DEVELOPMENT AND PRODUCTION OF WARTIME RADAR

At the time of the outbreak of the war in Europe in 1939, the value of radar for early warning of the approach of enemy craft was well recognized. In both England and the United States, scientists and engineers joined in a concentrated effort to advance radar research and development. Even before the entry of the United States into the war, in line with our policy of national defense, President Roosevelt established, in June, 1940, the National Defense Committee to unify research, including radar activity, in the United States. This later was made part of a larger organization, the Office of Scientific Research and Development. The National Defense Research Committee set up no laboratories of its own, but contracted research and development to the universities, non-profit research institutions, and commercial concerns. Thus was established a clearing house for the interchange of information. Because of the work already accomplished by RCA in radar, the company was able to supply both components and radar equipment immediately.

In July, 1940, the Microwave Committee was created, and the Radiation Laboratory was established at Massachusetts Institute of Technology under its direction. RCA was represented throughout the war on this committee which was later designated Division 14, Office of Scientific Research and Development. It was possible for RCA to supply test equipment used by the Radiation Laboratory during its early days, due to the microwave development work done by the company in the pre-war years. The extensive program of microwave development carried on by the Radiation Laboratory, substantially assisted by RCA and other commercial firms, reached a point in 1943 which warranted microwave production on a large scale.

During much of the war, lower- and medium-frequency radar was used. Appreciable work was done within these frequency ranges by the commercial companies. However, RCA was essentially the only organization active in the field of f-m radar. Research and development work on this type of radar resulted in the production by RCA of a very accurate absolute altimeter which became standard equipment on all Navy aircraft, and of an automatic bomb release equipment which made possible particularly accurate bombing at low altitudes.

A considerable amount of work was done by RCA Victor involving correlation of the radar information available, as well as the development of test equipment which made practical the estimation of the performance of a radar system with a reasonable degree of accuracy prior to actual field tests.

As the international picture grew darker, a program was put into effect to equip all Navy vessels of the first and second classes, as well as the submarine fleet, with radar as standard equipment. RCA made all its facilities available to the War Department, the Navy Department and the National Defense Committee. The facilities of RCA for the development and manufacture of radar were expanded. In the RCA-Victor Division, the Camden plant was expanded to provide increased facilities for the development and production of radar equipment; the Harrison plant was enlarged for the production of receiving tubes; a plant was established at Lancaster, Pennsylvania, for the production of cathode-ray tubes and special high-power tubes; and the plants at Indianapolis and Bloomington, Indiana, were geared for war production. RCA Laboratories were built at Princeton, New Jersey, to carry on research work, much of which was in radar. The other divisions of the Radio Corporation of America, RCA Communications, the National Broadcasting Company, RCA Institutes, the Radiomarine Corporation of America, and the RCA Service Company also swung into full cooperation with the government program. Any producer of radio or radar equipment sent by the Services to RCA was given engineering and manufacturing information. RCA granted to the government a royalty-free patent license on all RCA patents in the radio field.

When the United States entered the war, the program of radar research and development was further intensified, with a success which was due in no small degree to pre-war research and development in the fields of television and communications. RCA and several other large companies had acquired a knowledge of short waves, cathode-ray tubes, and timing-synchronizing circuits which proved of direct value in radar development.

RCA is the largest manufacturer of electron tubes in the United States. Quantities of both standard and special purpose tubes are produced in the plants at Harrison, New Jersey, and at Lancaster, Pennsylvania. Until 1942 all tubes were manufactured in the Harrison plant, but the wartime need of electronic tubes necessitated the opening of the second plant in order to fill not only RCA requirements, but also those of many other manufacturers of electronic equipment.

RCA prewar tube research and development produced many tubes, some of which were found applicable to the special equipments required by the Armed Services. Special high frequency tubes developed for use in television equipment were found satisfactory for application to radar equipment. The most important of these were the special cathode ray tubes employing fluorescent screens which provide the visual display of the radar signal. The development of the technique of design and manufacture of this tube was due largely to RCA's prewar television work. RCA produced more than half of all the cathode ray tubes used in wartime radar equipment built in the United States.

Other tubes found adaptable for use in radar equipment, which were developed by RCA before the war, include the acorn tube, the miniature tubes, and a high frequency amplifier tube, RCA-6AC7. The acorn tube was used in practically all types of early radar. The miniature tubes, used in almost all airborne radar and in many types of non-airborne radar, proved of such importance to the military program that very large quantities were required. Between January, 1942 and August, 1945, 20 million miniature tubes were manufactured by RCA alone.

As the war progressed, new methods, controls, and techniques were evolved by RCA tube engineers to improve the performance, quality and efficiency of the prewar tubes being applied to radar. The lighthouse tube, originally developed by another company, was made practical by the ingenuity of engineers at the RCA-Victor Harrison plant.

The wartime development of new tubes for radar equipment by RCA engineers was noteworthy. The RCA-8014A, a special external anode triode was developed for use in the shipborne Models SA and SD transmitters. Other new special tubes included high frequency transmitting and receiving tubes, high voltage rectifier tubes, the beam deflection tube, the orbital beam tube, air-cooled oscillator tubes, and the transmit-receive switch tubes used in duplexer units.

GROUND RADAR EQUIPMENT — When the United States entered the war, the Army had in the field 580 sets of long range ground radar equipment for aircraft search. This was known as Type SCR-270 equipment, which had become a standard item of Army procurement in 1940. For this equipment RCA had done the production engineering on the receiver and indicator, and had supplied the necessary quantity of these units. In 1942 RCA engineers designed an improved antenna for this equipment. It was a bedspring type antenna, 20 by 40 feet, constructed entirely of metal, which made it far superior to the wooden model which it replaced. It was remarkable for both bandwidth and low back and side lobes, and was sufficiently simplified, both mechanically and electrically, to permit operation by relatively unskilled personnel. The development of this antenna, which was the result of basic antenna research by RCA engineers, and its installation on the SCR-270, greatly increased the efficiency of the equipment.

The Army at this time became interested in the development of a maplike display of radar indications showing azimuth and distance, which later became known as the plan position indicator type of presentation described in "Preeminent Features of Radar." RCA engineers began development work on this type of unit in 1941. In 1942 ten indicators giving this type of display were delivered to the Signal Corps for use with long-range ground radar sets. These indicators employed a magnetic deflection type cathode-ray tube with a long-persistent screen, a mechanically rotated deflection yoke, and the conventional synchronizing, deflection, and blanking circuits.

In September, 1942, the Army requested RCA to modify five equipments for lightweight, early warning radar. The Navy airborne Model ASA equipments were used, with the altimeter feature and the antenna switching unit removed. The modified equipments were designated Type SCR-602-T2. This was accomplished, including field testing of the sets, within sixteen days.

Shortly afterward, because of the urgent need of the Marine Corps for lightweight, early-warning equipment which could be easily moved and set up in a short time, RCA was requested to modify 300 additional Model ASA equipments for this purpose. These were known as Navy Model SB radar equipments. The first of these were shipped in March, 1943, and it is understood that some were used in the African campaign.

In the fall of 1942 RCA engineers began development work on a lightweight search radar equipment packaged for transportation by truck or plane. This equipment was known as SCR-602-T5. One model was completed and shipped in June of 1943. Modifications were then made, and the resulting equipment was designated Model AN/TPS-8. Three of these equipments were delivered to the Army before the end of the war.

GROUND RADAR

TYPE AN/TPS 8 LIGHTWEIGHT RADAR EQUIPMENT. This equipment is a lightweight, ground radar designed to give warning of the approach of planes. It is so constructed that it may be transported by truck or plane, and set up comparatively quickly and easily by a small group of personnel.

The major components comprising the equipment (Figures 106 to 118) are as follows:

UNIT

Low frequency transmitter
High frequency transmitter
Receiver
Range Indicator
Plan Position Indicator
Duplexer
Antenna Assembly
Modulator
Low voltage power supply
High voltage power supply

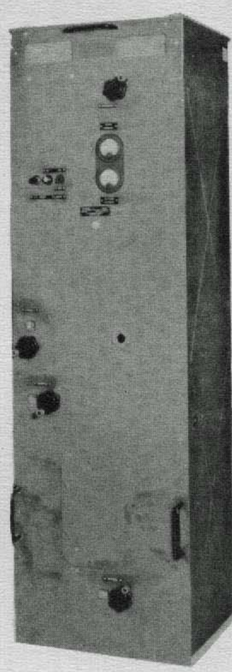

Figure 106. Cabinet for Model AN/TPS-8 Transmitters

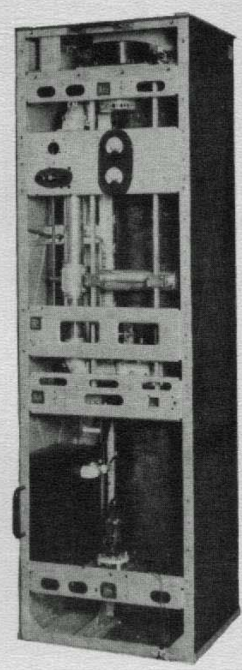

Figure 107. Inside View of Model AN/TPS-8 Low-frequency Transmitter

Figure 108. Model AN/TPS-8 Receiver

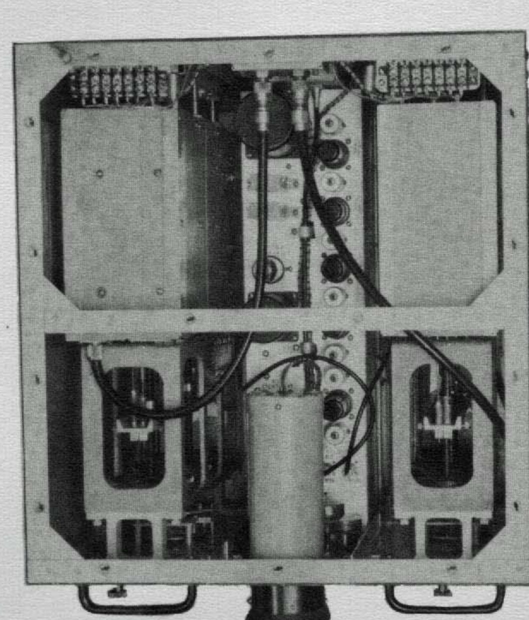

Figure 109. Model AN/TPS-8 Receiver Chassis

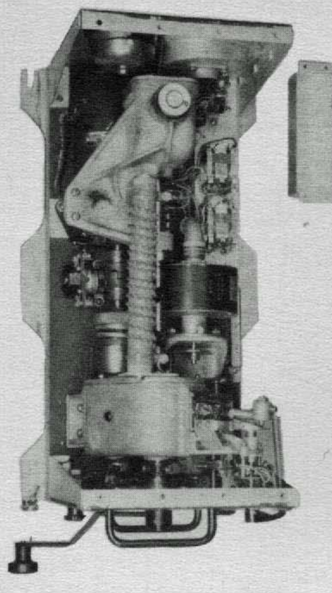

Figure 110. Model AN/TPS-8 Antenna Control Unit Chassis

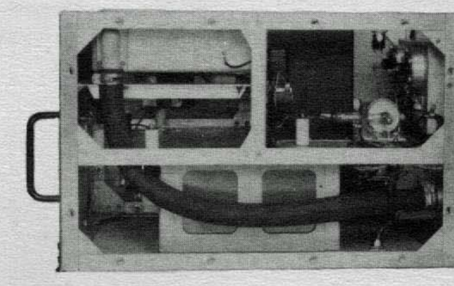

Figure 111. Model AN/TPS-8 Modulator

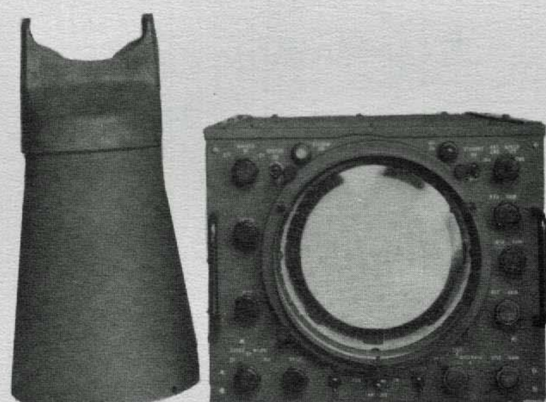

Figure 112. Model AN/TPS-8 PPI Unit and Light Screen

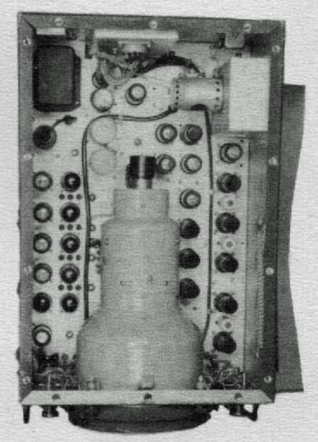

Figure 113. Model AN/TPS-8 PPI Chassis

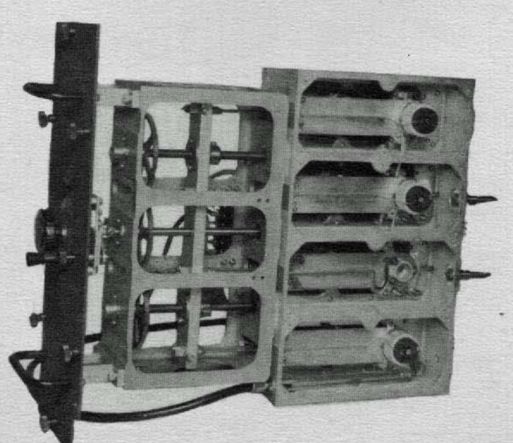

Figure 114. H-F Tuner Section of Model AN/TPS-8 Equipment

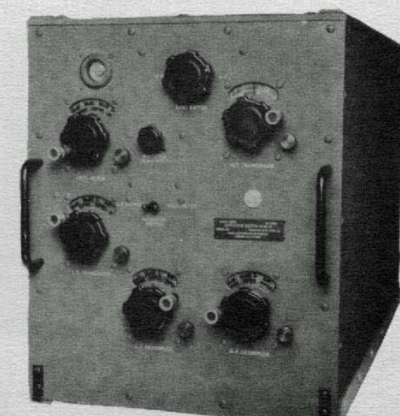

Figure 115. Model AN/TPS-8 Duplexer

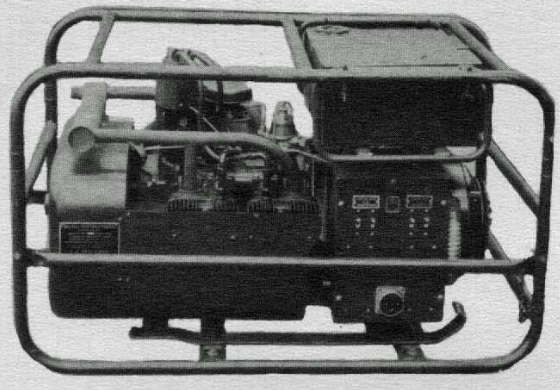

Figure 116. Gas Engine Generator, Model AN/TPS-8 Equipment

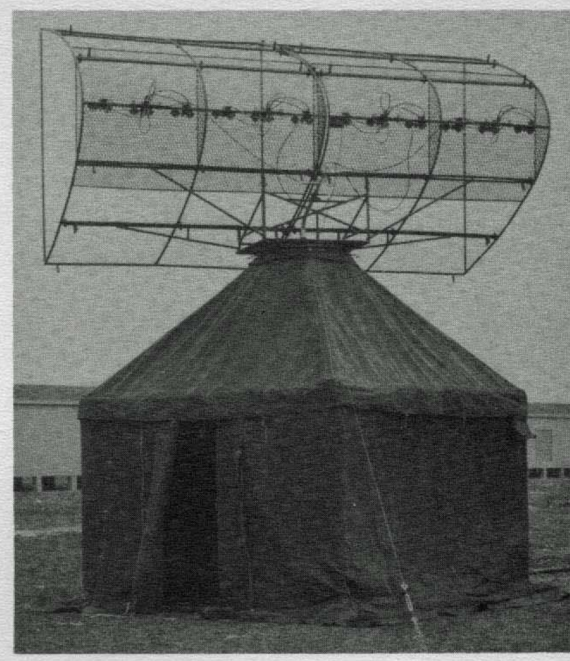

Figure 117. Model AN/TPS-8 Antenna, Tower and Tent

Figure 118. Model AN/TPS-8 Equipment Units Installed

Tower
Generator
Equipment Rack
Equipment Tent
Generator Tent

A broadband antenna and a 2-channel system with provisions for rapid frequency change permit the AN/TPS-8 equipment to be operated over a broad frequency band. The low-frequency transmitter, tuner, and duplexer cover the band between 390 and 465 megacycles; the high-frequency transmitter, tuner, and duplexer provide for operation over the band from 510 to 725 megacycles. The PPI, the modulator and the range indicator units operate over both bands.

The low-frequency transmitter, consisting of two type 4C33 tubes in a push-pull oscillator circuit, emits pulses of r-f energy of approximately 4.5 microseconds duration at a repetition rate of 200 pulses per second. The construction of the high-frequency transmitter is similar, except that it is designed to cover its frequency band in two steps, each of which requires a separate anode structure.

The receiver consists of a high- and low-frequency tuner, a 5-stage i-f amplifier, and a monitor which contains a 2-inch tube used as a type "A" indicator for tuning the receiver to the transmitter when the range indicator and the PPI indicator are at a remote point.

The range indicator unit of the Type AN/TPS-8 equipment operates in conjunction with the PPI unit and gives the distance from the zero pulse. In this unit are also provided controls and tubes for the presentation of IFF indications, although an IFF unit is not supplied as part of the Type AN/TPS-8 equipment.

The PPI unit contains the conventional PPI circuits and indicator tube as well as anti-jam circuits, a master switch for controlling all the power supplied to the system, a high-voltage switch for removing power from the transmitting circuits, and switches for remote control of the antenna control unit. A 60-foot interconnecting cable permits operation of the system when the range and PPI indicators are removed to a remote point.

The duplexer unit consists of a band-selector switch, a high-frequency and a low-frequency duplexer, a frequency meter, and output indicator.

The antenna is a steel-tubing frame with a steel screen in the form of a cylindrical parabola. The screen is illuminated with the r-f output of 12 colinear dipoles in the focal axis. The antenna is fed r-f power through an r-f rotating coupling of the capacitor type. The output detector is mounted near the center of the screen. It is used as a relative transmitter-power-output detector.

The antenna control unit is used to rotate the antenna and the trace of the PPI unit. It is provided with a crank for manual operation and with a motor and relays for remote operation from the PPI unit.

The modulator consists principally of a charging reactor, a pulse-forming network, and a rotary spark gap. It converts the direct-current power supplied by the high-voltage power supply into pulses suitable in shape, magnitude, and repetition rate for pulse modulating the transmitters. It also provides a synchronizing signal for triggering the sweep circuits of the PPI indicator, the range indicator and the monitor, and for use with the IFF equipment.

A gasoline-driven generator supplies power for operating the equipment. The low-voltage power supply contains rectifiers, regulator tubes and filters for supplying the low voltage required by the other units. It serves also as a junction box connecting the high voltage power supply, the receiver, the antenna control, the PPI and the IFF units. The high-voltage power supply furnishes a direct current potential variable in 12 steps from approximately 3500 to 7500 volts for the modulator. It serves also as a junction box for other units.

The antenna is supported by a tetrapod of steel tubing called a tower. The pedestal, which is a part of the tower, houses the antenna coupler. The tower also serves as a support for a tent which houses the equipment. Another tent protects the generator.