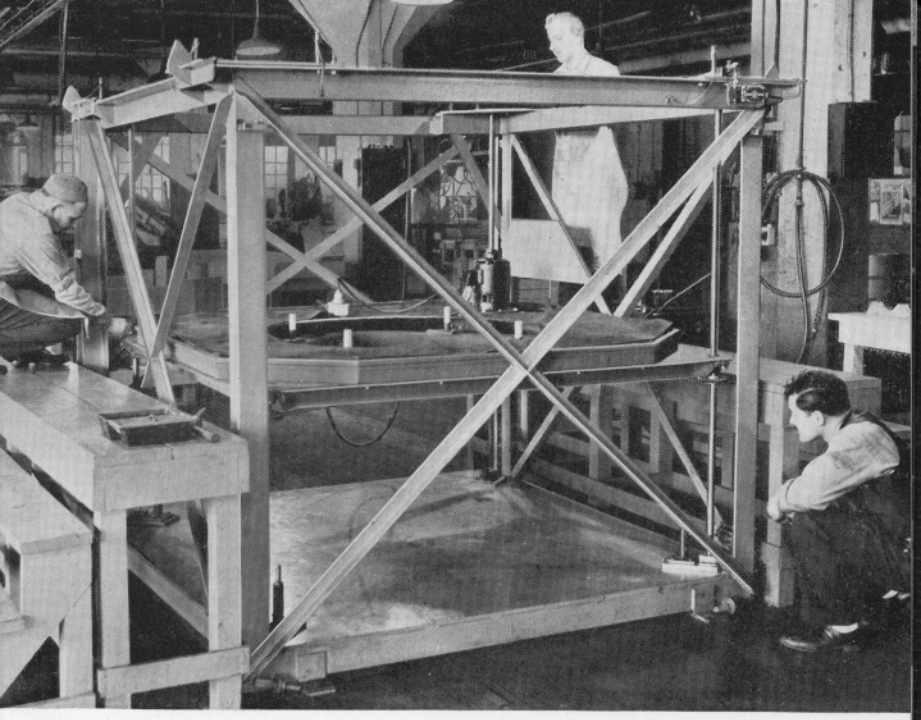


Detroit calls this a "fixture." A fixture is anything which holds work in fixed position during machining or assembly.

undependable at low elevations, particularly over water. While water is a better reflector than is the earth, its surface is so flat that the beams tend to ricochet off it, leaving a margin at the water line where planes might slip through undetected by radar. This German practice became so general that Allied pilots were instructed never to return across the Channel at less than 1,000 feet, and any plane crossing West at less than this altitude was fired upon at sight.

The Germans were on the defensive and an enemy plane seldom ventured over England by the time the first 132 sets of the SCR-584 radar reached Britain as

Final touches on the semi-trailers before installation of radar sets.

part of the invasion equipment of the army General Eisenhower was assembling there. But even before Christmas of 1943 the British Intelligence had warned the Government to expect Hitler's secret weapon, the V-1 buzz bomb at any time.

The British and American invasion armies and all the vast stores of supplies accumulated for them had to be protected, as well as the civil population, against this new threat, and so most of the SCR-584's soon were deployed along the Channel coast in the hope of intercepting these small and very fast robot bombs which, even with radar, gave a maximum warning of only three minutes between the alert and the opening of fire.

Before the capture of the original launching sites which finally stopped the V-1 bombs over England six weeks after the attack began, Hitler already had lost faith in this no longer secret weapon, only 10% of which were penetrating the radar-directed defense, and had turned to his final card, the V-2. But when the Germans had been driven from France and coastal Belgium they concentrated their V-1 fire on Antwerp in an effort to prevent Allied use of that great port. Here the buzz bomb defense was exclusively by radar-directed guns and two SCR-584 sets were partly destroyed by the bombs.

When our 8th Air Force began to pioneer daylight pin-point bombing over North Europe the Luftwaffe still was a formidable force, and German radar was good and German flak wicked. Nevertheless, the 8th found that its No. 1 problem was not the enemy but just plain navigation to the target and back. In the weather which prevails from November through March over North Europe they did well to grope their way home, let alone to find a designated target from 20,000 feet and hit it.

Just twelve of a new microwave airborne radar set hastily produced by the Radiation Laboratory, however, multiplied the winter effectiveness of our strategic bombers ten to twenty times. The British christened them "Mickeys." Twelve were all that could be given the 8th, that most important winter, yet

Each semi-trailer was put through a high pressure shower bath to test the tightness of its joints against rain.

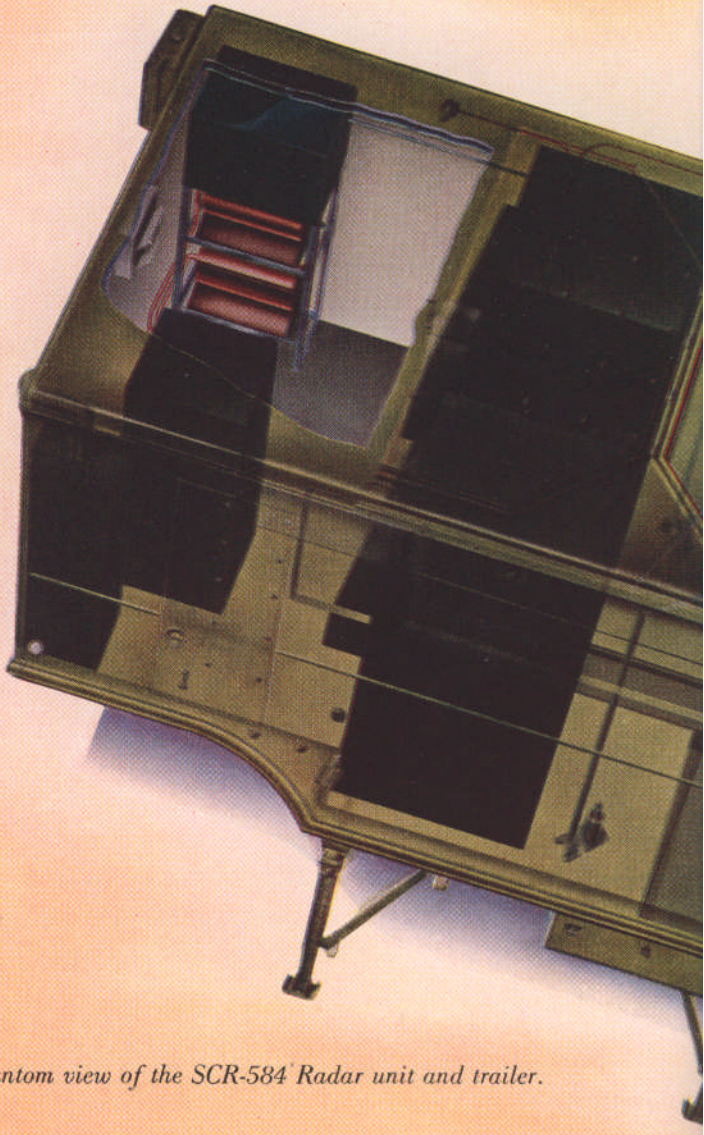
one squadron of "Mickey"-equipped planes could lead sixty times their number on a raid, getting them up through the soup, guiding them direct to the target, telling them when to drop their bombs and getting them home again—so far as navigation hazards were concerned. The first such raid was on

Wilhelmshaven which eight earlier visual raids had missed. They hit it on the button through a heavy overcast.

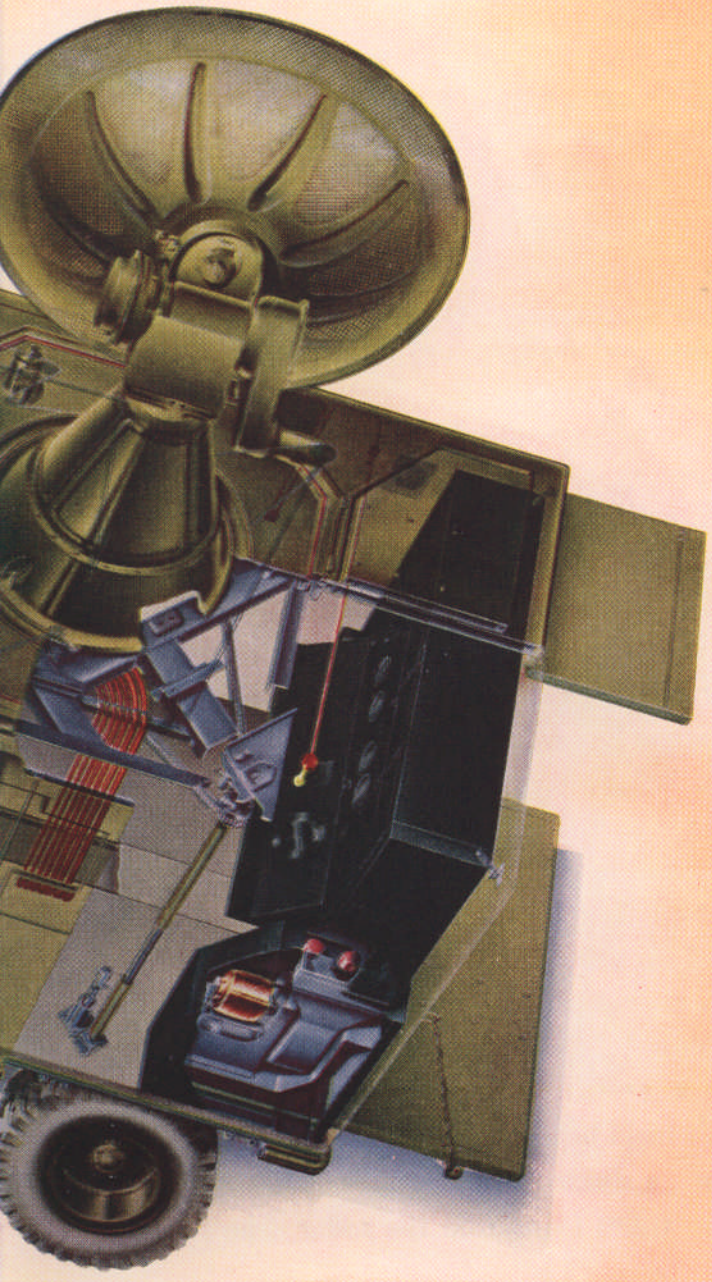
By the next winter all American and British strategic bombers were "Mickey"-equipped. But there were other planes, the tactical aircraft. They are fast, small, short-ranged, 1-place fighter-bombers and strafers. One of their duties is systematically to harass enemy ground forces and reduce their positions in close liaison with our ground forces, brief missions calling for speedy action and a minimum of briefing. We had an increasing surplus of such planes as the Luftwaffe declined, giving our fighters less and less to do in good weather. In bad weather, they were grounded.

In good weather, an Air Force observer sits up front, in possibly a tank, and radio-telephones a plane flying over to look for a camouflaged gun position which the ground forces have not been able to locate closely enough to knock it out with counter fire, or to warn of a column of enemy armor spotted in the distance. The pilot locates the target and dive bombs or machine guns it.

But in bad weather the tactical aircraft pilot, swooshing over at tremendous speeds, either can not see the ground or sees it so hazily that his support may be worse than his enmity. Because he is likely to bomb or strafe his own infantry or artillery, he is pulled out, leaving the poor foot soldier stuck in the mud without air support.



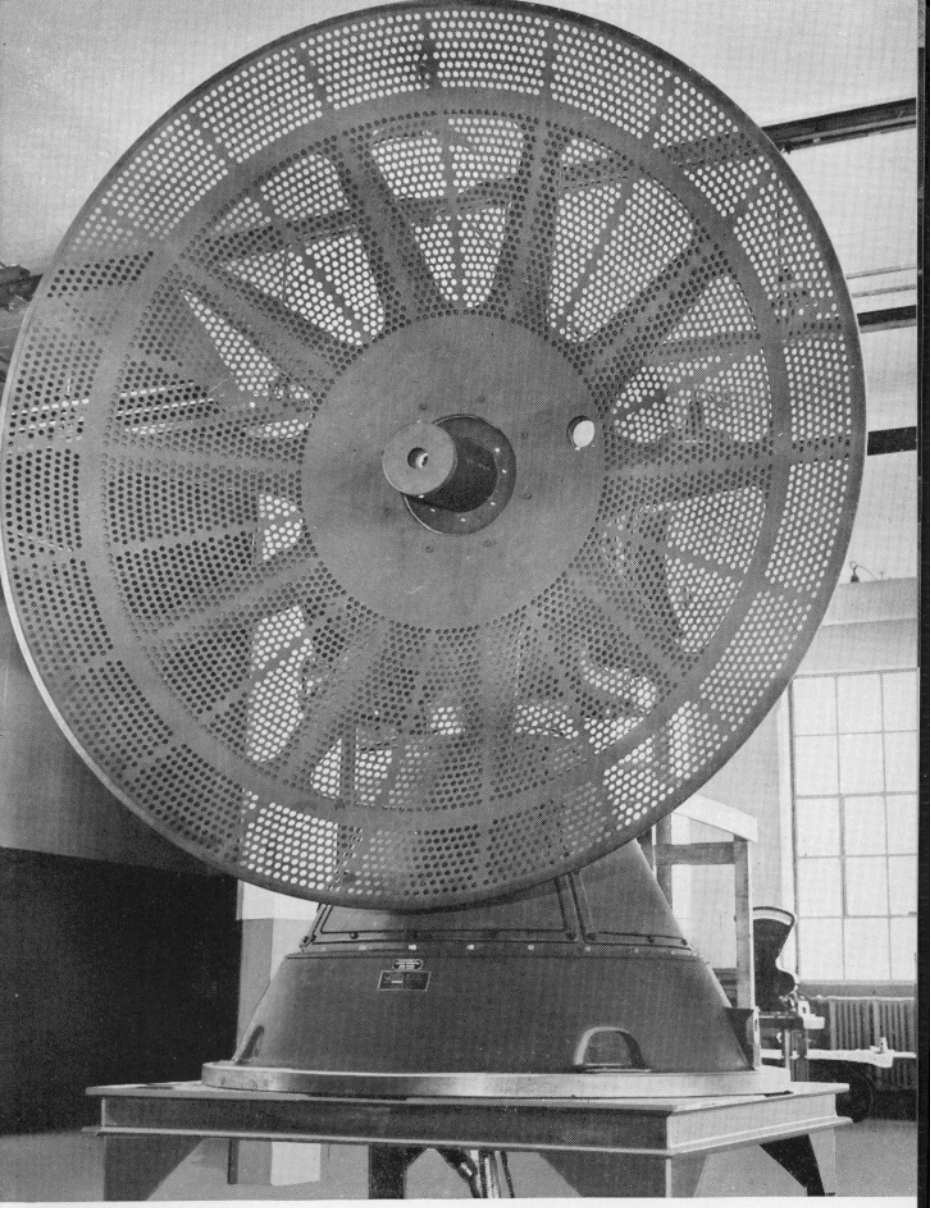
Phantom view of the SCR-584 Radar unit and trailer.



A radar set would be an awkward addition to the cockpit of a single-place plane. More important, the pilot of such a fast plane has no time for the study of a radar scope. But by a brilliant adaptation of the SCR-584, the Radiation Laboratory gave the tactical aircraft eyes to see through the dark or the weather.

The Laboratory reasoned that if the SCR-584 could find the position of a plane and plot its track accurately enough to enable guns five miles below to fire shells to the point in space which the plane would reach twenty seconds later, then a controller on the ground, using the SCR-584, should be able to guide a plane to exactly the spot in space which is correct for the blind release of bombs to hit an unseen target, or the right spot in space for the beginning of a dive-bombing attack on a target which the pilot isn't able to see when he begins his dive.

By this new technic of warfare which we called Close Support, fighter-bombers and photographic reconnaissance planes were pointed to their targets from ground radar plotting rooms. There an electronically-moved pen traced the ground course of a plane across a military grid map. Radar pulses echoing back from the plane were tied in with an electromechanical plotting board with a glass surface illuminated from below, a 1/250,000 scale map laid over the glass, a sheet of tracing paper laid over the map. Vacuum tubes translated the radar echo's report to



The SCR-584 radar as made by Chrysler undergoing its final test for backlash in the elevation and azimuth gear trains.

a servo mechanism which drove the pen.

As the target was neared, the large map was replaced by an 800-yards-to-the-inch scale map of the immediate target area. In effect, the SCR-584 controller in the plotting room of the Fighter Control Center saw the plane or flight of planes approach the target much as an airplane pilot might see an automobile below him approaching a town.

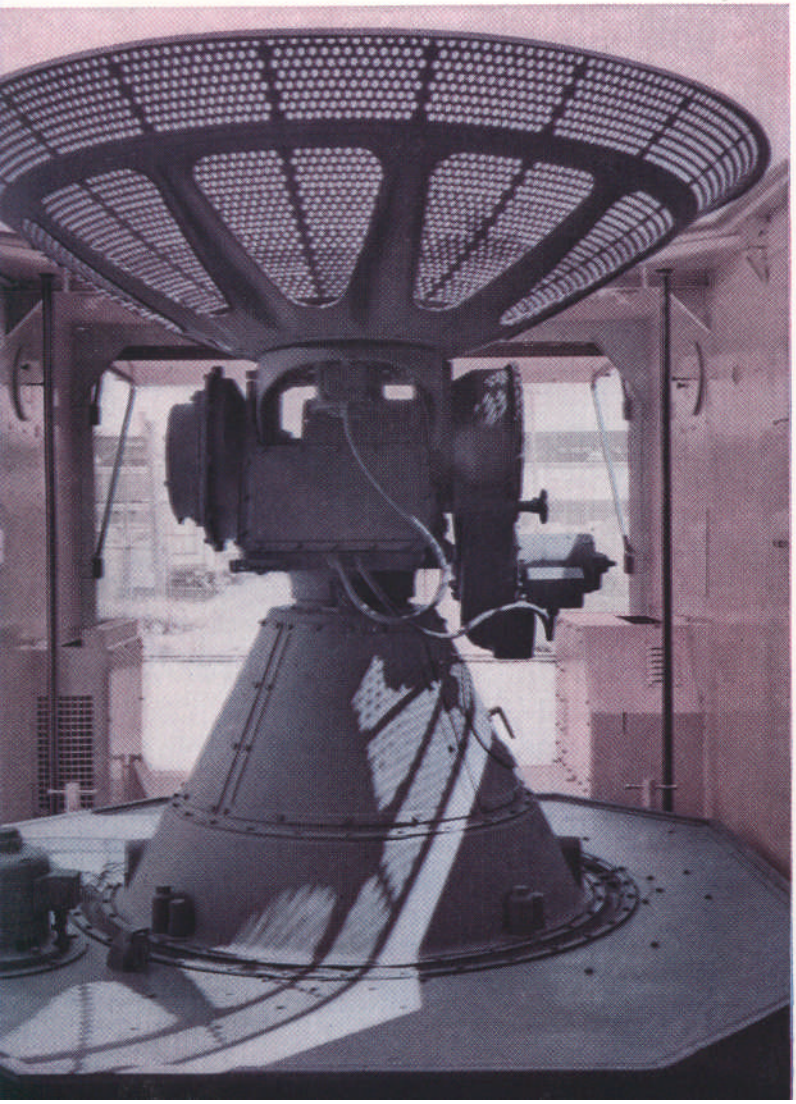
In the big strategic bombers the target would be sighted through the clouds by airborne radar and the bomb drop made by the Norden bomb sight which computes the altitude, the speed of the plane, gravity pull of the bomb and deflection of the wind. In Close Support all this is done by remote control in the plotting room, the altitude, speed, gravity and deflection added algebraically to the map parallaxes of the target, as corrected for the curvature of the earth. The Norden bomb sight often was used in the plotting room, though only for the computation.

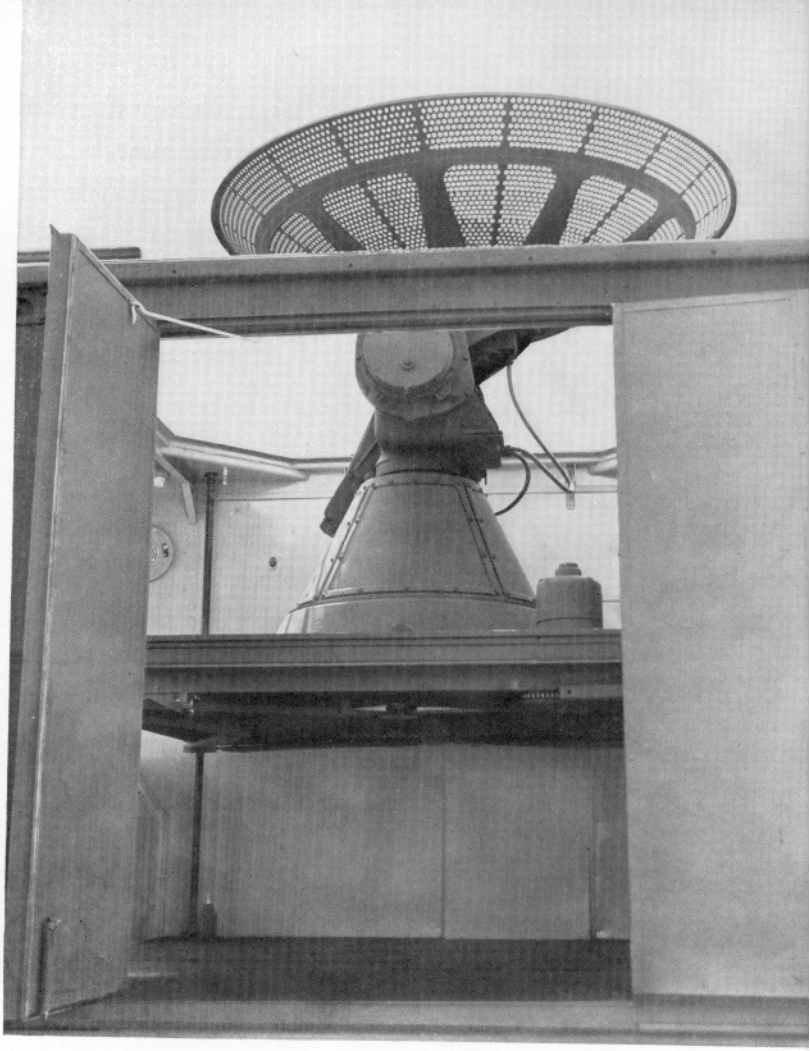
Radiation Laboratory physicists made the first plotting tables by hand at the Laboratory's British branch at Great Malvern of such parts as they could pick up in England plus what could be rushed to them from home by plane. Production models were made later by the Bell Telephone Laboratory though not in time to reach Europe before the war's end. A field modification set designed by the Radiation Laboratory extended the SCR-584's range to 50

The Chrysler-built radar unit in place inside the 10-ton semi-trailer which housed it and accessory apparatus.

miles for Close Support liaison, even to 100 miles if the plane was equipped with a responder beacon.

Close Support first was used in July, 1944, to direct three P-47's on a flight to dive-bomb visually a bridge behind the German lines obscured by overcast. The SCR-584 sent them over the target at 9,000 feet, directed them into a 90 degree turn, then into a





When put into use, the SCR-584 radar is raised through a trap door. Side panels are opened to show the process.

45 degree angle dive which brought them through the clouds directly over the target. Communication between the controller and the pilot is by very high frequency radiophone.

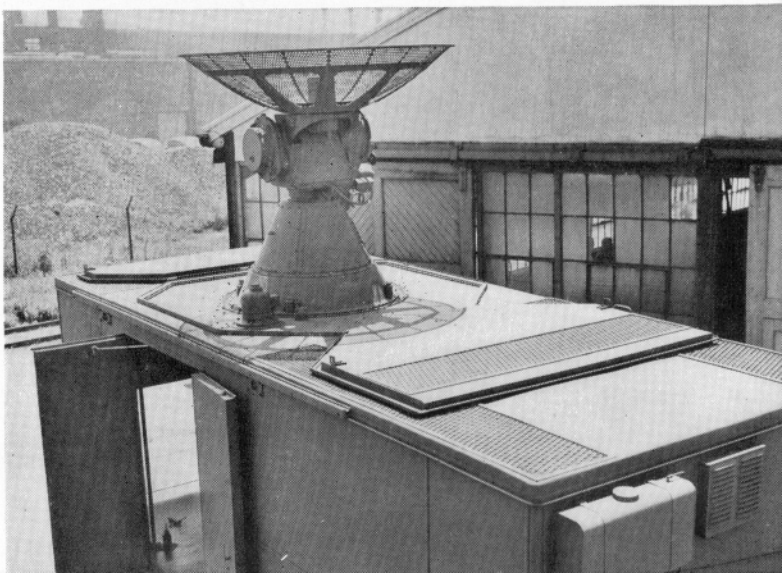
Similarly, it enabled the direction of photographic planes by night or in daylight under weather which had until now prevented the taking of mosaic photographs. Suppose that the ground forces wish a set of mosaic pictures taken by night of a highway behind the enemy lines when the traffic on it will be densest. The controller directs the pilot on a course parallel to and immediately over the road, tells him when to drop his flares to illuminate it for his camera.

In the battle of the Bulge the only planes able to take the air in the first few days of near zero visibility were SCR-584-directed tactical planes. Major General Elwood Quesada, commanding the 9th Tactical Air Force, said of that battle in an official report: "Radar's work during the period of the German break through was outstanding. The Bulge contained no well-defined topographic features. The whole thing could be flown around in less than ten minutes. Roads were chockablock with movement. From the air we couldn't distinguish our vehicles from theirs. (One reason was that snow had blotted out identification marks.) It is our hope to track by radar each flight directed into the Bulge. The number of American lives saved by our ability to stop attacks on our own columns and installations can not be measured; nor can we measure the number of Germans killed because our fighter-bomber boys can be informed with assurance that other columns are enemy."

In other words, knowing pretty well where our own forces in the Bulge were, and knowing exactly, by means of radar, where each of our fighter-bombers was at any moment, the control room was able to tell a pilot whether the column below him was our own or German.

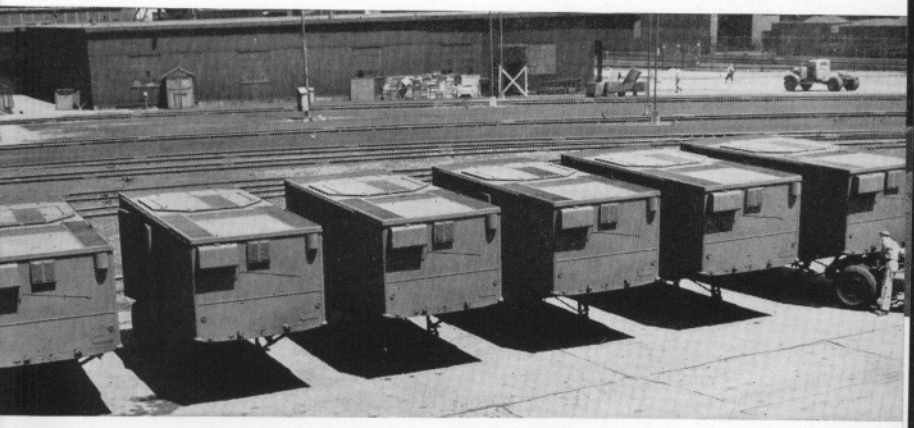
As might be expected of a people of their technological skill, the German radar was excellent, though they had neither the PPI scope, the IFF identification nor the unjammable microwave. Between Cap de la Hague on Cherbourg peninsula and the Dutch border they had as of D-Day 75 major radar installations just behind the coast. This, of course, did not include such mobile radars as the Wurzburg set supplied every four heavy anti-aircraft guns. A necessary preliminary to D-Day was the destruction or temporary disabling by rockets, bombs and strafing of each of these major radar stations—and only one

Close-up of a radar mechanism in position for scanning on the roof of its rolling home.



survived within gun range of the beaches chosen for the Allied landings.

This, however, did not so much account for the failure of a single German fighter to intercept the 844 transport planes and 105 gliders which dropped or landed 15,000 airborne troops behind the beaches



The semi-trailer radar housing was designed by Chrysler but made by the Fruehauf Company, as sub-contractor.

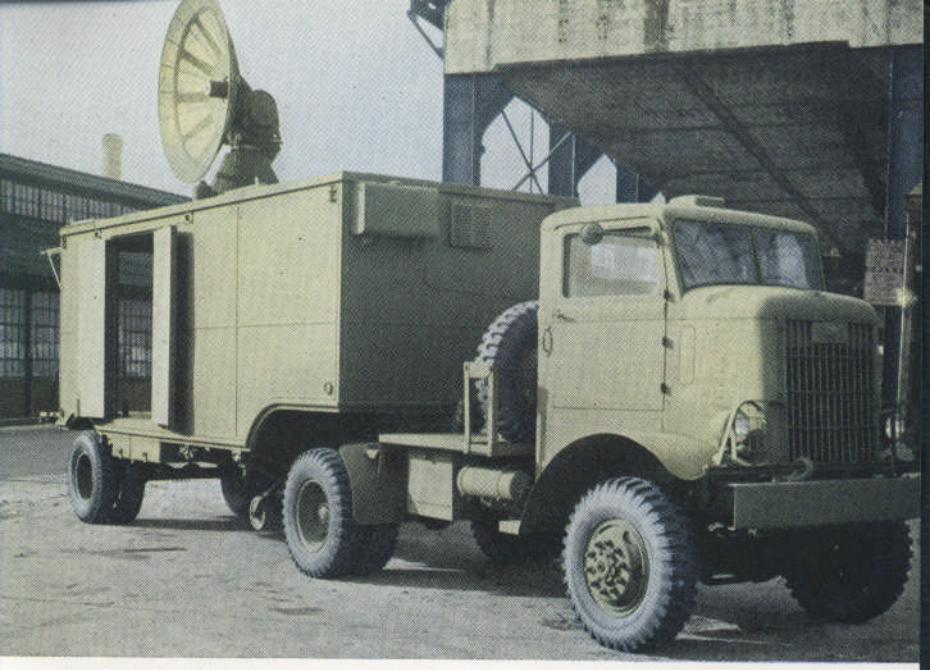
on D-Day as did an elaborate ruse. On the left flank of the invasion area heavy British plane concentrations with radar jamming equipment, and dropping dummy parachutists, decoyed a great part of the German fighter strength into the Dover-Calais area the night before. These Luftwaffe planes spent most of the night circling there. Similar diversionary feints on the right flank, each using jamming equipment which simulated on the German radar full airborne invasions, pulled much of the rest of the German fighters into the region East of Cap d-Antifer. With

the German backfield lured to each side, the invasion bored through the center.

How do you jam radar? There are two known ways. One is by beamed interference, as radio is jammed, an electronic raspberry, so to speak. As a rule, two planes of every flight were equipped with three transmitters each tuned to the wave length of the enemy's radar. The British often put mikes on their aircraft engines and transmitted their roar as an all-effacing Bronx cheer. The Allied code name for this form of jamming was "carpet." Birds in flight were killed and cooked almost instantly when they crossed the path of high-powered radar-jamming ground stations.

"Window" was the code name of the second form, though the British usually spoke of it as "chaff." This employed quantities of tin foil strips fed out of a tube. These strips were light enough to float long in the upper air and, being metallic coated, radar pulses echoed back from them, hopelessly confusing long wave sets. One chaff-equipped plane could convince all but microwave radar that the sky was full of hostiles.

The Germans were using chaff as early as February, 1942, when it enabled the battleships *Scharnhorst* and *Gneisnau* to make their escape up the Channel from a French port where they were supposedly bottled-up. Though every square foot of the Channel was watched by radar, a shower of tinfoil strips and a barrage of beamed static blinded the



Completed job moving to the drive-away line. Here the radar unit has been elevated to the roof for photographic purposes.

British sets. The British first used chaff July 24, 1943, in a 2,000 plane attack on Hamburg, the heaviest of the war until then. How well the Germans kept their military secrets from the civil populace was demonstrated by the reaction of the people in the Hamburg vicinity who believed the falling foil to be some new form of poison attack.

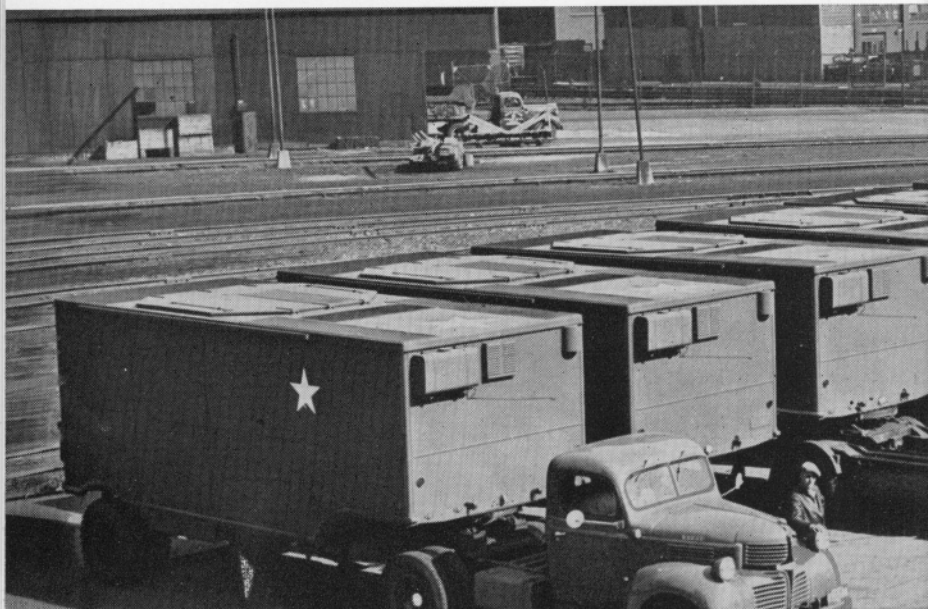
Ground Control Approach, or GCA, was another microwave development of the Radiation Laboratory. This unit operating in an 11-ton truck landed twenty B-29's on Iwo Jima on one day of particularly filthy weather, bombers returning from Japanese raids which almost certainly would have been lost otherwise.

This set included two distinct radar systems. With

one, the operators search on the PPI scope the air surrounding a field, directing plane traffic approaching from all directions into the sector scanned by the second system. The latter, a high-precision short range radar, giving practically continuous information on the unseen plane's position, is used by the final controller to guide the pilot down the glidepath. One precision indicator shows the height of the plane and of all ground obstacles along the path; the other shows the plane's lateral position with respect to the runway.

These replaced beam systems by which pilots land on instruments in the plane, demanding special installations in the plane, considerable ground equipment and rigorous training of the pilots.

A letter from a Radiation Laboratory engineer assisting in the introduction of the Army's first GCA



set, near Verdun, reported: "Two P-61's returning from a night mission were caught up in the soup. The ceiling was essentially zero and so was the visibility. The first P-61 came in right on the button the first time. They asked him when he had seen the runway and his now-famous answer was 'I didn't. I just felt a bump.'

"The second P-61 was off in azimuth on the first run so they told him he'd have to go around again. He came back with: 'You'll have to make it quick or I won't have enough gas to go high enough to bail out.'

"They brought him around in a very tight pattern and this time he touched down though he couldn't see more than one runway light at a time. When he stopped rolling he had twenty gallons of gas left which, for the 2,000-hp. engine in a P-61 is just about one

Drive-away line of mobile radars about to leave Dodge plant under armed guard for Syracuse and Baltimore.

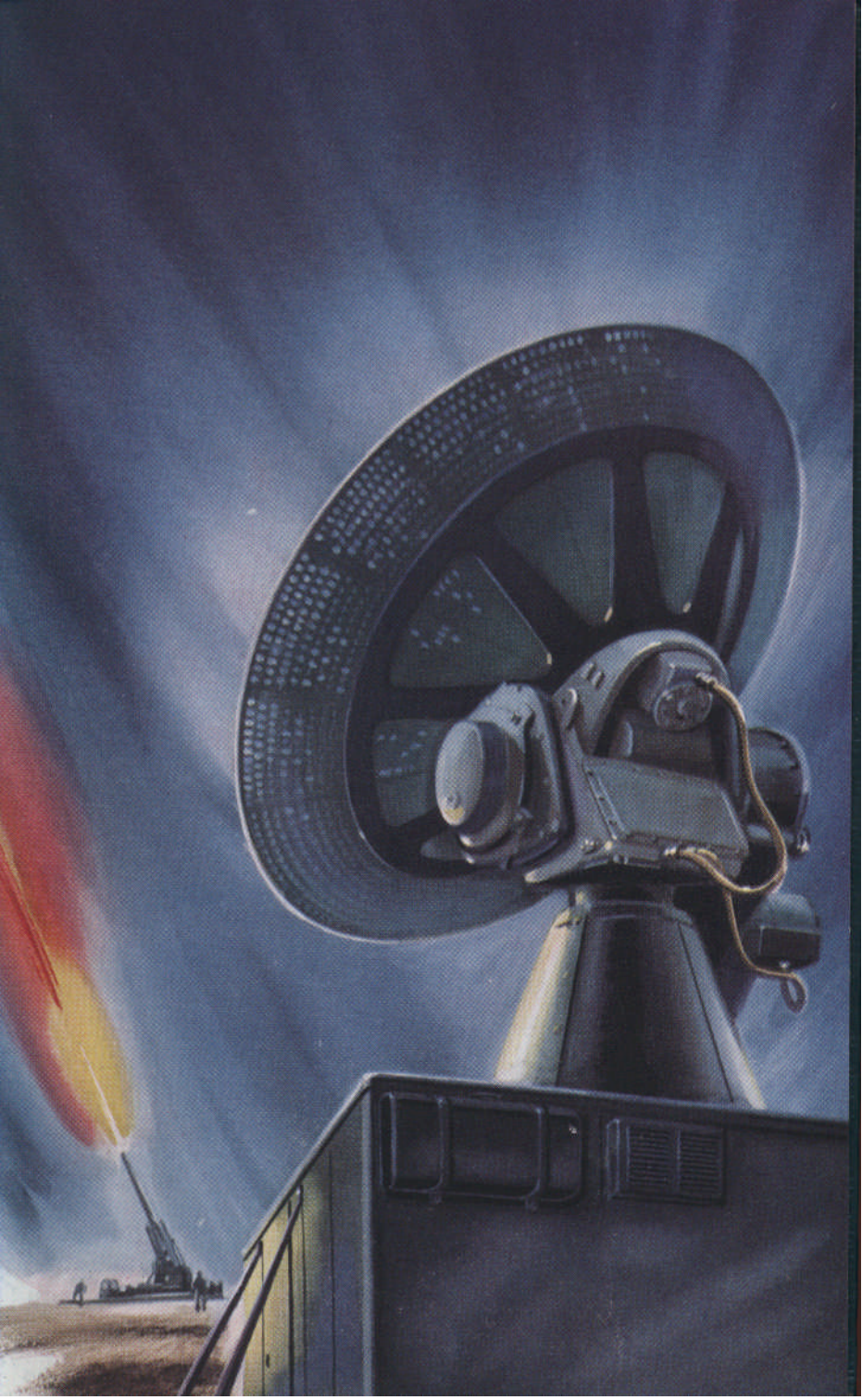
good cough. A major told us that really made GCA part of the outfit from then on."

Another form of radar, the long-range or early-warning detector, first was put to use at Panama on October 7, 1940, and the next day picked up a Pan-American transport from Miami when it was 118 miles away. These long-range sets were shipped out on high priority as fast as they could be manufactured to the most dangerous points.

They should not be confused with the long range navigation system called Loran by which a ship or a plane at distances up to 1,000 miles from a "radio light house" can accurately locate itself. Loran is not properly radar because its pulses are non-directional and because they are received and amplified at the ship rather than being reflected automatically. Loran uses long waves and, therefore, its beam is trapped by the ionosphere and follows the curvature of the earth just as commercial radio waves do.

Nor does the radar principle account for the precision flight of bats, as has been stated in the newspapers. In flight, the darting bat emits a constant stream of cries pitched at 50,000 cycles or beyond, far above the limits of the human ear. This continuous squeaking is reflected back from branches, wires, walls and all obstructions. It is supersonic radiation, a phenomenon of sound, not of electronics.

When Theodore Roosevelt sent the fleet around the world in 1907 the ship which could drop a shell upon



a stationary target the size of an ordinary hull at 4,000 yards or a little more than two miles could paint an E for excellent on its gun turrets. Even in World War I fleets still fought on visual contact and admirals jockied and feinted in an effort to maneuver the enemy "up sun"—that is, with the sun in his eyes. Firing ceased with dark.

Ranges beyond twelve miles were of little value except for shelling fixed shore installations, unless supplemented by aircraft reconnaissance information, until the advent of radar which enables a warship to "see" electronically and hit a moving target on the remote horizon or hidden by night, fog or smoke screen, as we repeatedly found and punished the Jap Navy when there still was a Jap Navy. In a modern naval battle, the Admiral on the bridge may never catch a glimpse of the enemy he has engaged, but that enemy is visible to his subordinates below decks in the Combat Information Room, made so by radar.

The Bismarck destroyed the great Hood with her second salvo at 23,000 yards or more than 13 miles and was hunted down in turn by radar. An American battleship's 16-inch guns hit the Jean Bart at Casablanca with her first salvo at 26,000 yards, put the French battleship out of action with her second salvo.

Radar first made it possible to cruise and fight in fleet formation at night under a total blackout, eliminating all danger of collision. Early in the war a formation of cruisers was ordered to bombard by night

Whatever the short-wave radar beam discovers appears as a recognizable image on the face of this cathode ray electronic tube.

a Jap stronghold from close in. These waters were reef strewn and never had been charted accurately—except by the Japanese. Yet blacked-out on the darkest of nights, the cruisers steamed in formation at 30 miles an hour, avoiding several mine-sweepers in their path, went straight to the unseen mark, blasted it, returned without a scratch on any hull and reported that one reef was six miles out of its true position on their charts. The eyes of radar did it all.

Radar, of course, accompanied our forces at every step on our island hops from Australia toward Japan. For the first few weeks after each new landing, the SCR-584 radar and its anti-aircraft guns were the front line of defense. Ships had to be discharged, depots, hospitals, bivouac areas and headquarters set up and protected from sneak attacks by night from Jap aircraft, of which a troublesome number always remained in the vicinity for a while.

Japan's over-extended empire came apart through lack of shipping. One 14th Air Force group flying B-24's from a field many hundred miles inland in China sank 110,000 tons of Japanese shipping in the China Sea in one month entirely by night and by radar direction. That presumably was why the Japs in the last weeks of the war made such a drive in force against our forward air bases at Liuchow and Kweilin.

Such a little way has man penetrated into the unknown world of electronics that it is easily possible that today's microwave radar will seem as crude

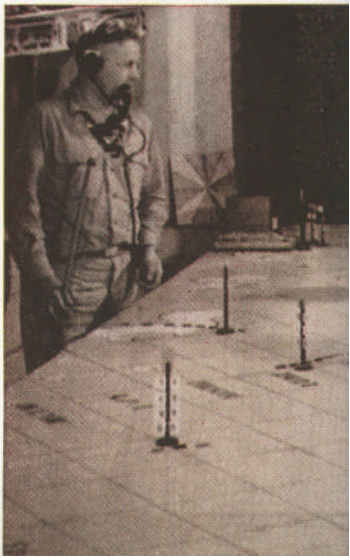
Plotting board for "close control" of tactical aircraft set up inside an SCR-584 radar truck.

as a 1921 crystal radio set alongside tomorrow's all-seeing eye; and that these military applications are the least of its potential magic.

Already we know that it is a post-war necessity of all sea and air traffic. The Maritime Commission has ordered it installed on all our merchant ships. A ship so equipped will be forewarned of any obstruction to navigation whether land, iceberg, derelict, exposed reef or another vessel. Radar-equipped planes will have a constant visual picture in any weather and by night of the ground beneath and ahead, will be forewarned of other planes, of mountains; can land in emergencies anywhere the pilot could sit down on a clear day; will be guided by radar in and out of fields, navigated by it to their destinations. The mapping of the moon by radar short waves has been forecast by the English physicist, Sir Edward Appleton.

As radar rewrote the rule books of war, so it has given man a sixth sense whereby almost any fantasy seems possible.

When the Radiation Laboratory was disbanding in October, 1945, Dr. Getting wrote to Mr. Keller: "Those of us who have worked so closely with you and your engineers feel particularly sad that the closing of our Laboratory will also mean



the end of this close association with you. I can honestly say that nowhere during the past five years have I met with a more efficiently administered engineering laboratory or a finer group of fellows than at the Chrysler Corporation."

Dr. DuBridge, director of the Laboratory, wrote a few days later: "No company has cooperated with us in a more patriotic and self-effacing way than the Chrysler Corporation. I have been deeply impressed by the efficiency and speed and ability of both your engineering and your manufacturing people. I am certain that the SCR-584 anti-aircraft radars would not have been completed in time or designed with such reliability had not your group played such an important role."

The Corporation treasures such praise for a war product which it designed and built from scratch.

South Seas radar information pool, First Island Command, Noumea. 53 radar posts are listed on the blackboard.

Courtesy "Army Ordnance" Magazine