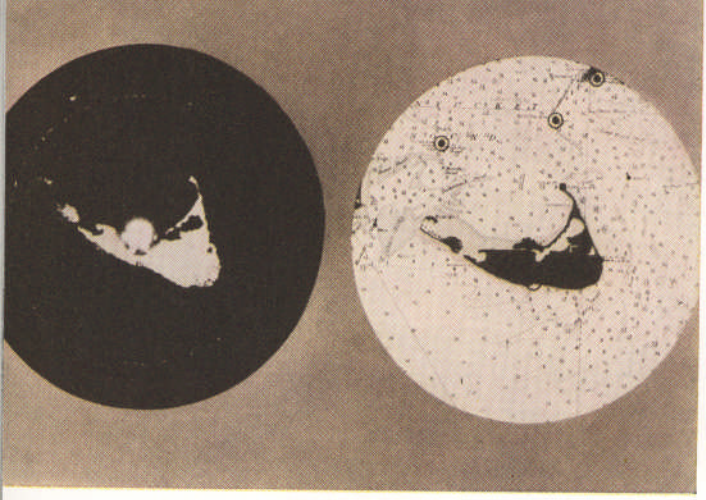
If the IFF gets no response, indicating a hostile plane, one member of the radar crew now locks the antenna mount on this specific target. From then on

the mount ceases to search and points unerringly at the target, however it may maneuver. The battery will have been alerted on first contact. The position of the mount is transmitted automatically by self-synchronous generators to the gun-director. This robot brain of 160 tubes, most of them not unlike the vacuum tubes in your home radio sets, precisely predicts where the plane will be at the instant the 90mm shells will arrive, often as much as 20 seconds later. This position is transmitted again by self-synchronous generators to the guns, the muzzles of which are swung by remote control power drives. From radar to gun, approximately 500 vacuum tubes are at work, and not a single human hand except for that of the range operator who locks the radar mount on this one target.

The pilot may climb into the stratosphere or drop to 50 feet, he may duck into a cloudbank, he may swing 90 degrees to right or left; as long as he does not retreat out of radar range the microwave beam will follow and hold him inexorably. Clear or stormy, night or day, high or low, there is no place to hide from this electronic feeler except at a harmless distance.

The order to begin firing is given, the fuses are cut and the flak storm of 80 rounds a minute meets the plane. The pilot's only hope is to play hide-and-seek with the flak by what the Air Force calls "evasive tactics" and you would call broken field running.

The microwave beam is so powerful that it can "see" the shells traveling through space. When one



Nantucket on aerial radar scope (left) and actual chart of the island. Land appears white, water black, on radar screen.

Courtesy "Army Ordnance" Magazine

bursts, the reflection on the scope shows a characteristic increase and the operator knows whether the shells are exploding short of, beyond or on the target.

During the hours of quiet between attacks, the SCR-584 is a watchdog standing 24-hour sentry duty, the antenna mount never ceasing to rotate as the beam probes the skies.

Though the Corporation ceased in 1944 to manufacture radar mounts, the Engineering division, under a separate development contract with the Radiation Laboratory, located at Massachusetts Institute of Technology, perfected a spiral scanning mechanism using even shorter waves to replace the antenna in the original SCR-584, which was the bulk of Dodge's production.

During the war, each side jammed or blocked the other's radar at times, and the longer the wave length the more vulnerable it was to jamming. Though the Nazis never effectively jammed the

SCR-584, the Signal Corps and the Radiation Laboratory knew that it could be jammed and so the latter asked Chrysler Engineering to go to an ultra short wave and spiral scanning pattern, jam-proof in their professional judgment.

Just as the Dodge radar shop was concluding manufacture in April, 1944, the first performance reports reached the Corporation. Dr. I. A. Getting of the Radiation Laboratory wrote Mr. Keller April 4, 1944:

"It was not until the last month or so that any SCR-584 arrived in the active theaters of war. They are now in use on the major battle-fronts . . . Recent experiences in landing in Sicily and Italy have shown the absolute necessity of adequate anti-aircraft protection. When such protection was absent, destruction of men and supplies by enemy airplanes was extreme. This emphasis on anti-aircraft fire and the usefulness of the SCR-584 already has created a shortage of this equipment within the Army.

"There is very recent evidence from combat experience in England and Italy that the enemy is attempting to counteract the effectiveness of the SCR-584 with jamming methods. Last year, at the request of General Colton, the Radiation Laboratory undertook the responsibility for anti-jamming developments. This program now has been given very high priority. One part of it requires the modification by field kits of the SCR-584 to shorter wave lengths. A necessary part of this modification is a spiral scan mechanism. Your Engineering division has been very

cooperative and has succeeded in developing a mechanism which we are confident will satisfy our needs."

Dr. Getting had the Anzio beachhead in mind, in particular. The first SCR-584's to leave this country in 1943 were sent to North Africa for crew instruction. The German-Italian air forces had jammed the 268 radar, the predecessor of the SCR-584, and were bombing the Anzio beachhead and harbor shipping indiscriminately by night, an area so congested that any bomb dropped was almost certain to hit men or equipment.

The enemy artillery in the surrounding hills had every foot of the beach and harbor indexed and bomber raids always were timed with intense artillery fire. To turn on a search-light was an invitation to annihilation; even flash-lights or the lighting of a cigarette were banned. It was touch and go whether we should be thrown back into the sea.

The first two SCR-584's rushed from Naples were landed at Anzio from an LST February 24, 1944, and the trailers quickly buried up to their roofs in outsized fox holes. The second night a formation of twelve Nazi bombers came cruising over unsuspectingly. Four 90mm guns directed by these two radars shot down seven of the twelve in flames, though the radar crews were unfamiliar with their new equipment. A 58% loss is even more decisive than it sounds, for the surviving 42% will be driven into saving themselves rather than harassing you.

The Germans never again came over Anzio in for-