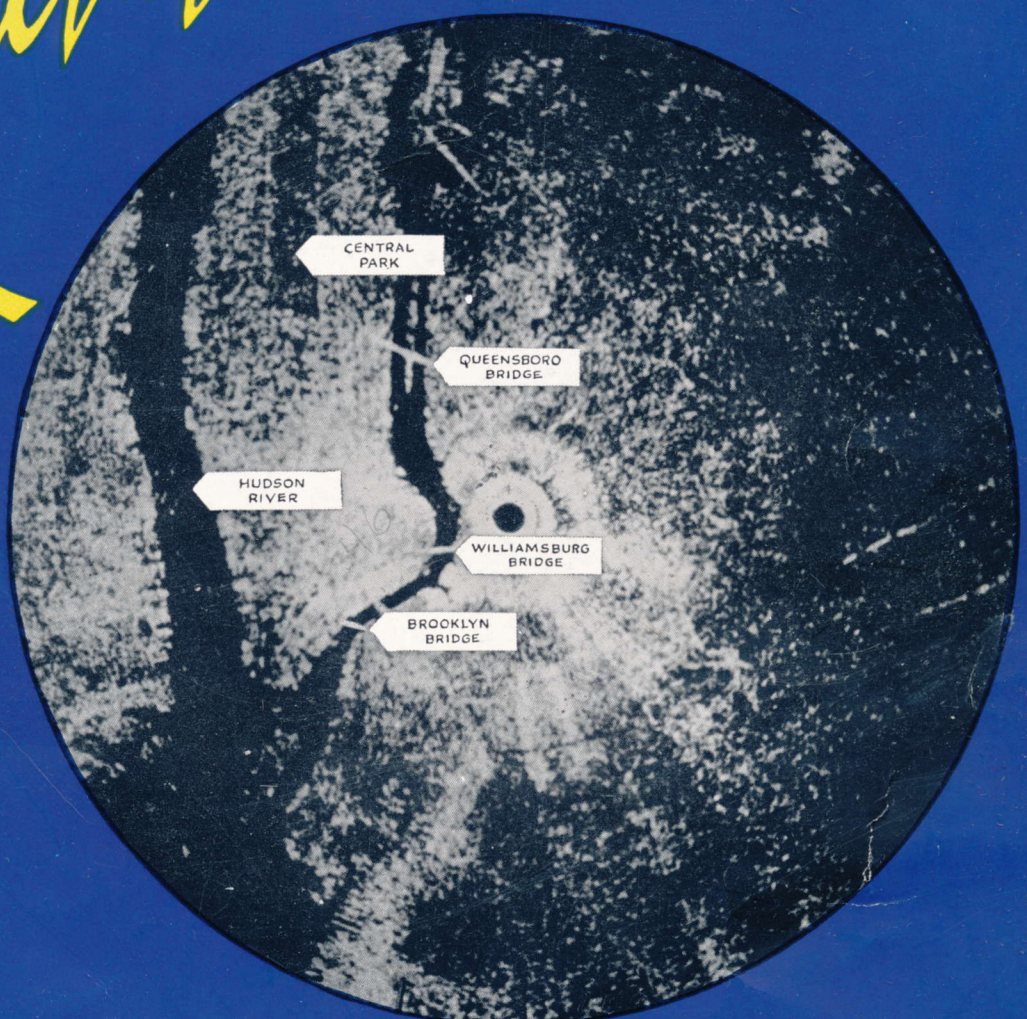
Radar on Wings



PHILCO CORPORATION

January 4, 1946

PHILCO CORPORATION takes pleasure in sending you this copy of "Radar on Wings," which makes public for the first time the salient facts about the Corporation's development and production of airborne radar equipment for the United States Army and Navy. Philco during the war also produced large quantities of communications equipment, quartz crystals, armor-piercing shot, artillery fuzes, rocket projectiles, industrial storage batteries and office equipment. Undoubtedly, however, its greatest contribution to victory was in the field of airborne radar, for this represented more than 80% of its war work and involved the exploration and utilization of micro-waves and the ultra-high frequencies, which now hold such great promise for our peacetime future.

PHILCO CORPORATION

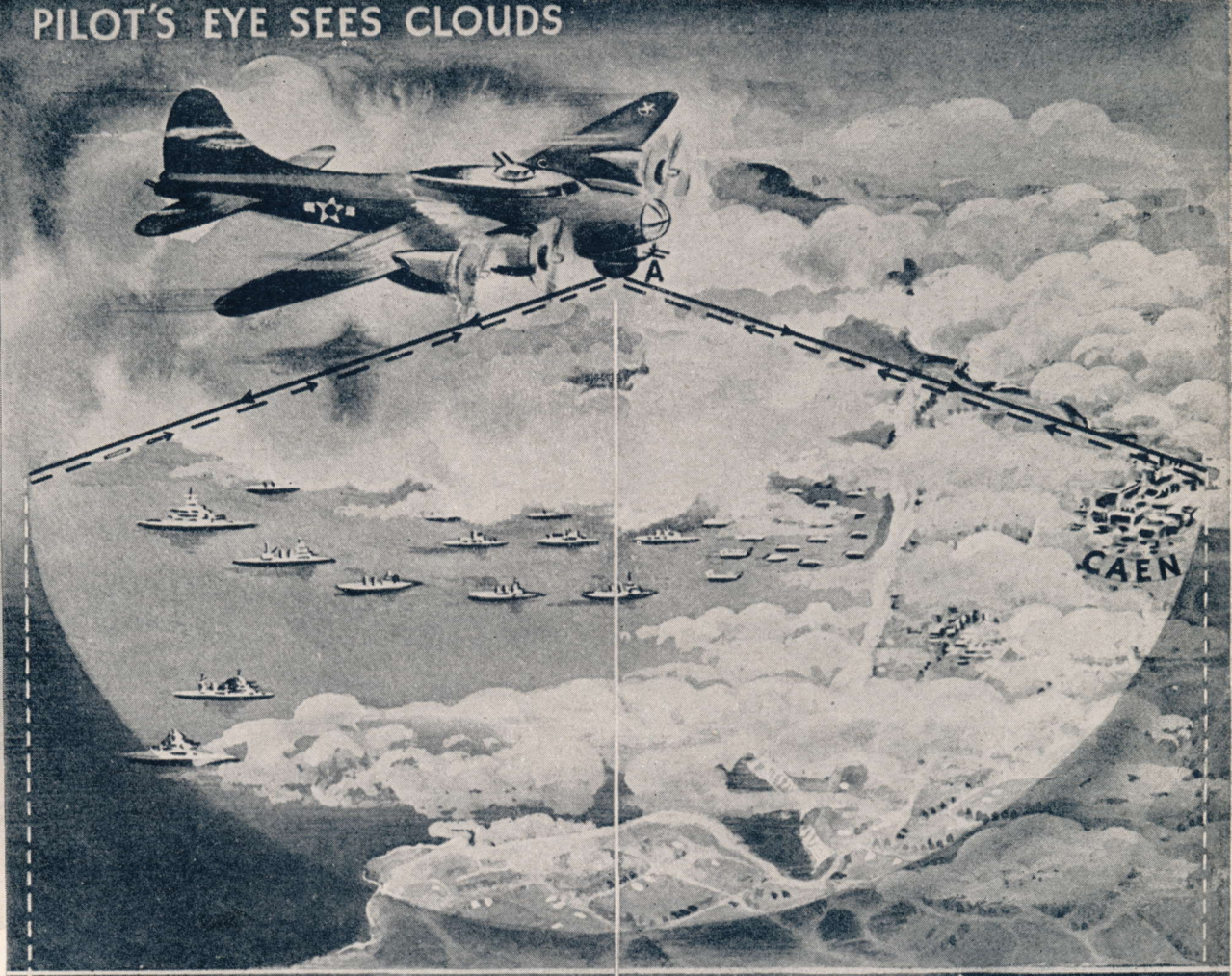
JOHN BALLANTYNE
President

COVER photograph is a radar map of New York City, showing what appears on the picture tube of a Philco-built radar in a B-17 bomber, flying at night at a high altitude.

Radar on Wings

Radar is the science of radio detection and ranging. It provides electronic "eyes" that can detect objects 150 miles or more away, and can see equally well at night, in fog or storm. This booklet tells how Philco airborne radar . . . an important factor in victory over the Axis . . . was developed and produced.

PHILCO CORPORATION, PHILADELPHIA, PENNSYLVANIA
December, 1945



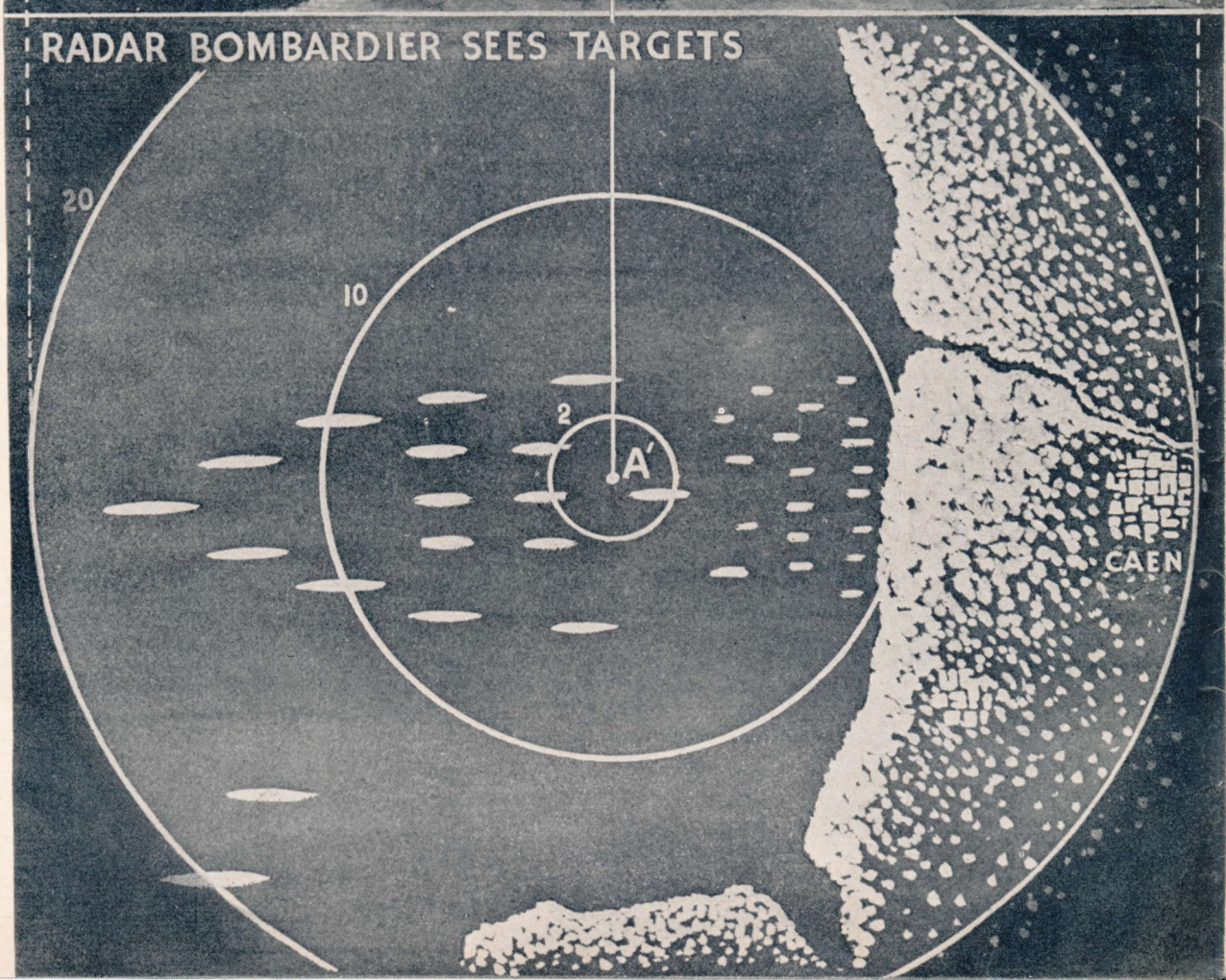


Diagram showing what the Philco Radar Bombsight ("Mickey") does.

"RADAR ON WINGS"

For the first time, many of the hitherto secret facts about airborne radar —"Radar on Wings" — in World War II can be told. It is a story almost without parallel in the history of warfare.

Of all the many types of radar equipment, none underwent more intensive development, called for more ingenuity in its design, or played a larger part in actual combat operations than the radar installed in airplanes and lighter-than-air ships.

Working under conditions of extreme secrecy, protected by armed guards 24 hours a day, American scientists developed and perfected airborne radar to such a point that it became one of the most potent of our offensive and defensive weapons and played a role of great importance in the victory of the United Nations. Its all-seeing eyes pierced through pitchblack darkness, the densest fog, and the heaviest overcast to search out the enemy and warn our forces of his presence or direct them exactly to where he was hiding.

Airborne radar was used in Allied bombers and blimps to crush the Luftwaffe and bomb Nazi industry into extinction, to sink U-boats and Japanese shipping, to guide aircraft with unerring accuracy on trans-oceanic flights, and to distinguish the planes and ships of the United Nations from those of the enemy. A large part of this airborne radar equipment was developed by the research scientists and engineers of Philco Corporation, the world's largest radio receiver manufacturer, and manufactured in Philco plants. "Radar on Wings" is the record of how this equipment was developed and produced, and the part it played in actual warfare.

From a modest beginning, turning out the first American IFF (Identification, Friend or Foe) aircraft radar in record time, Philco engineers and production experts demonstrated a genius for developing and manufacturing a wide variety of radar devices with unprecedented speed. Utilizing their previous electronic and mechanical experience in radio and refrigerator design and manufacture, as well as in pioneering numerous advances in television, Philco research scientists and engineers contributed to the development of 48 different radar systems for the Army and Navy during World War II. Over

Air Force operator uses "George" radar to find U-Boat.

half a million complete radar equipments with a value of more than $250,000,000 were produced on Philco's high-speed production lines. This was the largest number of radar units manufactured by any company.

Philco was especially well qualified for these vital war assignments because of its peacetime work in radio, television and refrigeration. Particularly in television research in the ultra-high frequencies, Philco scientists had done much of the fundamental development necessary as a foundation for designing radar devices to operate on micro-wave frequencies.

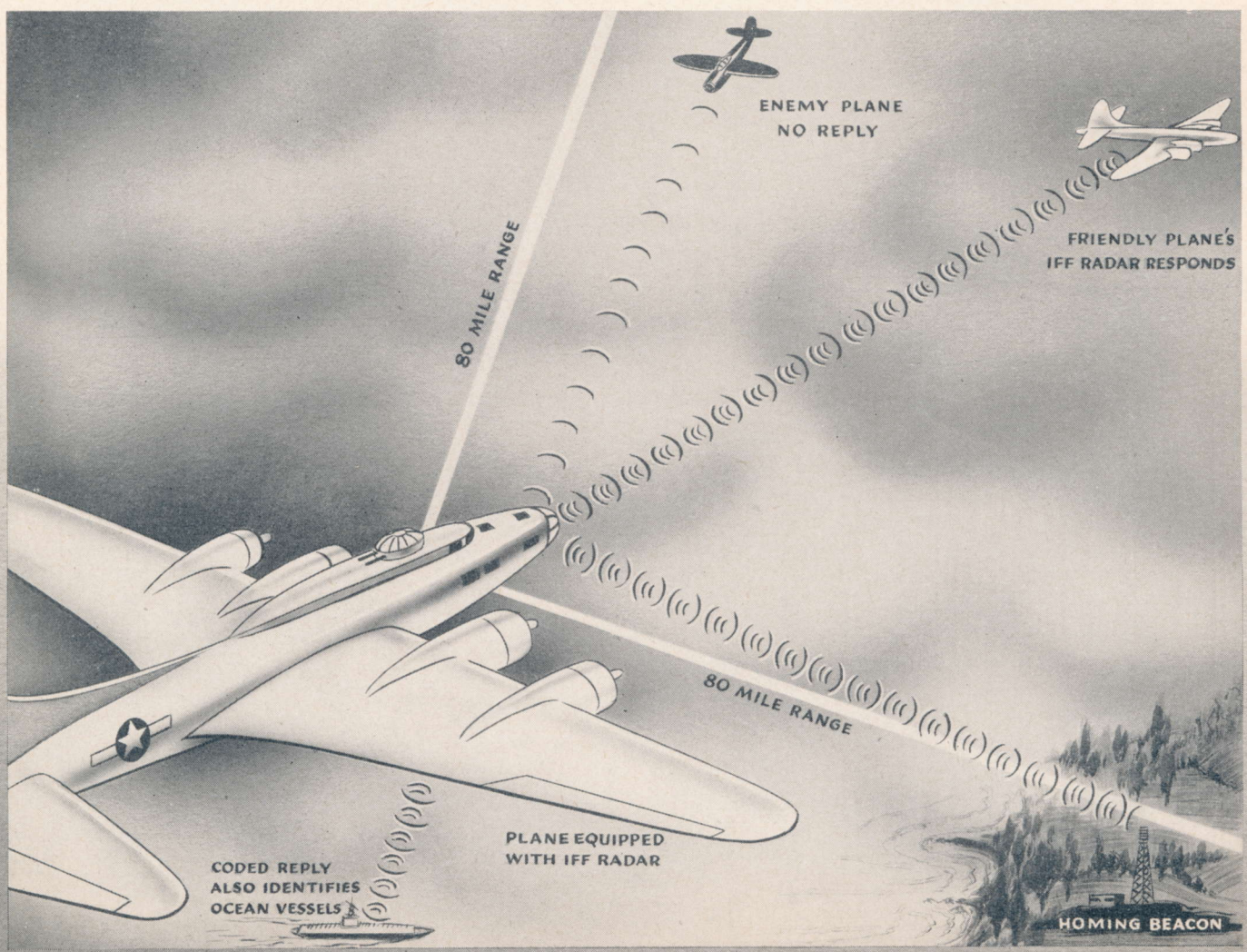
Furthermore, Philco was in a position to assume the responsibility for turning out complete aircraft radar equipments in large volume rapidly, because of its experience in the automobile radio field since 1931. A radio for use in a motor car must be compact, light in weight, powerful and well shielded from electrical interference. So must an aircraft radar system. Thus, both in fundamental research knowledge and in the practical engineering and production of electronic instruments in large volume, Philco had qualifications to offer the Army and Navy that were possessed by no other manufacturer.

LABORATORY IN A BAGGAGE CAR

Philco's first radar assignment had the glamour of a Hollywood mystery thriller. When America was attacked at Pearl Harbor, there immediately arose the critical need for identification radar for all Army and Navy aircraft, so that Allied anti-aircraft on the ground and on ships would not confuse our own planes with those of the enemy. To meet this urgent need, the Philco vice-president in charge of engineering and three of his associates were summoned to Wright Field, Dayton, on December 11, 1941, just four days after Pearl Harbor, for a secret conference with high-ranking Army officers. They were asked to undertake an all-important job: the complete redesigning within *a month* of a British identification radar for American manufacture. This new radar was urgently needed for every plane going into combat areas.

Philco took the job, promised to deliver two sample IFF sets to Wright Field within 30 days. Rushing back to Philadelphia, engineers called conferences, scoured the country for special parts, designed others in locked laboratories. Soon a picked production crew from the Philco automobile radio plant in Ohio was working night and day under armed guard in one of the company's Philadelphia plants.

How aircraft IFF radar operates.



Every Philco electronic part is pre-tested.

On December 27, 1941, just 14 days after the job was begun, the first two radar models had been completed and were being tested by Philco engineers. Four days later, 24 additional IFF equipments were about 90% completed.

That was on New Year's Eve. To rush these secret aircraft radar sets to Wright Field, Philco asked the Pennsylvania Railroad to couple a special baggage car on the "Spirit of St. Louis." Feverishly, engineers and production men loaded IFF radar sets and test apparatus aboard this baggage car while the "Spirit" paused impatiently at North Philadelphia station.

As the "Spirit" sped across sleeping Pennsylvania and Ohio, Philco engineers and production men, protected by armed guards, celebrated the New Year by setting up laboratory equipment in the baggage car, and by completing production and testing on the unfinished IFF radar sets.

On the morning of January 1, with the Baggage Car Laboratory safe on a siding at Dayton, Philco engineers marched into the office of an Army officer at Wright Field and presented him with two completed IFF sets.

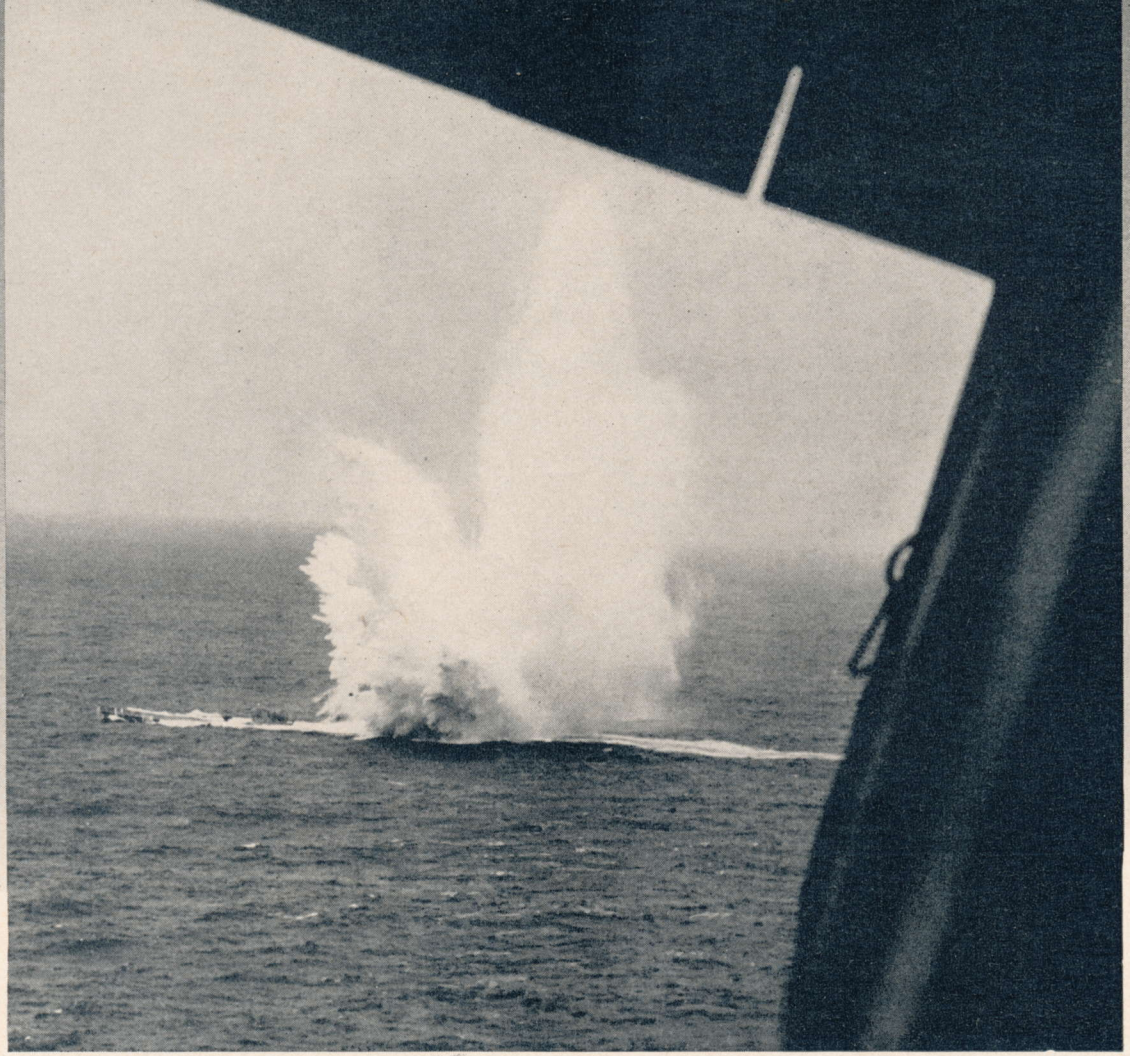
His amazement was unprintable, especially when he was told about the Baggage Car Laboratory . . . ready to work on flight tests and modifications . . . and the other 24 radar sets.

Philco's record of producing 26 complete sets, instead of the two promised, in three weeks, instead of a month, impressed such AAF officers as General (then Colonel) George C. Kenney so much that Philco was given a contract calling for immediate production of $5,500,000 worth of this equipment.

In anticipation of just such a development, the company had already proceeded with tooling for mass production, so that actual volume manufacture began well in advance of Army expectations. This resulted in the equipping of American planes with IFF radar early in the war, and thus saved a great many of our trained airmen from attack by friendly planes or anti-aircraft fire.

Another result of this demonstration of engineering and production skill was that the Navy gave Philco the assignment of producing similar IFF radar sets for naval aircraft and fighting ships. The equipment manufactured for the Navy was delivered in time to play a vital role in the Battle of Midway in June 1942.

Special jig speeded Philco production of radar sub-assemblies.



U-Boat sinking by a radar-guided patrol bomber.

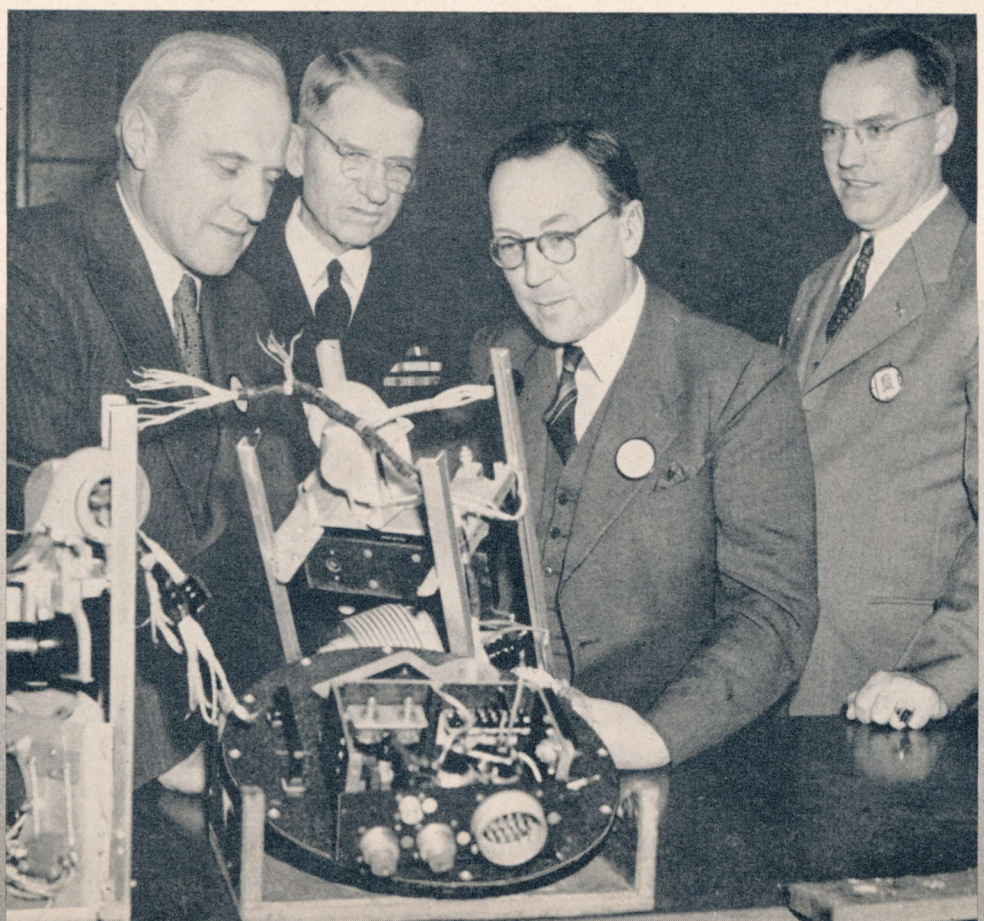
RADAR TO DEFEAT THE U-BOATS

Early in 1942, the thin thread of trans-Atlantic shipping that tied the United States to Britain was menaced by U-boat wolf packs. Not only the ships on which Britain's very life depended but also American coastal vessels were being sunk at an alarming rate, as the pyres of burning tankers blazed within sight of cities all along the Atlantic seaboard. At that time, with the U-boat the major German weapon against the United States, a counter-weapon had to be developed quickly . . . and airborne radar was the answer. The Navy Department turned to Philco as a source of the aircraft search radar it so urgently needed to defeat the U-boats.

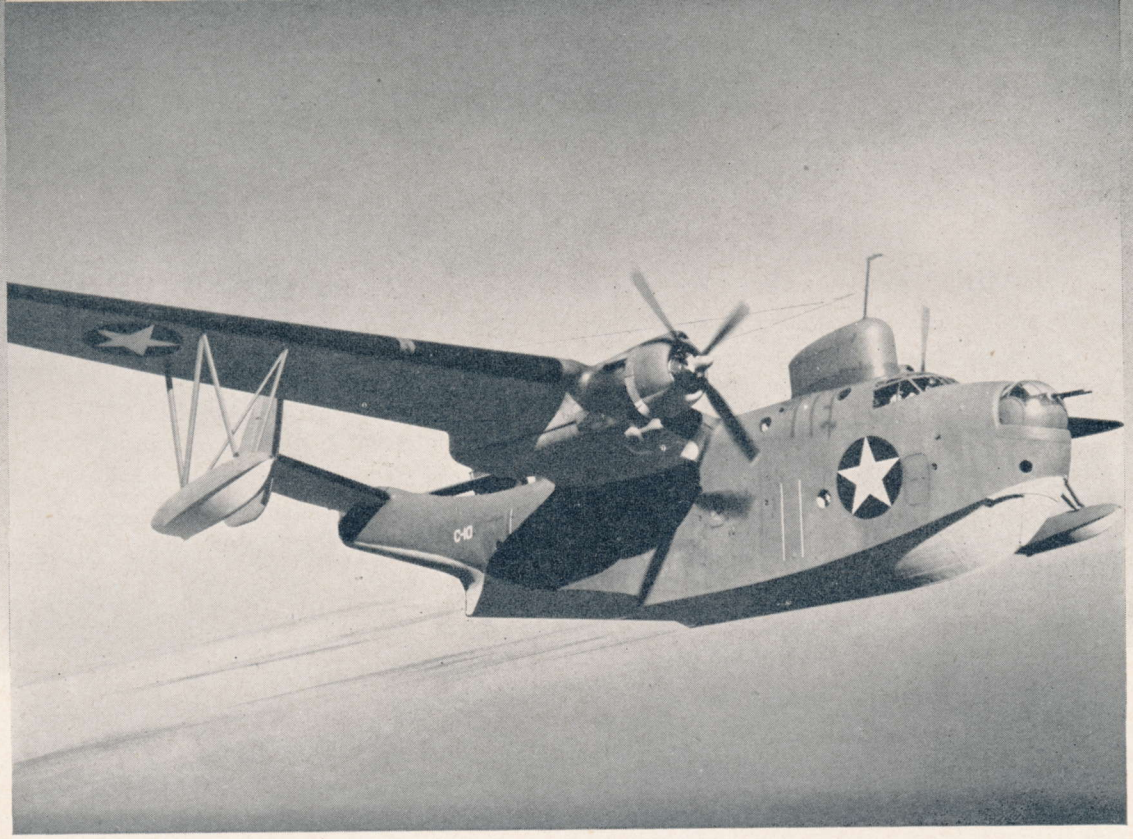
Within a period of weeks after Pearl Harbor, Philco engineers had developed the first aircraft search radar manufactured in quantity in America. Patterned after a British prototype, this early anti-submarine radar presented with fair accuracy the *range* of targets such as submarines, ships or convoys, but gave only a general idea of the target's *direction* from the radar-equipped bomber. A target appeared on the radar picture tube as two electronic bulges or "pips." If the pips were of equal size, the target was directly ahead of the bomber. If the right-hand pip was larger, the target was to the bomber's right.

The first American aircraft search radar built by Philco and nicknamed the "Easy," could spot a surfaced submarine no further away than 8 nautical miles, or a 30-ship convoy at 34 nautical miles (39 land miles). However, this "Easy" radar was so valuable in hunting U-boats at night or in cloudy weather that it was installed in many Navy Catalinas and Mariners, as well as patrol bombers of the Army Air Forces and RAF. It helped to account for several dozen U-boat kills before the end of 1942, when the Germans equipped their submarines with a special "Metox" radar receiver capable of detecting the "Easy" radar frequency . . . thus obsoleting this original anti-submarine radar. During this brief period, Philco manufactured nearly 2000 complete "Easy" radar sets, each weighing about 225 pounds and containing about 35 tubes, many of which had never been produced before.

One of the major accomplishments of Philco engineers in improving the performance of this and later aircraft radar equipments was to develop better cathode ray tubes. This tube, similar to the picture tube in a television receiver, gives the information which a radar operator wants. The performance of this tube and associated electronic circuits is a major factor in whether or not the radar picture is good enough for finding targets like U-boats and bombing them successfully. Philco research engineers vastly improved the clarity, sharpness and detail of radar pictures, just as they had previously done with television pictures.



Scientists visit Philco plant. (L. to R.) Dr. Karl T. Compton, president of M.I.T., Rear Admiral Julius A. Furer, USN, Sir Robert Watson-Watt, C.B., F.R.S., chairman, British Radar Mission, Joseph H. Gillies, Philco vice president in charge of radar-radio production.



Navy Mariner patrol bomber equipped with "George" radar.

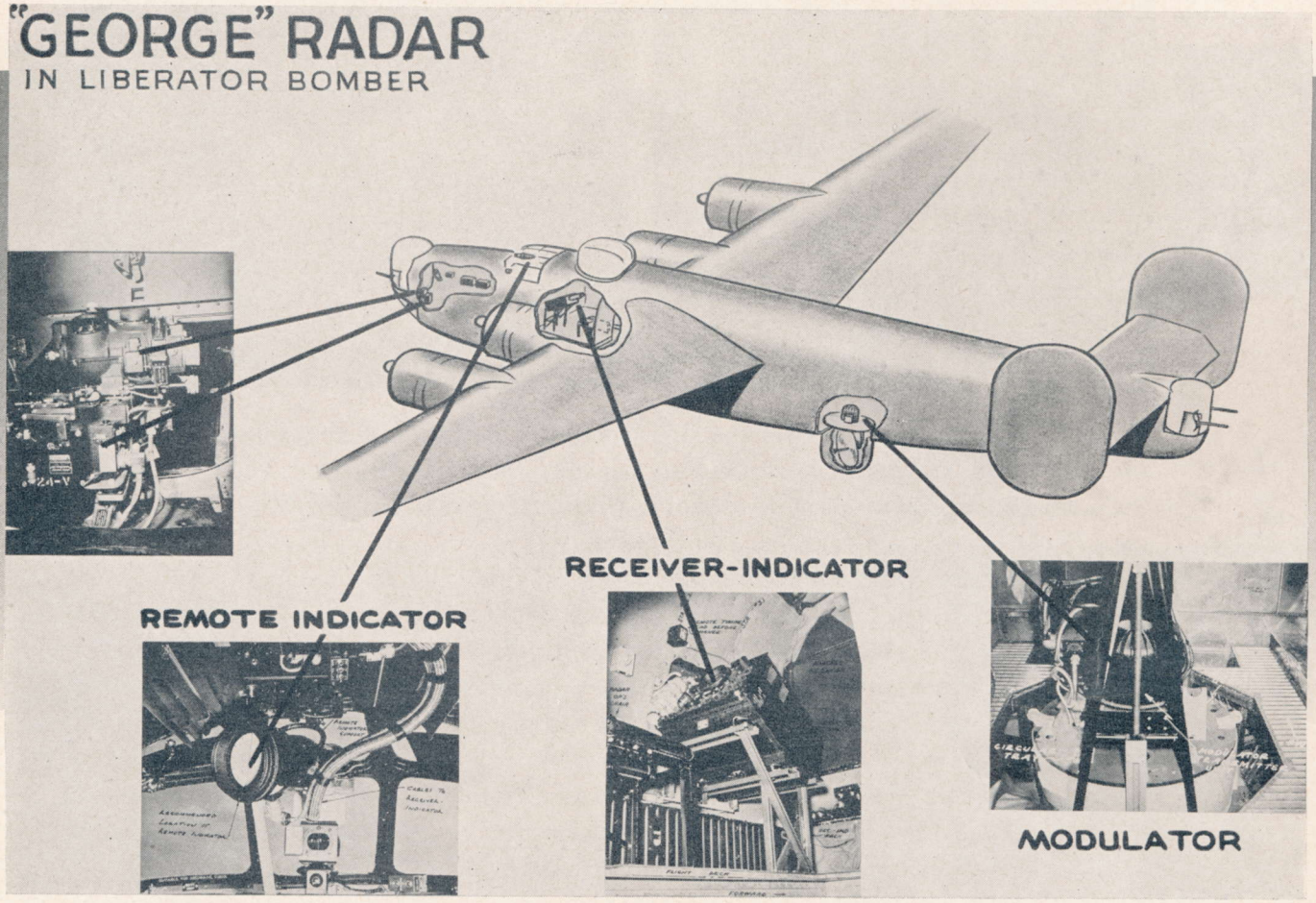
GETTING "GEORGE" TO DO IT

Meanwhile, Philco research scientists and radar engineers, working with scientists of the Navy and Radiation Laboratory, Massachusetts Institute of Technology, had designed a vastly improved anti-submarine radar. This was the first modern micro-wave aircraft radar manufactured in quantity, and it became internationally famous among Allied bomber crews under its nickname of "George."

In designing this first micro-wave radar system and later models, Philco engineers made many notable contributions to an entirely new field in electronics . . . the transmission of superhigh frequency waves a few inches long through special coaxial lines and wave guides that looked like, and were commonly called, "plumbing." Along with this pioneering in the hitherto unexplored higher radio frequency bands, Philco research scientists developed the special measuring equipment and techniques needed to convert these new radar devices quickly from a laboratory curiosity to a practical military weapon which could be produced in large quantity, to precision standards, and at high speed.

"George" was the first production aircraft radar to present a complete map on its picture tube, showing in detail the shapes of coastlines, ships, cities and other targets in a vast circle beneath the radar bomber. From this circular radar picture, it was easy to tell not only the distance of a target, but also its exact direction in degrees from the bomber. Using "George," a plane's radar operator could spot a surfaced submarine at three times the range obtained with "Easy" radar. Convoys were seen on the "George" picture tube at 85 nautical miles and coastlines up to 100 nautical miles (114 land miles). Squadrons of enemy fighters were also spotted by this radar at such distance as to permit Allied patrol bombers to take evasive action.

Development of this 300-pound multi-purpose radar, which contains over 60 special tubes, was so rapid that the first model was flight-tested in a Navy blimp only four months after Philco first received the assignment. Within another two months, mass production of "George" had started in the Philco plants, and soon hundreds of American and British patrol bombers, as well as Navy blimps, were using this radar to find and destroy U-boats by the score.



NEMESIS OF THE U-BOATS

In one case, a Liberator bomber was equipped with "George" radar under the direction of a Philco installation engineer. Only 48 hours later, the bomber's British crew had sunk their first U-boat after spotting it and tracking it down by radar!

Although exact statistics are not available, it is probable that well over 100 kills of Nazi U-boats can be credited to bombers and blimps using "George" radar. Both the Navy and the RAF found the performance of this Philco-built radar to be excellent in the severest service. A Naval Aviation Confidential Bulletin published in 1944 reported:

"Experiences with ASG (George) radar have been highly satisfactory with respect to reliability. Lighter-than-air ships have in many instances accumulated more than 1,300 hours of service in the course of their long coastal patrols. They report 95-100% satisfactory radar operation regularly . . .

Philco high-speed assembly line for radar transmitters.

"The Coastal Command of the RAF continues to send over enthusiastic reports on the ASG radar, and indicate excellent performance with high efficiency. Their experience indicates 150 to 200 hours of operation (per aircraft) without any failure of the equipment."

Philco engineers developed a special mass production technique with long continuous assembly lines for rapid manufacture of this highly complex aircraft radar in volume, along with several hundred special test instruments for assuring performance of this equipment in combat aircraft. Result: in a period of a few months more than 5000 complete "George" radar sets were produced, each comprising 10 separate units . . . with each unit far more complicated than the largest home radio! Most important was the fact that when the U-boat menace reached its peak and the earlier "Easy" radar was useless, micro-wave "George" radar was rolling off Philco production lines ready for installation in the Allied bombers and blimps that destroyed so many U-boat wolf packs. In the official Government report, "RADAR — A Report on Science at War," released August 15, 1945, this job done by Philco with "George" radar is described as "a superhuman effort on the part of the development and production engineers."

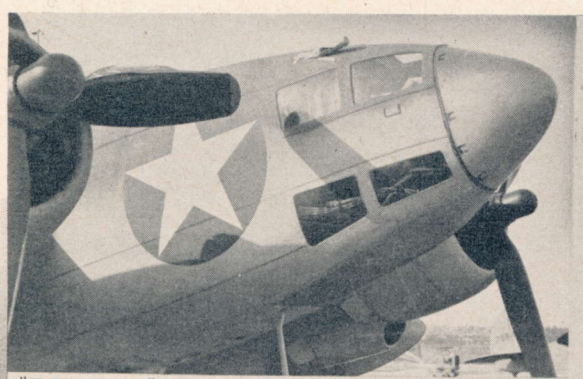
Of special interest to American taxpayers is another fact. Through its remarkable production efficiency, Philco reduced the price of "George" radar more than 50% . . . even though later models had many special improvements, developed and added by Philco engineers to increase both its searching ability and bombing accuracy.

RADAR FOR TORPEDO BOMBERS

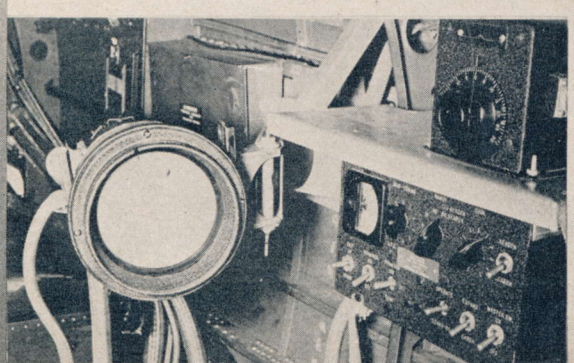
Third phase in the campaign of radar-equipped aircraft against Nazi submarines was the use of lighter planes equipped with a new lightweight radar operating from the famed "baby flattops" or escort carriers. According to the official Government report "RADAR": ". . . escort carriers, or CVE's, were sent with the convoys where they were most needed. Their planes were equipped, of course, with . . . radar. . . . They marked the real doom of the Nazi submarine menace. . . . From one side of the Atlantic to the other, day or night, clear weather or foggy, there wasn't a square mile where a U-boat was safe from the prying eyes of radar, air-borne or ship-borne." This radar, nicknamed the "Dog-One," was designed jointly by scientists of Radiation Laboratory and Philco. Its units were made smaller and more compact than those of "George" radar, to permit installation in smaller bombers, both carrier-based torpedo bombers and land-based medium patrol bombers. For instance, in several types of aircraft, the "Dog-One" radar transmitter and antenna were placed in a special nacelle on the bomber's wing. Solving such special installation problems required much cooperative work by Philco engineers and the aircraft manufacturers.

"Dog-One" radar operated at an even higher micro-wave frequency than "George." It presented a slightly different type of radar picture, covering only an arc directly ahead of the bomber's path instead of the complete 360° circle. This picture, however, showed targets on land and sea in considerable detail; and Philco-built "Dog-One" incorporated

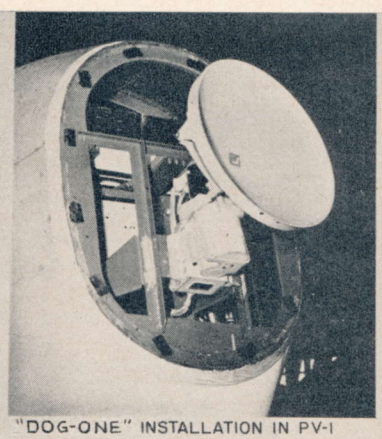
Details of typical "Dog-One" radar installation for low-level and torpedo bombing.



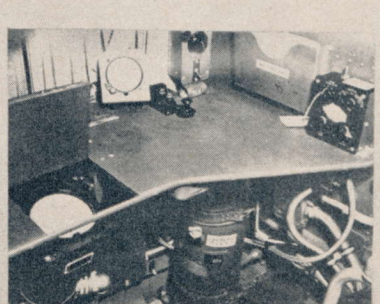
"DOG-ONE" IN A PV-1



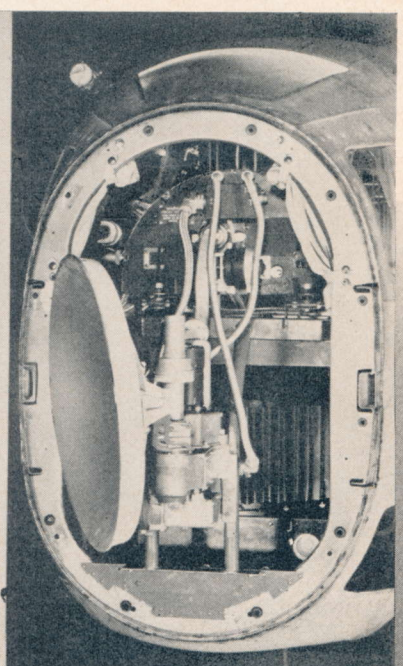
"DOG-ONE" OPERATOR'S POSITION



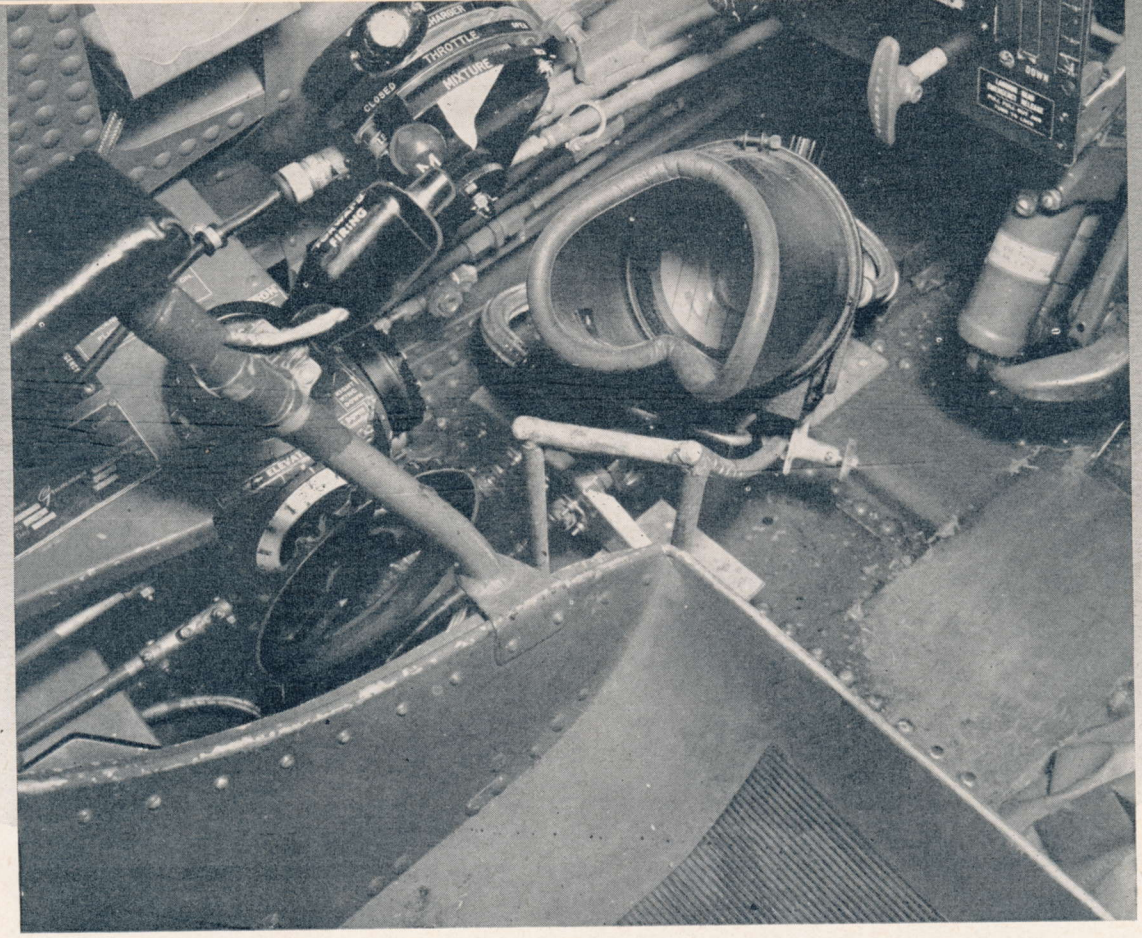
"DOG-ONE" INSTALLATION IN PV-1



OPERATOR'S SCOPE WITH CONTROL BOX ON RIGHT



MOCK-UP OF "DOG-ONE" INSTALLATION IN PV-1 SHOWING RF HEAD AND WAVE GUIDE



"Dog-One" radar picture tube in bomber pilot's compartment.

numerous features that made it the ideal radar for directing medium and low altitude bombing, including torpedo bombing attacks.

This Philco radar has found surfaced submarines, even at night or in dense fog, at distances over 30 nautical miles . . . even better performance than "George" radar. "Dog-One" operators have also reported convoys at 80 nautical miles (about 93 land miles), and large ships at 65 nautical miles.

One of the most important uses of "Dog-One" radar, like "George," has been as an aid to aerial navigation. Bombers equipped with either of these radars can utilize the normal radar map used to search for submarines as a guide for navigating on missions. Or, by flipping a switch, the radar operator can obtain special navigational information on his picture tube either from fixed land radar beacons or "racons," or from racons aboard aircraft carriers.

"Dog-One" radar helped Allied bombers to destroy numerous Nazi and Japanese submarines. It played an essential part in convoying operations of the U. S. Atlantic Fleet which escorted 17,707 ships across the Atlantic with a loss of only seventeen! The RAF also used this radar in long-range fighter bombers patrolling the Murmansk convoy route. In Pacific warfare, this Philco-built radar proved even more important used in Navy torpedo and patrol bombers which sank hundreds of thousands of tons of Jap shipping in low-level attacks.

"MICKEY" RADAR — CRASH ASSIGNMENT

Development of "Mickey," the Radar Bombsight, was what the Army Air Forces and the Navy called a "crash" assignment for Philco. It came at a time when the 8th Air Force had just been built into a formidable striking force, with hundreds of heavy bombers available in England. This huge fleet of bombers, however, was grounded and useless day after day because of the bad weather so prevalent in Western Europe. A radar set for directing pinpoint bombing regardless of weather was needed at the earliest possible date if our air attack was not to fail.

Out of scores of electrical manufacturers in the United States, Philco was the one company selected for the critically important assignment. This was in mid-June 1943. Radiation Laboratory had done preliminary research on this equipment, and the development was rapidly completed by a combined team of Navy, Army, Radiation Laboratory and Philco engineers working night and day. Meanwhile production designs for "Mickey," tooling, and the creation of special test equipment were initiated and carried to completion by Philco factory engineers in a remarkably short time.

To illustrate the complexity of the Radar Bombsight, each "Mickey" set weighs about 325 pounds when installed in a B-17 or B-24 bomber. It utilizes over 80 tubes, most of them far more intricate and expensive than ordinary radio tubes. There are 11 separate units in this complete radar set, with more than 2100 different components and a total of about 15,000 individual parts.

"MICKEY" RADAR FOR SEARCH AND HIGH ALTITUDE BOMBING

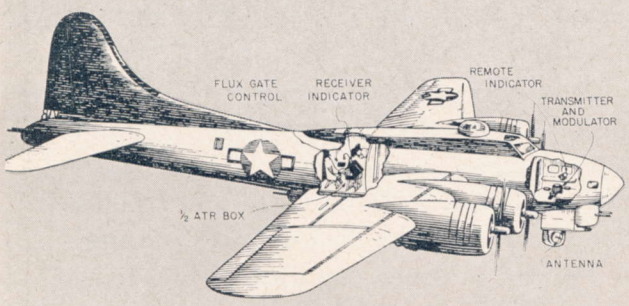
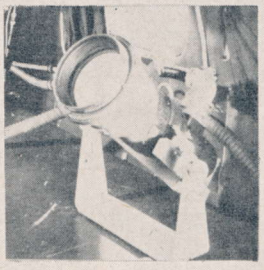
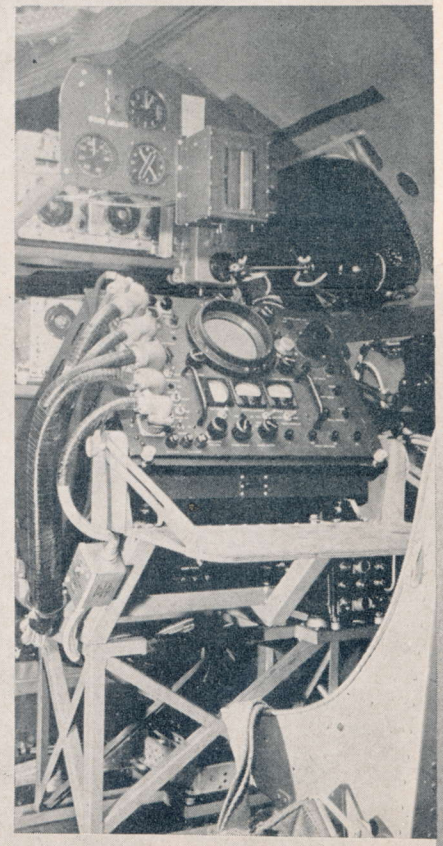


DIAGRAM OF "MICKEY" INSTALLATION IN B-17

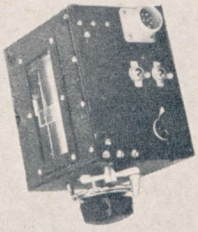


REMOTE PPI



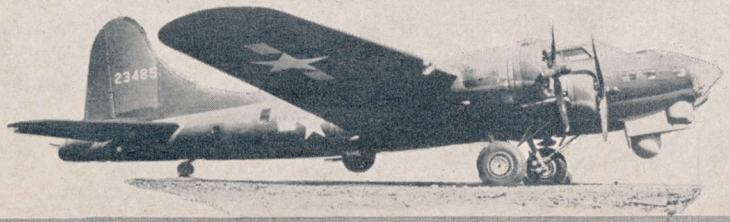
OPERATOR'S SEAT

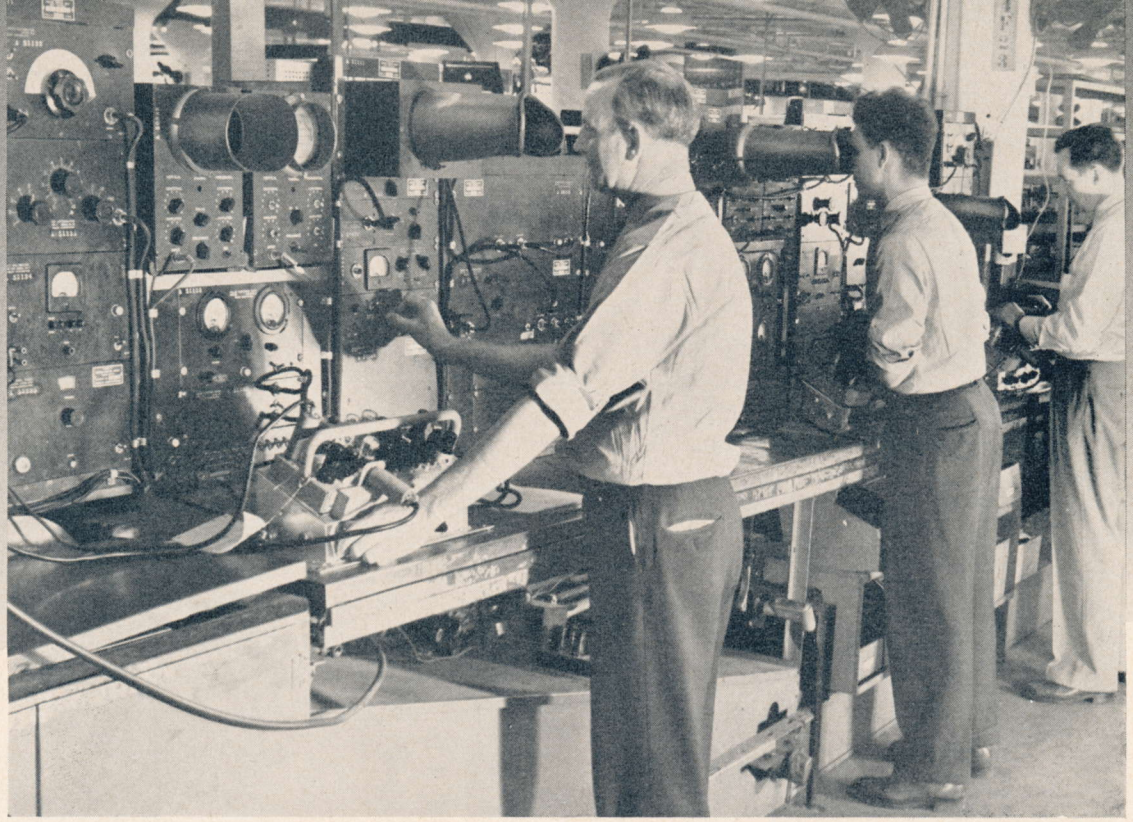
An outgrowth of micro-wave sea search equipment so altered as to be useful for overland navigation and bombing. Special features are cosecant squared antenna for better coverage and range unit and computer box circuits which provide means for precision beacon ranging and for medium precision high altitude bombing. Weight of set - 325 lbs. installed. Status: in use.



RANGE COMPUTER

B-17 WITH "MICKEY" INSTALLED





Special Philco test equipment developed to check "Mickey" sub-assembly.

Philco engineers made numerous improvements in the design of these units to make "Mickey" the precision instrument it had to be for pinpoint bombing. One example was the designing of two types of Computer and a better Range Unit. These two units formed the "electronic brain" that puts a bright bombing circle on the radar picture tube to tell the bombardier when to release his bombs. Among other instances of Philco engineering improvements were the compensation of all electrical circuits for temperature changes at high altitudes, the creation of a better transmitter and antenna system to assure a clearer radar picture, and the development of new cathode-ray tubes for better definition in radar mapping.

Philco delivered the first "Mickey" radar sets late in 1943, in about four months. Meanwhile a dozen sets assembled at Radiation Laboratory with the help of Philco engineers were used to equip 12 special B-17 G Flying Fortresses, the pioneer Pathfinder bombers for the 8th Air Force, with six additional "Mickey" sets provided as spares.

WHAT "MICKEY" DID

On its first flight in November 1943, "Mickey" enabled 8th Air Force bombers to destroy U-boat pens at Wilhelmshaven through a cloud cover . . . pens that were missed in earlier optical bombing. During February 1944, "Mickey" guided the American bombers that destroyed most of Hitler's aircraft and ball bearing factories in a few days — a blow from which the Luftwaffe never recovered. Allied intelligence officers who interviewed Field Marshal Herman Goering reported that the Luftwaffe commander considered airborne radar a major factor in the annihilation of the once-proud Nazi air machine.

As Philco production started rolling on the first *moving* conveyor lines in the radar industry, Radar Bombsights by the tens, then hundreds, then thousands reached the combat zones and were installed in bombers of the 8th and 15th Air Forces. Hand-picked bomber crews, carefully trained in radar bombing and navigation, put "Mickey" to use with impressive results.

General Arnold himself, head of the Army Air Forces, wrote to Philco as the sole manufacturer of "Mickey" radar to indicate its importance in the battle against the Nazis.

HEADQUARTERS, ARMY AIR FORCES
WASHINGTON

2 March 1944

Mr. John Ballantyne, President
Philco Corporation
Tioga & C Streets
Philadelphia, Pennsylvania

Dear Mr. Ballantyne:

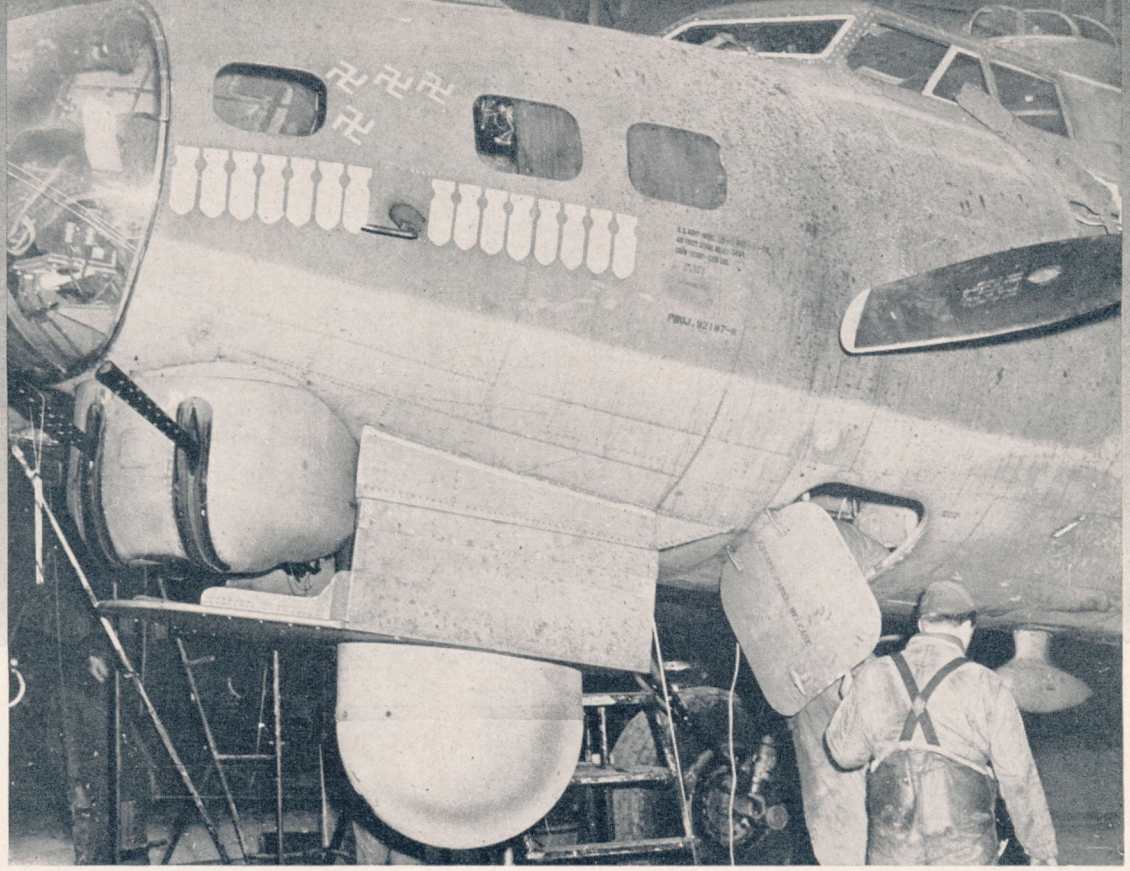
I take great pleasure in writing to you to express the Army Air Forces' gratification at the fine production record which your company is setting on the "Mickey" radar set.

This equipment is already playing a major part in the present air offensive against Germany, and the availability of these sets in quantity is essential to the carrying out of our program. I know the many difficulties of procurement and production engineering involved in the manufacture of such complex and delicate gear as the "Mickey," and your company is to be congratulated on the splendid manner in which you are solving these problems. It is my hope that you will be able to continue the good work and improve your production performance still further. There is a very urgent need for more of these equipments, which are performing such an important task in the vital job of inflicting total defeat on the enemy, and I know you will do everything in your power to keep the "Mickey" rolling.

Yours sincerely,

/S/ H. H. ARNOLD
General, U. S. Army
Commanding General, Army Air Force

It was "Mickey" radar made by Philco that pointed the way, through heavy clouds, for Allied bombers to pulverize the German coastal defenses along the Normany beach just 30 minutes before H-hour, saving many thousands of American lives. This pinpoint bombing of Nazi fortifications, impossible without "Mickey" radar, was so devastating that General Arnold is reported to have called the Radar Bombsight "the most important piece of equipment used by the Army Air Forces in the invasion of France."



Veteran B-17 Fortress equipped with "Mickey" Radar Bombsight.

In the Riviera invasion, the Philco-built Radar Bombsight again proved its deadly accuracy in providing navigational and bombing information for wave after wave of heavy bombers which opened a way for the ground forces. Casualties in this landing were far under expectations, largely because of the radar-directed Allied air attack.

KNOCKING OUT GERMAN OIL SUPPLIES

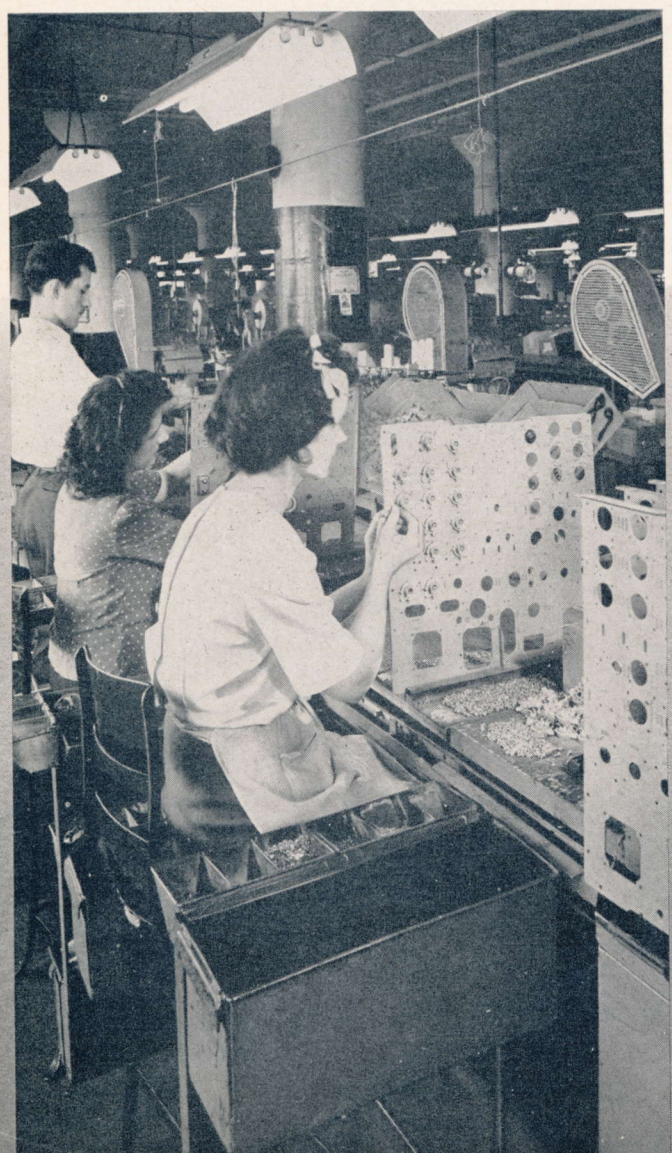
Meanwhile "Mickey" was being used by both 8th and 15th Air Forces to destroy Axis oil supplies. For instance, on July 15, 1944, a mission involving 80% of the 15th Air Force was led by 39 B-24 Pathfinders equipped with improved models of the Radar Bombsight. These Philco engineering improvements made it possible for the bombers, flying through thick clouds, heavy flak and the artificial haze caused by 2000 Nazi smoke generators near Ploesti, to hit the Creditul-Minier refinery in a "beautiful pattern." Results: 125 hits on the refinery, 18 in the storage yard, 21 in marshalling yards reduced Axis oil supplies by 1,500,000 tons in a single raid!

Improved "Mickey" radar sets helped continue the devastation of German industries, its transportation systems and other strategic objectives. But when Hitler rallied his forces for the Ardennes breakthrough in December 1944, heavy bombers of the 8th Air Forces trained their Radar Bombsights on tactical targets . . . enemy troop concentrations, tank columns and strong points. Philco-built "Mickey" radar guided these bombers on 5000 sorties from December 16 to 31, most of them in extremely bad weather. They helped turn the tide of battle at one of the decisive points in the war.

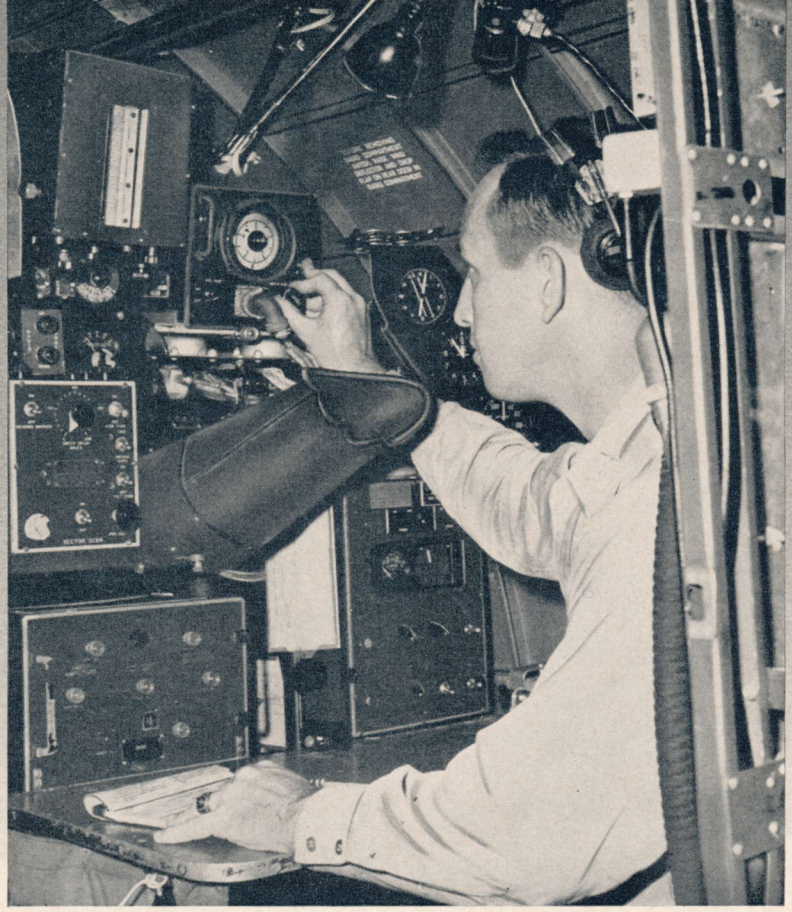
"MICKEY" FOR DEFEATING THE "SCHNORKEL"

Another use soon developed for "Mickey" radar. The Nazis, trying desperately to escape from radar, had developed a new large 1600-ton submarine equipped with the "Schnorkel" . . . a special type of breathing mast that enabled U-boats to cruise for long periods at periscope depth. With only the Schnorkel mast and periscope for a target, instead of a surfaced submarine, a new and even more sensitive type of aircraft radar than "George" or "Dog-One" was urgently needed by the Allies. In January 1945, a leading British radar authority visited Philco and emphasized the critical need for an anti-Schnorkel aircraft radar to keep the U-boats under control in the climactic months of 1945. Philco engineers, working in close cooperation with Navy and Radiation Laboratory scientists, developed a modified version of the famous "Mickey" Radar Bombsight. This modified "Mickey," with special features enabling Allied bombers to find and destroy Schnorkel-equipped submarines, was the ultimate radar weapon in the successful conclusion of the air war against the U-boats.

Starting assembly of "Mickey" receiver.



20 minutes later, receiver panel completed.



Radar operator using "Mickey" on bombing run.

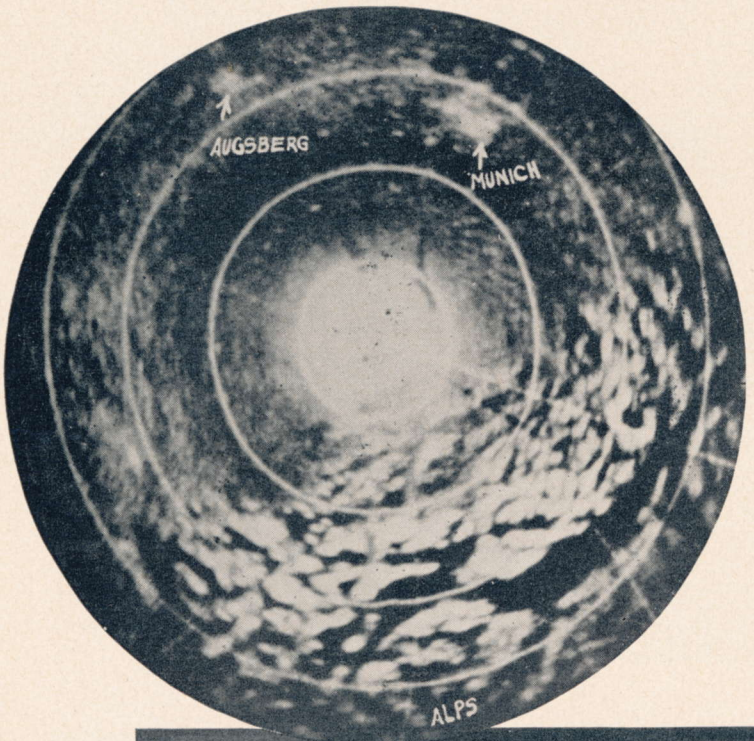
"MICKEY" PROVES QUADRUPLE-THREAT WEAPON

Using the familiar radar search principle, "Mickey" provides a virtual map of the terrain over which a bomber flies for a radius of 100 miles or more. Typical ground targets, such as a bridge or munitions plant, appear as bright spots on the radar picture tube, while lakes, rivers or the ocean produce weaker radar "echoes" and hence darker images on the radar screen.

A second function of "Mickey" radar is to permit precision bombing in any weather or at night. Using special attachments, the radar bombardier can select a specific target area, concentrate his radar picture on this area, and find the precise bomb release point electronically. Hence the Air Forces trained their crews to fly all bombing missions as *radar* missions, using the Norden bombsight in conjunction with "Mickey" for bombing in clear daylight, and this Philco-built radar alone under all other conditions.

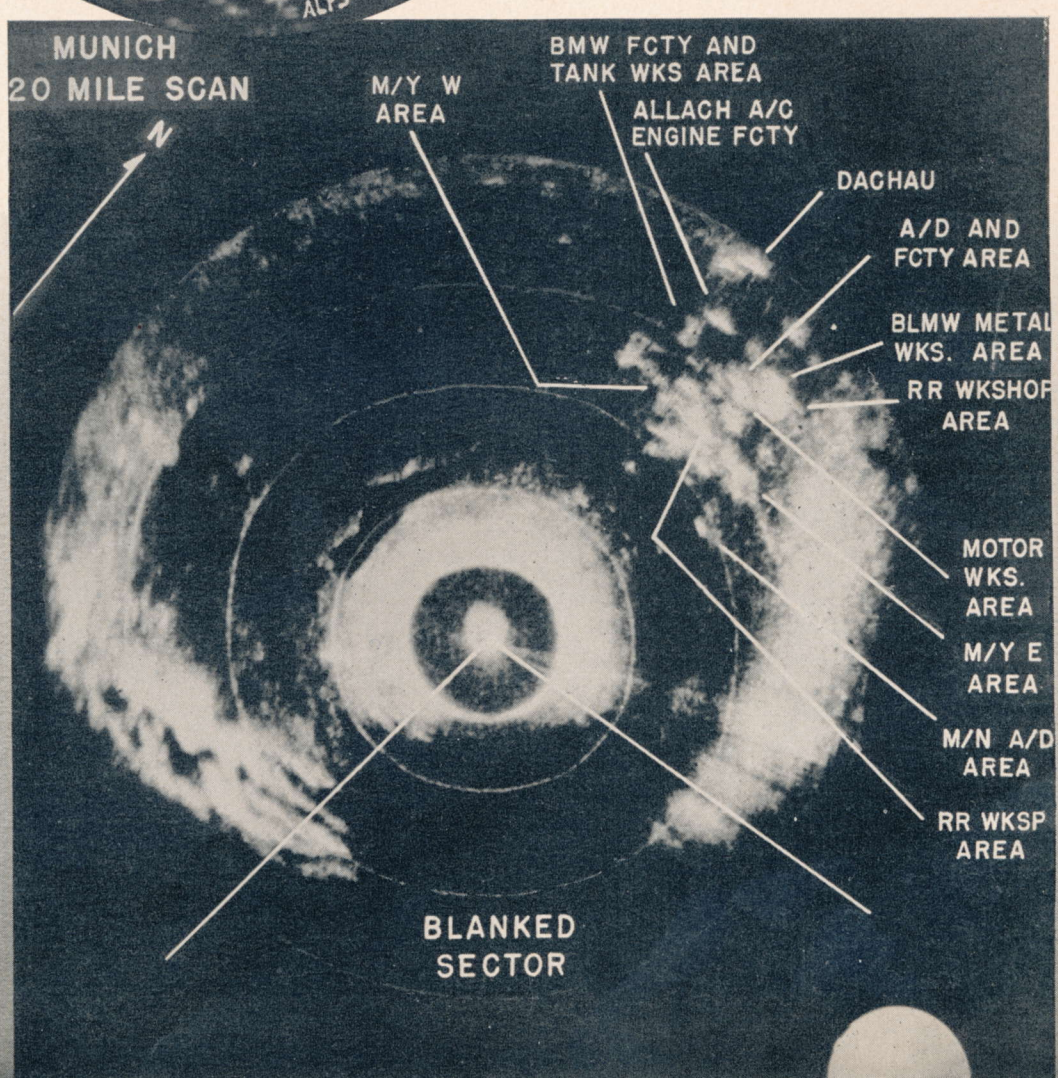
Navigation is a third important use of "Mickey" radar. The radar map is useful, of course, in aiding the aerial navigator to find his check points. In addition, he can use the signals from land radar beacon stations to guide his bomber to and from the target area. Thus the bomber can fly a direct course despite bad weather or darkness, and find its home field or an emergency field for blind landings.

A fourth function for "Mickey" was to detect the presence of enemy aircraft. Used in conjunction with Philco-built IFF radar in the bomber, "Mickey" could spot unfriendly planes many miles away and thus enable the bomber crew to be warned of "bandits." This feature saved many American bombers.



"Mickey" picture tube, set for 100-mile range, shows Augsberg, Munich and Alps.

"Mickey" radar map of Munich area, 20-mile range.



Radar mapping compared to actual map.

"REBECCA" — THE PARATROOPERS' RADAR

Another Philco-built radar proved an essential factor in airborne invasions by Allied troops, from Salerno to the Philippines. This radar, nicknamed "Rebecca," was a lightweight aircraft transmitter-receiver used with ground radar beacons or racons to guide paratroop transport planes and gliders to the exact DZ (Dropping Zones) and LZ (Landing Zones) desired.

Philco's peacetime experience in pioneering with the design and manufacture of automobile radios became enormously valuable in the speedy development and production of "Rebecca" paratroop radar. While much more complex than a car radio, "Rebecca" was similar in its light weight and small, compact proportions. It was built in volume on long, continuous production lines like those used in manufacturing automobile radios in quantity.

This Philco radar was first used in two *night* dropping operations at Salerno and guided C-47 troop carrier planes so accurately that hundreds of paratroops were dropped within 200 yards of the ground radar beacon . . . and no troops or planes were lost in either night's operations!

Again in the invasion of Normandy, 15,000 paratroopers were dropped before, during and after H-Hour with only 2% loss, thanks to "Rebecca." They played a vital part in defeating the Germans behind the lines and in making the invasion a success. During the Riviera invasion and the crossing of the Rhine, similar "Rebecca" paratroop operations were even more successful.

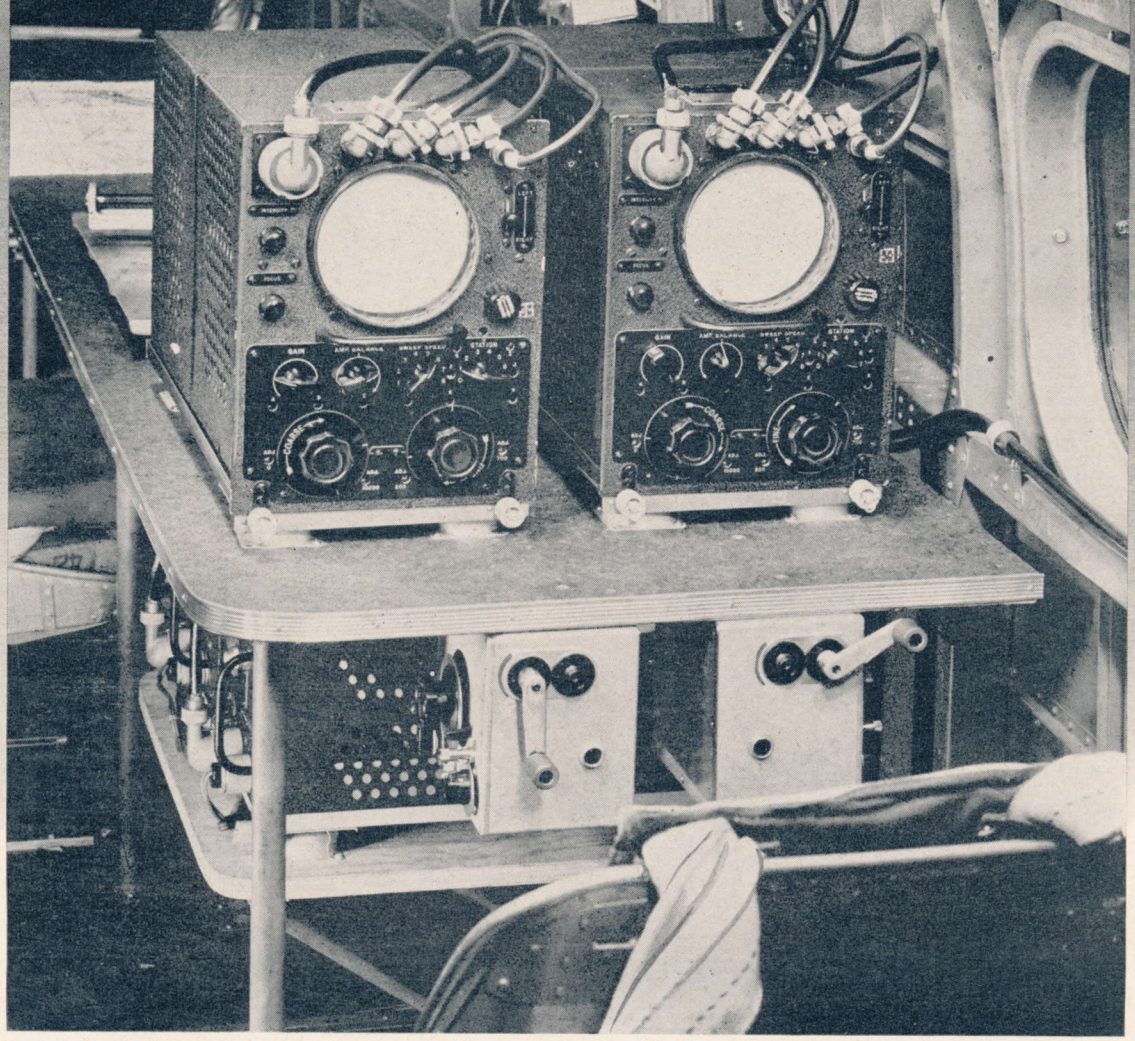
RADAR HELPS SINK HUNDREDS OF JAPANESE SHIPS

Meanwhile, thousands of miles away, under entirely different conditions, "Mickey" and other types of Philco-built aircraft search radar were proving invaluable in the war against Japan. Many of these radar equipments for use in bombers carried a special attachment called LAB for *L*ow *A*ltitude *B*ombing. This device included a bombsight and automatic bombing controls which enabled a bomber to make successful approaches on enemy ships at night and to sink these ships without ever seeing the targets. In fact, a "kill" was often reported when the target image disappeared on the radar picture tube . . . proving that the ship had sunk below the water where radar waves cannot penetrate!

Philco engineers played a prominent part in developing this LAB attachment, which was built in the Philco plants with special manufacturing techniques and special test equipment, which was made available to other manufacturers. The LAB radar was used in sinking more than a million tons of Japanese shipping, including many Jap naval vessels such as aircraft carriers, cruisers, destroyers and submarines.

In utilizing this device for night attacks, ship targets were always interrogated by means of a Philco-built IFF set with which all LAB bombers were equipped. This avoided any mistakes in the identity of targets attacked with the devastating accuracy of radar bombing.

Chemical spraying of radar chassis is part of Philco tropicalization process.



Early model of aircraft Loran in air navigator's compartment.

LORAN FOR TRANS-OCEANIC NAVIGATION

Superforts that carried the atomic bombs, incendiaries and high explosives that crushed Japan without the need of an invasion were guided to their targets and back to their bases in the Marianas by Loran, the most revolutionary navigation device developed since the invention of the first compass.

An airplane equipped with this new instrument can travel any pre-determined course regardless of weather, day or night, without depending on celestial navigation. Philco research scientists and engineers played a leading role in the design, development and production of this new "electronic navigator." In the peacetime world, this radar system of aerial navigation will help to make world-wide air travel safer and more rapid than ever before.

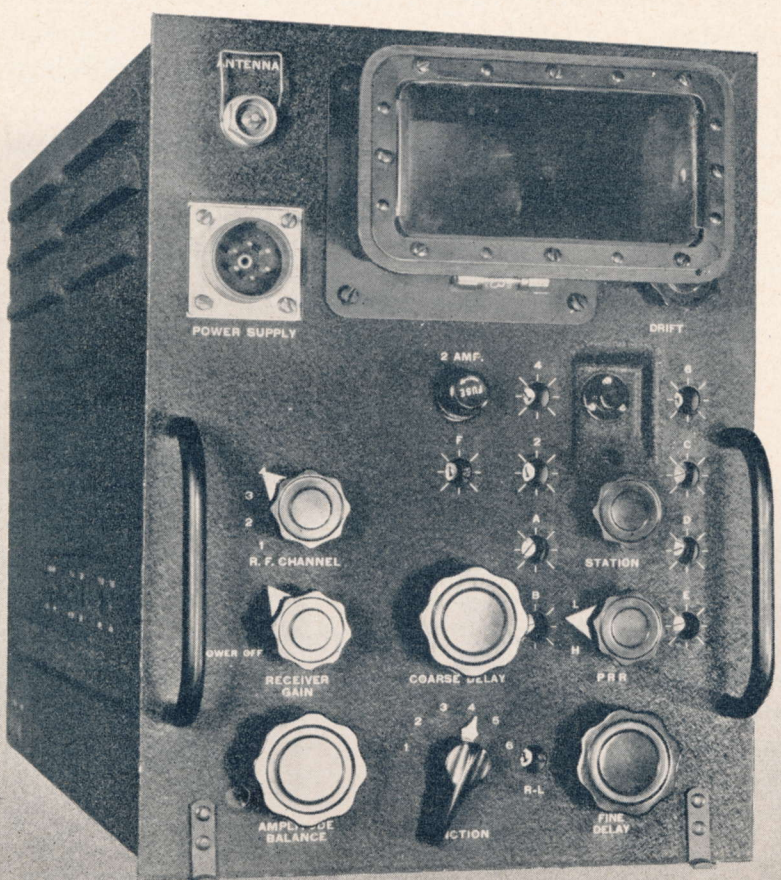
Loran enables the navigator of an airplane to find his exact position at any instant accurately and rapidly. In the plane, signals are picked up from pairs of "master" and "slave" beacon stations on the ground. These fixed beacons may be up to 1500 miles away.

Beacon signals appear on an aircraft Loran indicator tube similar to a television picture tube, and give the distance of the plane from the beacon stations. Then the navigator consults a simple chart and knows exactly where his plane is at that instant.

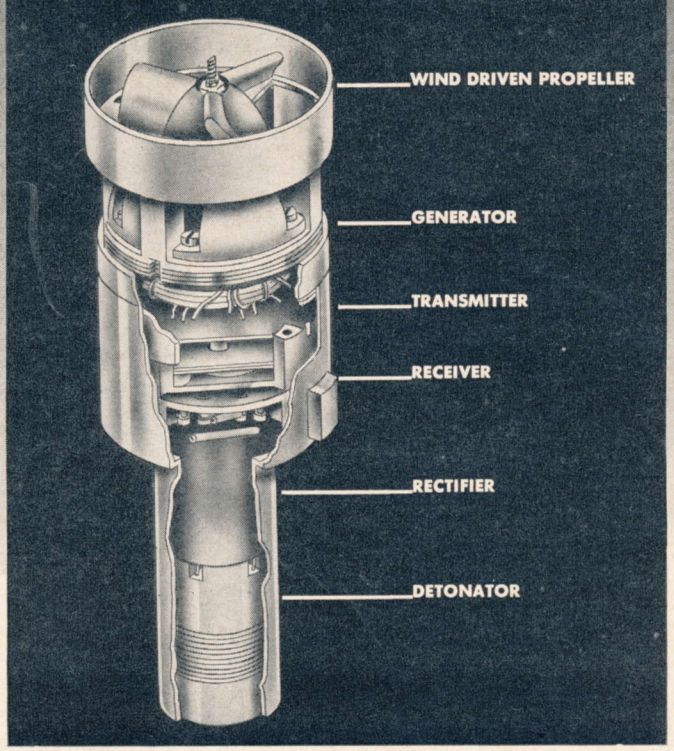
Airborne Loran ("*LO*ng *RA*nge *N*avigation") equipment designed by Philco engineers has proved invaluable in long trans-oceanic flights by the Army Transport Command and the Navy Air Transport Service, as well as our Allies. It has been used in flying thousands of bombers across the Atlantic. It has proved vitally important in long flights over the Pacific Ocean where island destinations are mere pin-points in a vast expanse of water.

In creating Loran equipment, Philco design and development engineers worked with research scientists at Radiation Laboratory to solve many electronic problems. The Philco laboratories developed many special types of electronic circuits to operate over widely varying temperature and humidity conditions, ranging all the way from those of the Arctic to the Equator, and from sea level to stratosphere.

Loran equipment, like other radar and military radio instruments, was pre-tested in the "Stratochambers" designed by Philco engineers to permit duplicating flight conditions anywhere on the globe. The vibration and shocks experienced by electronic equipment in various types of aircraft were simulated by engineering tests on one of several vibration machines, to make certain in advance that each unit would function precisely under conditions of actual warfare.



Latest lightweight Loran receiver used for navigating Superfortresses.



VT radio proximity fuze built by Philco.

VT FUZE FOR RADIO-EXPLODED SHELLS

A closely guarded secret until long after V-J Day, the radar-like VT (variable time) proximity fuze was recently described by the War Department as "secondary in importance only to the Atomic Bomb"!

This fuze, in the design and manufacture of which Philco engineers played a notable part, contains a tiny self-powered radio transmitter-receiver only three inches in diameter. It fits into an artillery shell or airborne 4½-inch rocket and detonates the projectile automatically 70 feet from its target.

Used in an antiaircraft shell, for instance, the VT fuze begins operating when the shell leaves the gun. The shell's spinning motion rotates a vane which operates a tiny generator to provide current for the radio unit. Then the midget transmitter starts broadcasting a continuous wave of high-frequency energy. When this transmitted wave strikes an airplane 70 feet away, some of the energy is reflected back to the fuze's receiver. The interaction of transmitted and reflected signals acts like an electronic switch to detonate the projectile.

Philco research scientists, working with those of U. S. Army Ordnance and the National Bureau of Standards, solved many difficult problems in perfecting this "all-but-thinking" fuze. They designed special circuits to keep the fuze from detonating as a result of the random electrical noise developed during the flight of a projectile. They kept tolerances within rigorous limits so that the fuze would operate only at the required distance from an actual target. They had to design specially rugged and reliable components for the pint-sized transmitter-receiver unit. These designs for mass production to high precision standards were rapidly developed by Philco engineers, along with much special test equipment. The result was speedy large-scale production of the VT proximity fuze when it was urgently needed.

During the war, hundreds of thousands of these fuzes produced by Philco were used to arm the artillery shells, including those which saved London from the V-1 buzz-bombing. In a single day, antiaircraft fire shot down 68 buzzbombs. The VT fuze was officially credited with a "truly sensational increase in kills . . . it increased the destructiveness of antiaircraft fire at least five-fold"! These fuzes, along with radar location, also accounted for the amazing accuracy of Allied antiaircraft fire against Nazi and Japanese planes. One out of every two VT-fired rocket projectiles, fired by a fighter plane, "could be counted upon to bring down an enemy airplane at 1,000-yard range," according to the War Department. The VT fuze in shells and rockets proved a major factor in winning the Battle of the Bulge.

NAVY TRIBUTE TO PHILCO RADAR

In testimony to the effectiveness of Philco's work as one of the two largest manufacturers of airborne radar for the U. S. Navy . . . which, in turn, provided many Philco-built radar equipments such as "George" and "Mickey" for use by the Army Air Forces and the Royal Air Force . . . Vice Admiral E. L. Cochrane, USN, Chief of the Bureau of Ships, wrote as follows:

BUREAU OF SHIPS
NAVY DEPARTMENT
Washington, D. C.

16 September 1945

SPEEDLETTER

SPEEDLETTER

TO THE MEN AND WOMEN OF
PHILCO CORPORATION
TIOGA AND "C" STREETS
PHILADELPHIA, PENNSYLVANIA

RADAR HAS BEEN ONE OF THE NAVY'S ACE WEAPONS DURING THE WAR. IT SOUGHT OUT ENEMY SHIPS AND PLANES DESPITE DARKNESS, RAIN, FOG OR SMOKE, AND ENABLED OUR GUNS TO DESTROY THEM WITH UNERRING ACCURACY. IT HELPED TO SAFEGUARD OUR SHIPS AND MEN FROM SURPRISE ATTACK. IT WAS AN INVALUABLE NAVIGATIONAL AID TO OUR TASK FORCES OPERATING IN CLOSE FORMATION IN UNFAMILIAR WATERS. THE MIRACLE OF RADAR HAS BEEN OF TREMENDOUS SIGNIFICANCE IN BRINGING ABOUT THE SURRENDER OF THE JAPS. YOU MEN AND WOMEN OF PHILCO CORPORATION HAVE, BY YOUR PRODUCTION OF RADAR EQUIPMENT, EACH STRUCK A BLOW AGAINST THE ENEMY WHICH AIDED IN HIS COMPLETE DEFEAT. THE BUREAU OF SHIPS WISHES TO EXPRESS ITS APPRECIATION TO EACH OF YOU FOR YOUR SPLENDID COOPERATION AND TO EVERY INDIVIDUAL ASSOCIATED WITH YOU IN SUB-CONTRACTORS' PLANTS FOR AN OUTSTANDING CONTRIBUTION TO THE WAR EFFORT.

E. L. COCHRANE
Vice Admiral, USN
Chief of Bureau

FIELD ENGINEERS FOR EVERY FIGHTING FRONT

One of the most important phases of Philco's war job was the installation and servicing of airborne radar and radio equipment for the Army, Navy and RAF, and the recruiting and training of radio-radar operators and maintenance technicians.

Philco helped the United States Army and Navy and the British Government to recruit thousands of trained radio servicemen from its own nationwide service organization. The Philco Training School was established to help meet the great need of the Army and Navy for technically trained personnel in the field of electronics, and more than 15,000 students were instructed in radio-radar operation and maintenance for the Armed Forces. A group of over 500 highly trained field engineers was placed on duty with the Army and Navy all over the world for the installation, modification and maintenance of airborne radar and radio equipments made by Philco as well as other manufacturers, and the instruction of service personnel. For these activities, which Philco conducted on a larger scale than any other radio manufacturer, the company received the highest commendation of military and naval authorities.

RADAR, RADIO AND TELEVISION

Many of the notable radar devices developed by Philco engineers during 44 months of World War II will have far-reaching peacetime applications, principally for air and marine travel.

Even more immediately important to the general public will be the refinements and improvements in radio circuits for both AM and FM, electronic components and mechanical features which will be based upon wartime radar research. The Philco engineering and research staff of more than 500 technically trained persons is now devoting much of its energy to "research reconversion" . . . that is, adapting the rich storehouse of war-born ideas to peacetime radio applications.

In television, too, which promises soon to become a nationwide service, Philco has long been known as a pioneer. Its early experience in television research formed the basis for many Philco achievements in radar. Now the current of ideas is reversed and flows from radar toward future developments in television transmission, relaying and the design of improved television receivers for American homes. It may take some time to adapt for television many of the radar devices developed by Philco scientists for operation in the upper or microwave frequencies. But this knowledge will ultimately, inevitably, result in the transmitting and receiving of television pictures of better quality . . . greater sharpness, clarity and definition.

Thus the radar, developed and built by Philco, that helped so notably in winning victory over the Axis, will be doubly useful in peace . . . both for its direct applications for safer, speedier commercial travel, and for its indirect influence in advancing the progress of radio and television.

Courtesy of the United States Army Air Forces, the United States Navy, and the Radiation Laboratory, M.I.T., is gratefully acknowledged for permission to reproduce many of the installation and radar 'scope photographs used in this booklet.

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