SECTION VIII

"TELERAN" -- For Air Navigation and Traffic Control

In 1941, RCA began work on the broad problem of air navigation and traffic control, and in December of that year devised the fundamentals of the Teleran system described herein. Even at that time, the traffic control problem was serious.

Today, the rapidly increasing density of civil and military air traffic demands the best methods for navigating and controlling aircraft. Collision prevention, all-weather landing and other new services must be provided, with a resulting decrease in required pilot skill and increases in safety and economy. Large numbers of commercial, military and private aircraft must be accommodated, both on and off the established airways.

Due to the urgency of war tasks, little work was done on the Teleran system between 1941 and 1945. Then in 1945 RCA, working in cooperation with technical personnel of Army Air Forces, Civil Aeronautics Administration, Airborne Instrument Laboratory, the airlines and aircraft manufacturers, expanded the Teleran system to extend its capabilities. New features such as talk-down and automatic landing, automatic on- and off-course flight, azimuth and distance indication and taxiing control are now within the realm of Teleran. Since April, 1946, work on certain aspects of the system having military uses has been sponsored by the Army Air Forces.

<u>TELERAN USES BOTH RADAR AND TELEVISION:</u> The word TELERAN, contracted from TELEvision-Radar Air Navigation, is an appropriate name for this dynamic new system. It is appropriate because, in operation, Teleran actually combines the technologies of television and radar into a single system, collecting its information by means of radar equipment, collating it with meteorological, geographical and control data, and transmitting a synoptic picture to the television receiver in the airplane.

<u>The Need for Television:</u> Many of the radar systems developed for military use during the war will have application in solving peacetime problems, particularly in the field of air navigation.

Radar used alone, however, whether airborne or on the ground, has serious limitations. Airborne radar equipment is relatively heavy and bulky, and requires experience and skill for operation. Because of limited antenna directivity due to size limitations, the equipment cannot produce information of sufficiently high "definition" or accuracy. Ground radar, on the other hand, furnishes adequate information in sufficient detail, but of course the information is not available to the pilot. The full advantages of radar can be realized only if ground search radar information is presented to pilots in convenient form. This is easily accomplished by television.

An abundant variety of information can be conveyed by television, information which is almost effortlessly perceived and used. Because of its unique manner of presentation, television provides the best means for transmitting ground radar information and other data such as weather maps, traffic instructions and ceiling and visibility information.

<u>THE TELERAN SYSTEM:</u> In its simplest form, Teleran employs a ground search radar which surveys the air-space of interest and displays the information on a cathode-ray tube. This radar presentation, with a map of the area superimposed either electrically or optically, is in turn viewed by a television camera, and the resulting picture is transmitted to the airplane. On the screen of a television receiver, the pilot sees his plane as a "pip" or spot of light moving across a map; other planes also appear as spots of light, each moving across the map according to its actual course. The pilot identifies his plane by a radial line passing through the proper pip.

Since the received picture might be confusing if all radar echoes were displayed in all aircraft, and because any pilot is primarily interested only in those aircraft at approximately his altitude, the Teleran system includes a method of separating the radar echoes according to altitude and transmitting a separate picture for each altitude level. This separation is accomplished by having each aircraft carry a transponder, which consists of a receiver and transmitter connected together so that the transmitter emits one or more pulses for each radar pulse picked up by the receiver. If the transmitter emits two pulses separated by a time interval, which depends on altitude, a discriminator at the ground station can be used to sort out the responses automatically according to altitude. These responses from different altitude levels are then displayed on separate indicators. Other methods of coding are possible, but the foregoing serves to illustrate the principles involved. These principles, first proposed by RCA in 1941, have since been incorporated in other navigational systems.

Figure 142 shows pictorially a typical airport equipped with Teleran. The various components of a Teleran system are illustrated schematically in Figure 143.

The air space may be divided into altitude levels as shown in Figure 144; of course, other choices can be made. At least 500 feet of overlap is provided to avoid collision hazards by climbing or descending planes. For example, a plane at

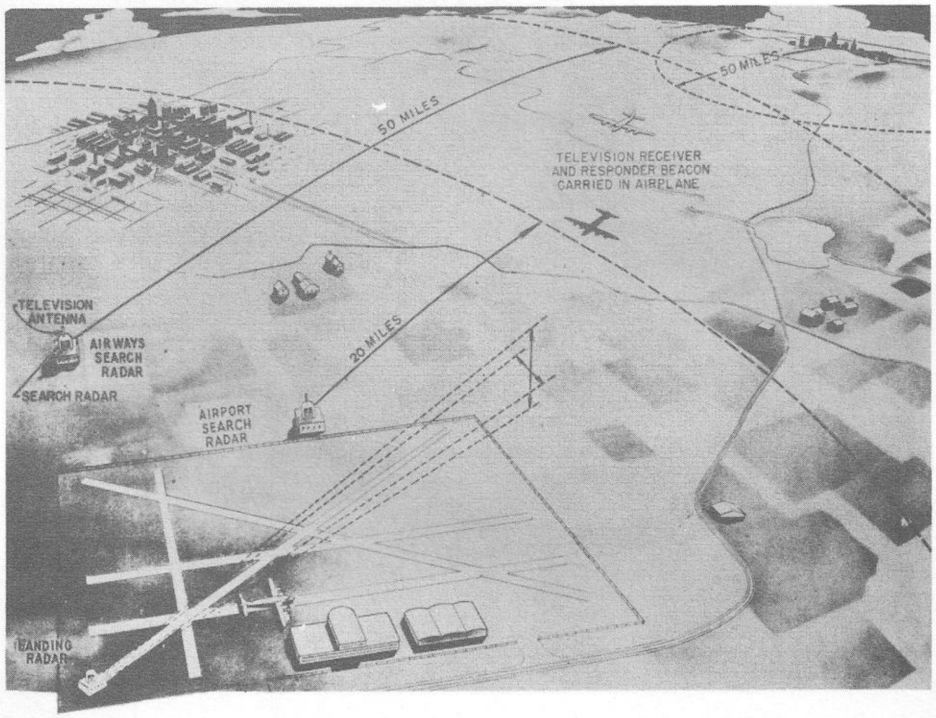


Figure 142. Sketch Depicting A Typical Teleran Layout.

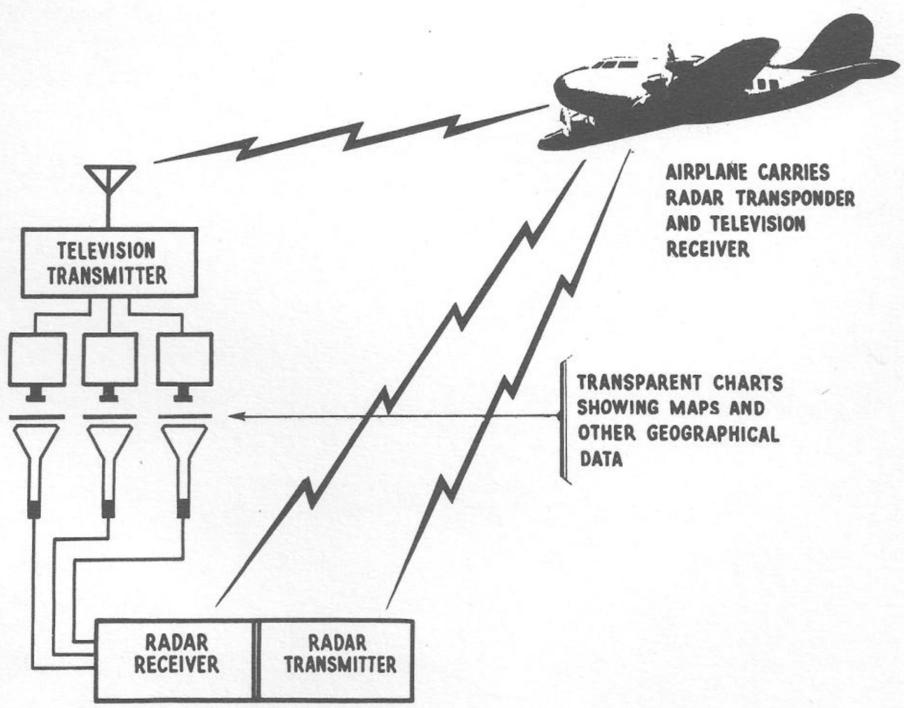


Figure 143. Components of the Teleran System. Radar indications superimposed on a map of the area can be reproduced in the plane by inserting a transparent sheet carrying the proper lines and symbols between the radar tube and the television camera.

2400 feet will appear on both the pictures for the 0- to 2000- and the 2000- to 4000-foot levels, which are displayed through separate television channels.

EN ROUTE NAVIGATION: A typical picture seen in an airplane flying in the 10,000- to 15,000-foot level is shown in Figure 145. The altitude, wind direction and velocity are shown. The airways and their headings are displayed, together with the frequency channels to be used. At this altitude the topography of the ground is of little interest and is not shown. Figure 146 illustrates the type of picture seen between 2000 and 4000 feet.

The pilot, beside seeing the position of all aircraft at his level, can see the direction in which they are travelling. This is made possible by the "trail" of each pip. Although the pilot can fly a course by observing the position of the pip and the direction of its trail, prompt indications of heading-changes provided by a stabilized gyro-compass repeater are of great assistance. Therefore a transparent disc engraved with red lines showing the heading of the plane is mounted in front of the television receiver viewing tube. This disc, illustrated in Figure 147, is rotated by a servo link to the stabilized gyro compass.

As previously mentioned, the pilot identifies his aircraft by means of a radial line which passes through the pip produced by his plane. Since the transponder is active only when the radar beam is pointed toward it, the radial line necessarily passes through the pip indicating his own plane. In case more than one aircraft appears on the same radial line, the pilot can momentarily interrupt his transponder, whereupon his pip disappears.

AIRWAYS TRAFFIC CONTROL: An important feature of the system is the possibility of providing a traffic controller with information as to traffic conditions beyond his particular control zone. If search radar equipment is installed for surveillance, the information can be relayed to the controller so that he may observe the traffic conditions approaching his control zone. In like manner, additional unattended search radars will be located in areas which cannot be served by the main radar. Thus blind areas caused by mountains, tall buildings, etc., can be covered by auxiliary radar sets keyed to the master equipment. Such an arrangement is shown in Figure 149. Electrical mixing of the signals from the two radar sets permits complete pictures to be constructed to the proper scale.

Traffic along an airway can be controlled by assigning to each aircraft definite locations along its course. These locations can be marked (as symbols) on moving tapes, superimposed on the television pictures transmitted aloft. Alternatively, methods similar to those employed in animated motion-picture production could be used to move symbols assigned to individual aircraft at appropriate rates and in the proper directions. In this way, the correct positions of all aircraft in the traffic pattern could be determined in advance, each pilot flying his plane so as to keep its pip in the assigned space. Any deviations from the prescribed plan of flight would then be apparent to both the controller and the pilot.

Since the position of all aircraft can be monitored both in the plane and on the ground, an almost unlimited number of parallel courses can be established and flown in safety. This would be an important advantage when weather conditions restrict the safe altitude of flight. It might also be of importance in setting safe approach courses into several airports located in the same area. A new course can be established for any pilot by the controller drawing the new course on the map. The system provides a maximum of flexibility to accommodate changing conditions. The controller can also transmit written instructions to a pilot by placing the writing before the television camera.

INSTRUMENT APPROACH AND LANDINGS: The Teleran system allows aircraft to execute landings in three ways --- by picture, by talk-down, or fully automatically. The display for the pictorial approach is rather unique, as shown in Figure 151. A vertical line representing an extension of the runway indicates to the pilot whether or not he is on course. Mileage marks along the line indicate the distance from the end of the runway. A horizontal line which moves toward the airport along with the aircraft pip, shows the altitude of the plane with respect to the correct glide path. When the altitude is correct, the line passes through the pip. If the plane is too high, the pip is above the line. If it is too low, the pip is below the line. This line is produced automatically without attention from ground or air personnel.

If the plane is not equipped with a television receiver, the ground equipment can be used for talk-down landing. The operator of a single control tower equipped with Teleran, as shown in Figure 152, can be of great assistance to the pilot during the letdown.

Automatic landings are provided for by adding a relatively simple modification kit to the Teleran equipment. The addition will not interfere with the television picture transmitted for manual landing.

AZIMUTH AND DISTANCE INDICATION: Azimuth information is obtained by transmitting a pulse from the omnidirectional television antenna at the instant the search radar antenna is pointing north. Electronic circuits in the airborne equipment then compute the time interval between reception of the pulse

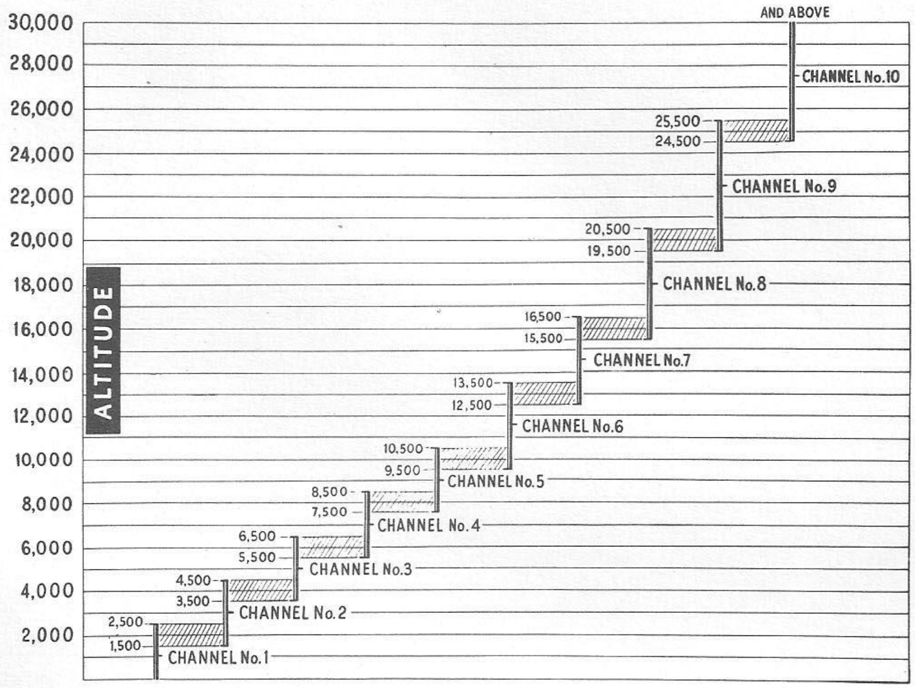


Figure 144. Possible Air Space Separation Into Altitude Layers. The transponder replies are sorted out on the ground according to altitude and displayed on appropriate receiving tubes. This permits placing most of the pulse separation or decoding equipment on the ground. Also, a pilot may look at any other altitude layer.

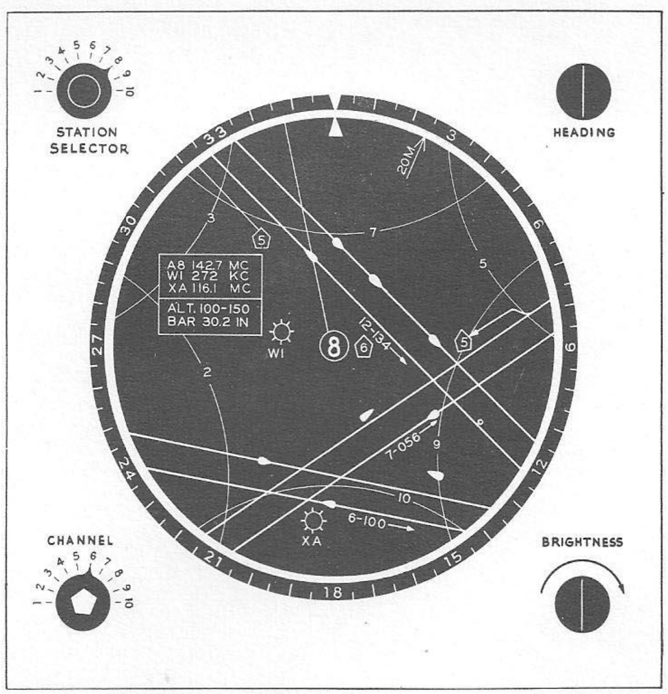


Figure 145. A Typical Picture Received at High Altitude. In the large block is shown the altitude, barometric setting and communications frequencies for airways station (A8), Wilkesbarre (W1) and Allentown (XA). Large "8" in center identifies area covered by this Teleran station; overlapping Teleran areas are denoted by numbered arcs.

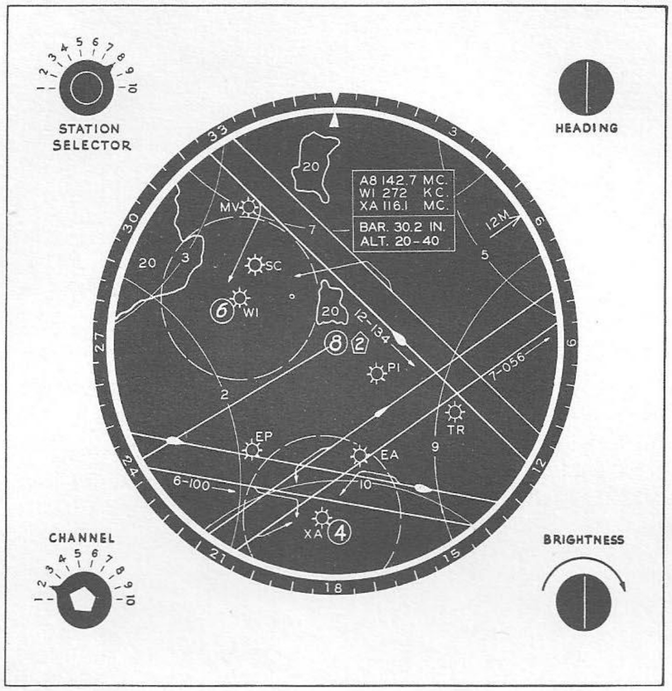


Figure 146. A Typical Picture Received at 2000 to 4000 Feet. Wilkesbarre and Allentown Teleran approach control zones are shown in dashed circles, with letdown paths into these areas. Contour lines are shown for 2000 feet.

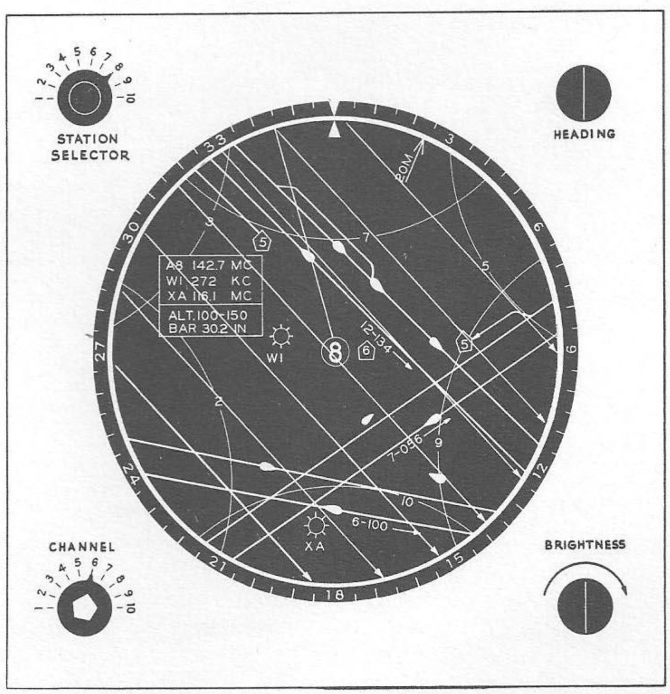


Figure 147. The heading of the plane is shown accurately by parallel lines on a transparent disc placed in front of the television receiving tube. This disc is driven by the plane's stabilized gyro compass.

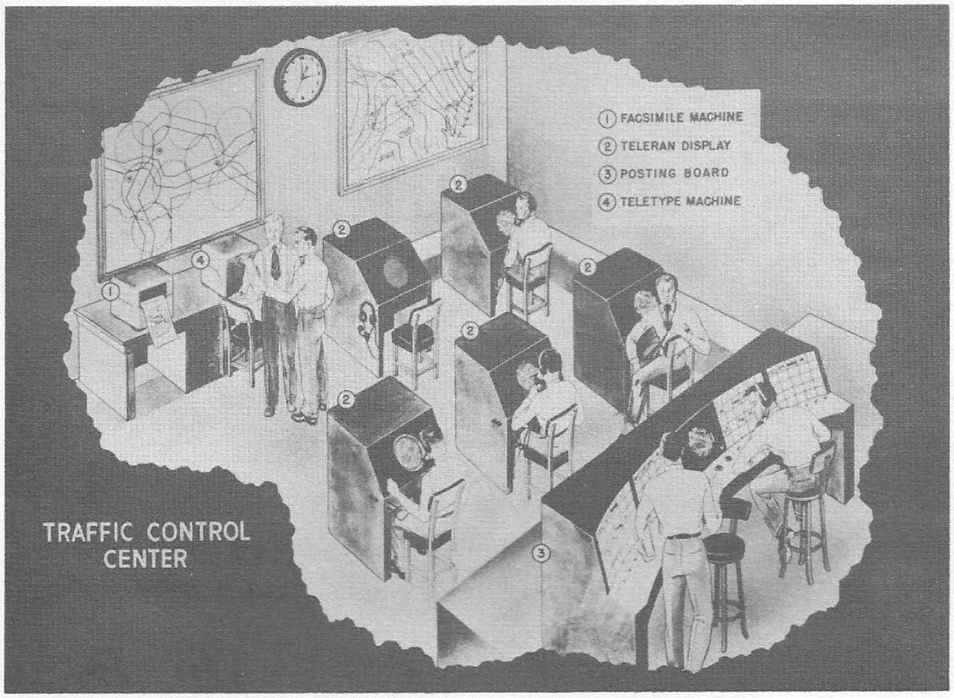


Figure 148. A Traffic Control Center Employing a Number of Teleran Indicators to Portray Different Altitude Layers and Adjacent Teleran Areas. Other arrangements of personnel and equipment are feasible. For areas having dense traffic, computers and other accessory equipment can be added.

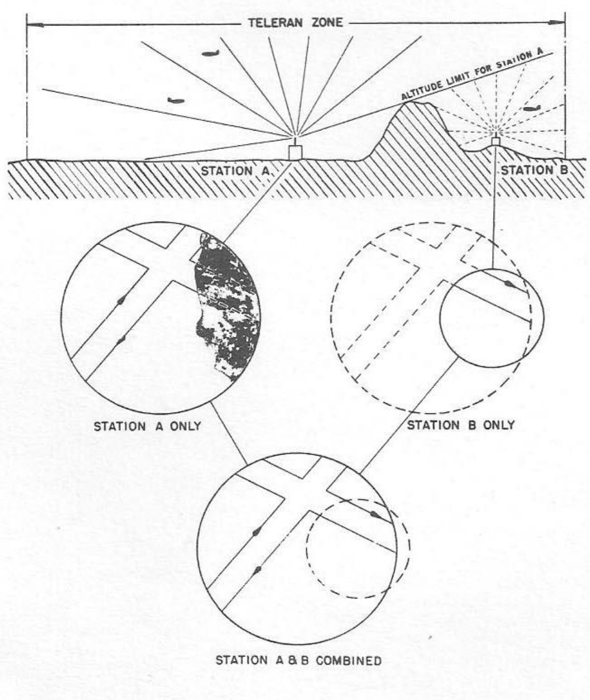


Figure 149. Diagram Illustrating How Shadow Areas may be Filled in by Combining the Displays from One or More Auxiliary Radars.

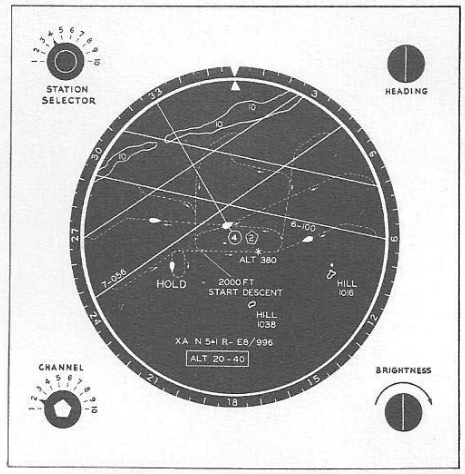


Figure 150. Teleran Picture of an Approach Zone. The approach paths will accommodate relatively dense traffic, New information may be quickly pencilled on the chart, and subsequently erased if desired.

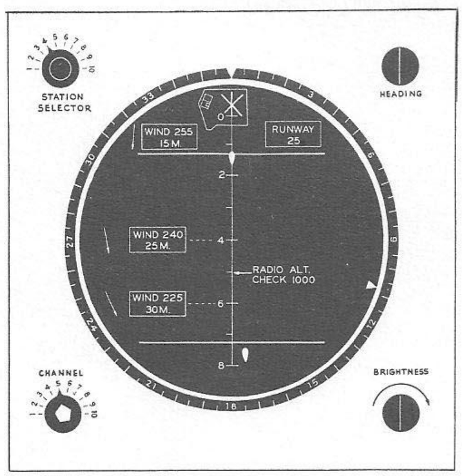


Figure 151. A Picture Received in the Final Stages of Airport Approach Prior to Landing. The pilot, guided by the moving horizontal line which indicates the altitude to be maintained, and by the pips of surrounding planes, can make his letdown with complete confidence.

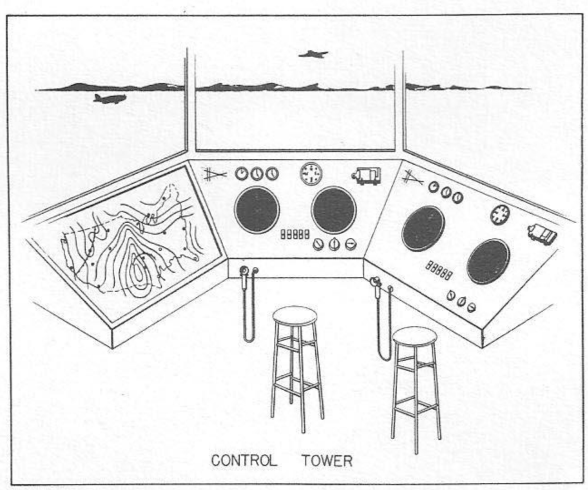


Figure 152. Control Tower Installation of Teleran, Showing Approach and Landing Displays.

and direct interrogation by the search radar beam. The azimuth information so obtained supplements that obtained directly from the television picture, but it is in more usable form for automatic flight and can be read from an azimuth meter if desired.

Distance information is obtained by using the transponder of the plane as an interrogator a short time after it replies to the ground station. The interrogating pulses are received on the ground and sent back on the television channel, affording a measurement of distance to the station. Distances can be read from a distance meter if desired.

Since range and azimuth information are supplied by Teleran, automatic flight is possible if flight is to be directly to or away from the station. Off-course flight and curved-path flights require additional information supplied by a computer.

WEATHER DATA: The prompt transmission of complete weather information is a unique feature of Teleran. Figure 153 is an example of the information which can be included. By a time-scheduling arrangement, data on weather conditions at all altitudes in various areas may be substituted as shown in Figure 154.

TAXIING CONTROL: The prompt dispersal of aircraft after landing, and the general policing of the ground area adjacent to the runways will be necessary for efficient traffic handling. There is reason to believe that radar can be developed capable of locating each aircraft on the airport. When such equipment is available, its integration into Teleran will be simple and logical. The pilot will see a picture of the airport and of aircraft on the ground, together with taxiing instructions.

TELERAN COVERAGE: The number of Teleran stations required in an area is influenced by factors such as the locations of airports and the desired minimum altitude coverage. These factors also affect the number of frequency channels required. Studies indicate that a maximum of ten television-transmitting channels would be necessary when complete geographical coverage of the airways is desired. Since the airport television transmitters are not required to cover an extensive area either in distance or altitude, about five channels would be sufficient for any probable disposition of airports accommodating large aircraft.

The traffic density in the Washington-New York-Boston area is the highest in the United States. In such a region, shown in Figure 155, the number of stations required to provide complete airway coverage is virtually the same as that required for the complete area coverage. Major airports are numerous, thus a large number of airport installations is justified. Figure 156 shows a region where congestion is almost restricted to terminals, and where complete Teleran coverage is not immediately necessary.

THE AIRBORNE EQUIPMENT: As shown by the Teleran pictures presented in this book, the front panel of the airborne indicator has four controls. Only three of these -- the station selector, channel selector and the brightness control -- are normally used. Focus, centering, synchronization and similar television controls, which need be set only during preflight checks, are mounted on a covered, countersunk panel. Great brilliance can be obtained from the cathode-ray tube. A block diagram of the necessary airborne equipment is shown in Figure 157.

SMALL AIRCRAFT: While the services in the Teleran system are comprehensive enough for large transport plane use, the needs of the smaller aircraft have not been overlooked. Since the Teleran receiver and transponder will be of moderate weight (See Figure 158) Teleran will be useful for medium-sized private planes.

Very small planes are not capable of carrying Teleran at its present weight, but it is possible to use portions of the system to supply basic information such as azimuth and distance. Simple equipment, light enough for the smallest aircraft, can be built for this purpose. Light aircraft will also have use of the auxiliary talk-down function of Teleran.

PLANES WITHOUT TRANSPONDERS: The position and movement of planes not equipped with transponders can be observed by means of the radar echo instead of the transponder response. Provision is made in Teleran for separating such echoes from the transponder responses of other aircraft and displaying them exclusively on a separate indicator. This data can be transmitted automatically to all altitudes, if necessary, depending on the hazard that such aircraft might present to Teleran-equipped aircraft.

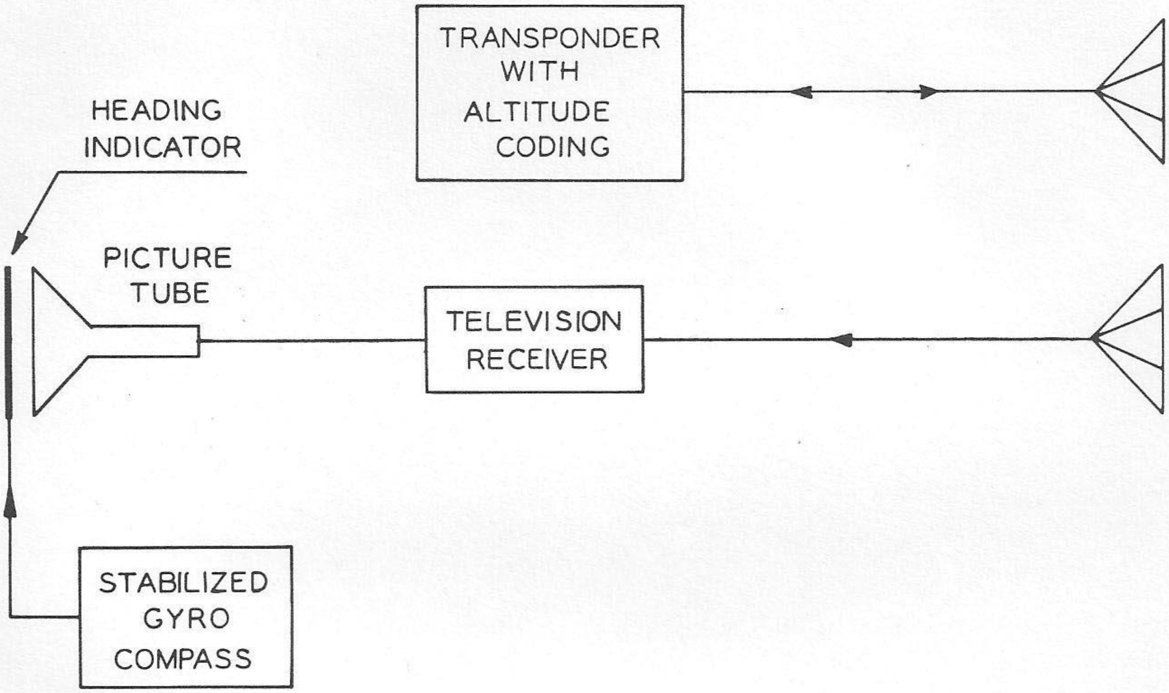


Figure 157. Block Diagram of the Airborne Portion of Teleran. The weight is approximately 90 pounds and undoubtedly will be less after further development.

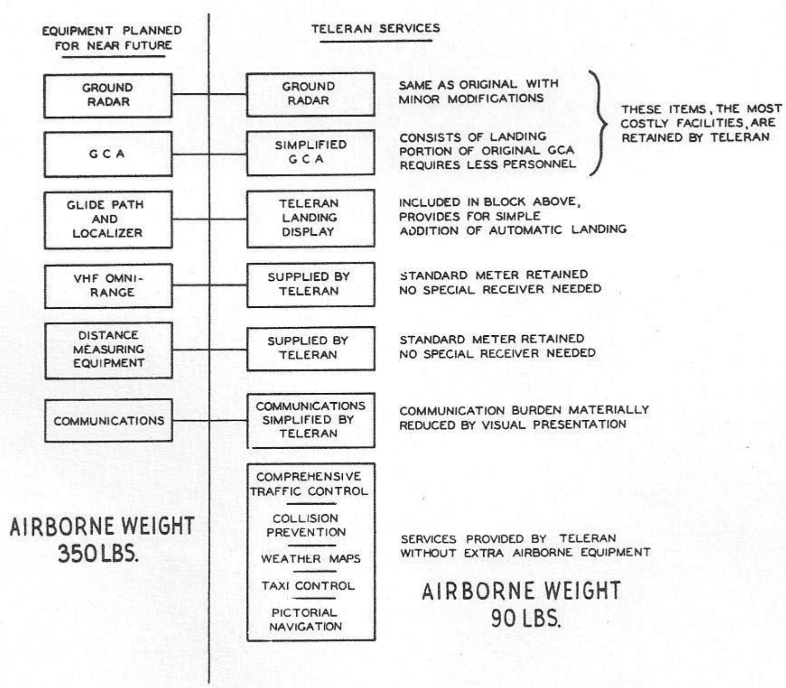


Figure 158. Transition to Teleran can be gradual and economical. Non-equipped planes can continue to use the services of all ground facilities, although they may be an integral part of Teleran equipment.

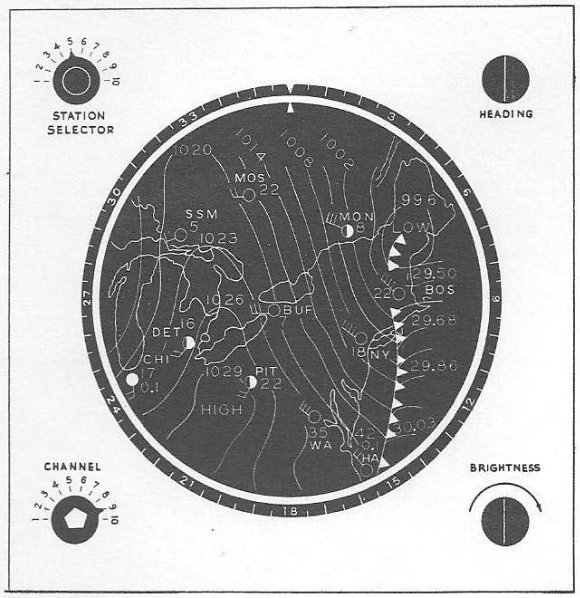


Figure 153. A Typical Weather Map, Always Available to the Pilot. By switching to the weather channel, the pilot is provided with advance information for several Teleran zones.

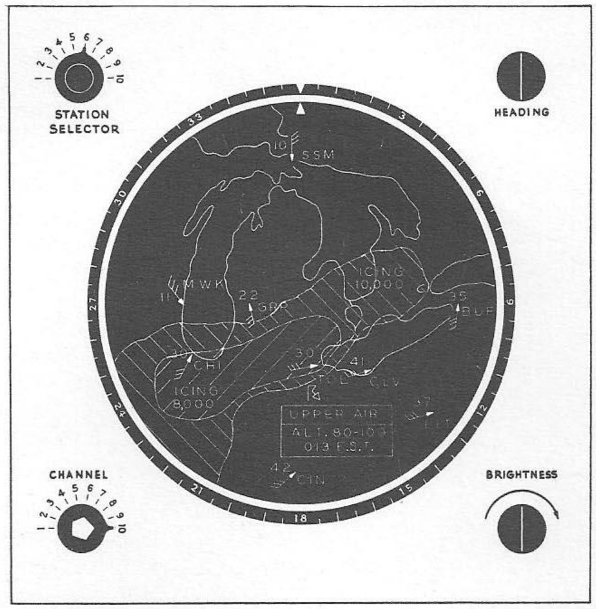


Figure 154. A Teleran Picture of the Upper Air, Indicating Areas with Hazardous Conditions.

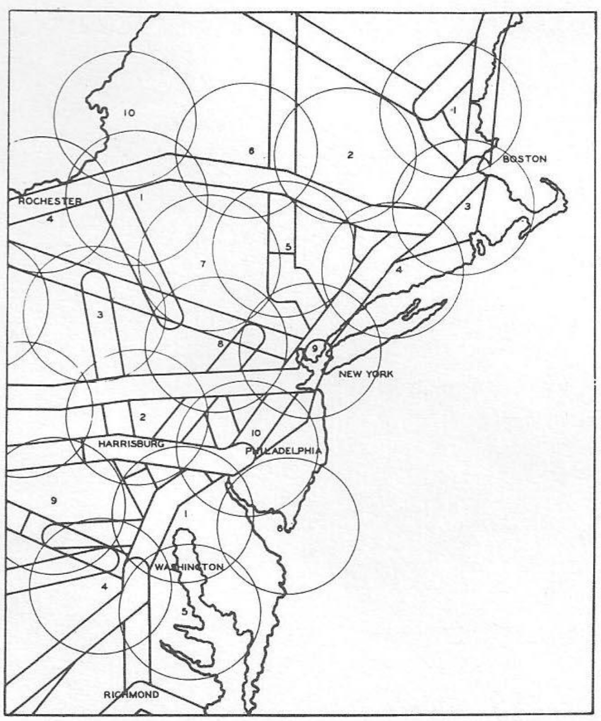


Figure 155. A Possible Distribution of Ten Teleran Stations, Providing Complete Airway and Geographical Coverage of the Atlantic Seaboard.

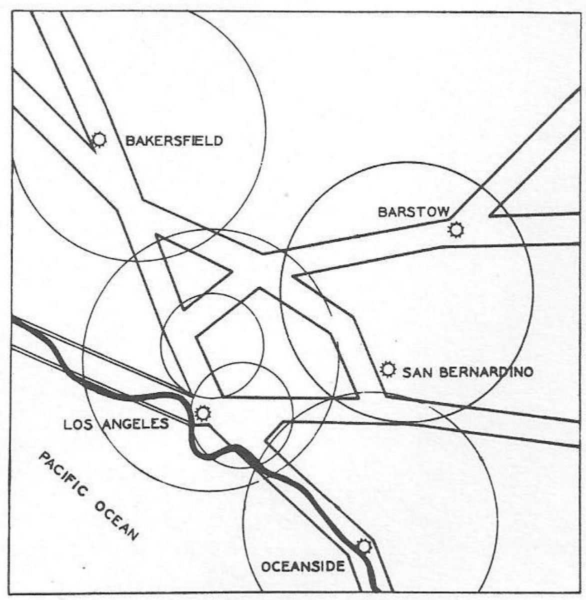


Figure 156. A Combination of Airway and Airport Teleran Stations in A Dense Traffic Area on the Pacific Coast.

SECTION IX

LARGE-SCREEN TELEVISION

Our entry into the war and the immediate conversion of RCA facilities to war production halted the commercial development of a television receiver capable of reproducing pictures brighter, clearer and five times larger than obtainable on prewar television sets.

The large-screen television receiver was made possible by four prewar technical developments: an improved high-voltage projection tube; a unique optical system of high efficiency; and a new type of plastic viewing screen.

One of RCA's early projection television systems consisted of a standard direct-viewing Kinescope plus a lens suitable for projecting an enlarged image on a screen a few feet away. The picture thus projected had very low illumination because the optical system had low "light-gathering" power, making available only part of the light in the original image, and also because the light thus made available was spread over a much wider area, making the average illumination low. A solution to the problem required increased illumination on the face of the Kinescope, and the design of an optical system with greater efficiency. The projection tube and reflective optical system are the result of long-extended research by RCA engineers. The optical system is diagrammed in Figure 159 on the next page.

The projection tube operates satisfactorily with 27,000 volts on the anode, and produces an image with an overall illumination about 12 times that of the 12-inch, prewar viewing tube. Used with the improved optical system, the five-inch projection tube is capable of producing 16-inch x 21-inch pictures having an average illumination of approximately 8 foot-lamberts, comparable to that of home movies. The face of the projection tube is too bright for comfortable direct viewing.

The main "lens" in the optical system consists of a bowl-shaped spherical reflector of polished glass with an aluminized surface. The other components are a molded plastic correcting lens, an inclined mirror and a transluscent screen. The projection tube in the home receiver model is mounted face downward in the lower part of the cabinet, with the bowl-shaped mirror below it and facing upward. Light from the face of the tube is reflected upward from the reflector through the plastic lens to the 45-degree mirror near the top of the cabinet, from which it is reflected to the back of the transluscent viewing screen. Some added advantage is gained here, since a transluscent screen can be made to have higher efficiency than a diffuse, reflective screen.

The spherical mirror and the correcting lens are manufactured by RCA. The correcting lenses are molded from clear thermoplastic material called methyl methacrylate.

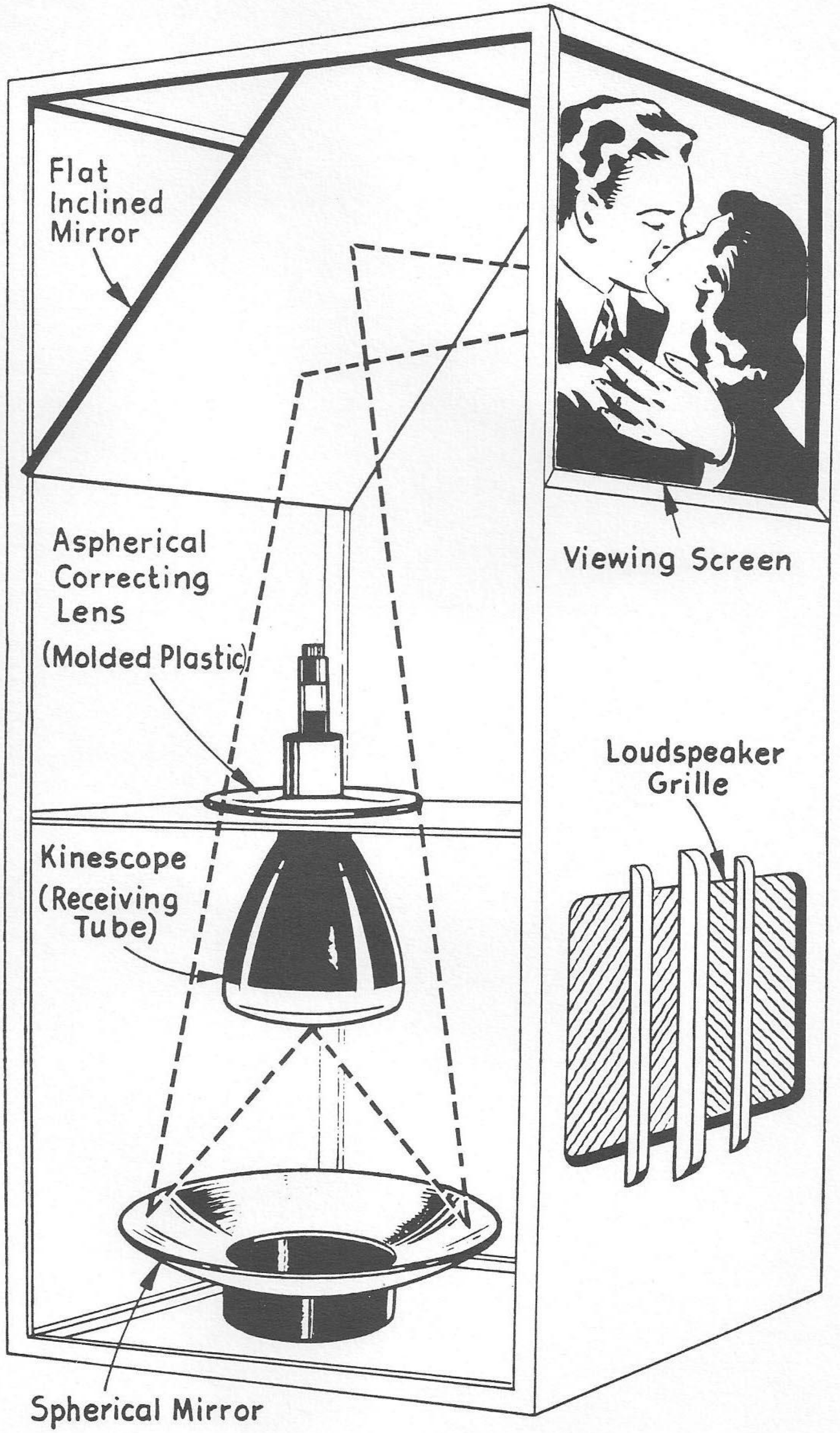


Figure 159. Schematic Arrangement of RCA's Large Screen Television Receiver. To obtain the desired magnification, the required distance from lens to screen was approximately three feet. The reflection system shown provided the required distance, and resulted in a receiver-cabinet of attractive size and proportions.

SECTION X

CONCLUSION

Approximately 90 per cent of all wartime work on television was done by the engineers and factories of Radio Corporation of America. As to production, RCA (a) actually built 4,400 complete television camera and transmitter equipments for airborne use, of which 250 were Image Orthicon cameras (b) trained other manufacturers in order that military services might have alternate sources of supply, and (c) designed and built an airborne system (i.e. RING) which transmits a 587-line picture from a plane with a power of 1200 watts at 100 megacycles. Two of the latter installations have been in operation in Navy planes since 1945.

Because of the increased range of many weapons, there appears to be a major trend in warfare to carry out most operations from a point at considerable distance from the enemy.

The fact that television can in many cases convey the information necessary to intelligent remote control of apparatus was demonstrated by the success of field tests conducted with television-equipped bombs and gliders. Moreover, the RING equipment, demonstrated at the Anacostia Naval Air Station after V-J Day, revealed that television was a valuable aid in reconnaissance work. Scenes picked up by television-equipped observation planes were transmitted over distances of 200 miles and reproduced with unusual clarity. Later, television-equipped, radio-controlled planes dived through lethal radio-active clouds mushrooming upward from the atomic bomb in the "Operations Crossroads" test at Bikini, revealing by television the immediate destructive power of the world's most dreaded weapon. Even the tests conducted in the manufacture of this bomb were witnessed through television.

The peacetime applications of television as an entertainment medium are well known. By the use of recently developed micro-wave equipment, television "coverage" can be made nation-wide, and the quality and size of the picture now possible should assure wide public acceptance. Another important peacetime use for television is the Teleran system described in a section of this book. When this system is fully developed, aircraft flying in the densest fog will be automatically landed and taxiied to the hangar. The introduction of natural colors into the transmission and reception of electronic television promises to be as significant a development as technicolor proved to be in moving pictures.

SECTION XI

OPERATIONAL TESTS for TELEVISION EQUIPMENT

The design and construction of special apparatus required for testing military equipment during manufacture represented a significant part of the total production work done for the armed forces. Very little of the test equipment used for military television existed when the television project was initiated. While it is true that some available apparatus was modified and adapted for use in the project, a number of other instruments had to be designed for the new frequency range. In some cases the problems involved in the design of these new test instruments rivalled those of the BLOCK equipment itself; these instruments were the electronic tools -- the yardsticks of quality and performance by which the BLOCK system was appraised.

One of the most important electrical tests applied to all the units was the tube-socket voltage check. An RCA VoltOhmyst provided accurate voltage readings while the equipment was in operation, insuring the correct tube voltages and currents, and hence longer tube life. Voltage measurements were made at various points in the circuits while the d-c input voltage was varied over limits simulating the line-voltage variation in aircraft. Other tests employed oscilloscopes, signal generators, sweep generators, audio-frequency oscillators, heterodyne frequency meters and slide projectors, depending on which television unit was under test.

For the television camera, measurements were made of the frequency and output of the deflection oscillators. With a pattern projected on the mosaic of the pickup tube, the video and blanking outputs were measured and compared. Visual tests were made to determine shading of the picture, contrast uniformity and resolution. The resolution test was carried out by projecting a pattern from a standard 300-line slide on the pickup tube.

Production tests for the television transmitter included use of a diode detector to obtain optimum antenna coupling and required power output. An oscilloscope was used for measurement of video and synchronizing amplifier gain and response, and a heterodyne frequency meter was employed for the adjustment and calibration of the master oscillator frequency, and for operational tests disclosing frequency-modulation and transmitted picture quality. In the picture quality tests a camera was connected to the transmitter, and the transmitter output fed into a standard receiver. Patterns from various tests slides were projected on the pickup tube and observed on the Kinescope of the receiver.

The receiver tests included alignment of the radio-frequency and intermediate-frequency stages as well as tests for sensitivity, selectivity, image ratio, and for picture size, linearity and resolution. The required i-f bandwidth was 6.5 megacycles at a center frequency of 50 megacycles.

The procedure for aligning wide-band receivers is generally well known, but a brief explanation is given here for those who may not be familiar with the principles involved. For complete alignment of the receiver, it is advisable to begin with the last i-f stage and work forward, aligning each i-f stage individually. Following this, some "trimming" of the individual stages may be necessary to obtain the desired response curve from the i-f amplifier as a whole when a test signal is introduced into the first stage. When the response of the i-f amplifier is satisfactory, the r-f amplifiers are then aligned. A sweep generator, with markers, an r-f signal generator and an oscilloscope are needed to align the receiver.

The sweep generator is a test device which generates an r-f signal, the frequency of which is automatically swept over certain limits. The width of the sweep frequency as well as the center frequency of the internal oscillator can be adjusted by manipulation of the generator controls. The marker feature is provided by a second oscillator built into the generator. The frequency of this oscillator is not swept, but is adjustable to any frequency within the range of the sweep oscillator. The marker oscillator output, because of the disturbance it produces in the oscillographic pattern when beating with the output of the sweep oscillator, is used to identify the center frequency of the sweep oscillator. Exact bandwidth can be determined by varying the frequency of the marker so that the center of the disturbance coincides in turn with two points on the pattern, one on each side of the center frequency indicating 70 per cent of maximum amplitude. The frequencies shown on the marker-frequency dial are then noted for each setting and their difference is taken as equal to the bandwidth.

In using the oscilloscope and sweep generator to obtain a response curve with linear frequency distribution, a sinusoidal sweep voltage of the same frequency and phase as that used to sweep the oscillator must be applied to the horizontal deflection plates of the oscilloscope. If the sweep frequency of the generator is 60 cycles per second, the horizontal deflection voltage for the oscilloscope can be obtained from the 60-cycle power line. Phasing of the sweep voltages is usually accomplished by employing a manually operated phase-shifting network between the source of deflection voltage and the oscilloscope. A signal from the sweep oscillator is then applied to the i-f stage to be aligned, and the output from the second detector of the receiver is fed to the vertical input of the oscilloscope. When the i-f amplifier is properly aligned, the response curve will be symmetrical on both sides of the 50-megacycle center frequency.

Alignment of the radio-frequency stages is obtained by using the signal generator adjusted to produce a signal of the proper frequency for the receiver being aligned. With a signal from the generator fed into the r-f section of the receiver and the vertical input of the oscilloscope connected to the second detector output of the receiver, the amplitude of response on the oscilloscope screen will increase as the r-f stages are brought into alignment. In some cases, the response of the i-f is affected by r-f alignment, and further tuning of the i-f system is necessary. Overall tests of the receiver sensitivity, selectivity, and performance were made with the aid of a specially-developed television signal generator.

The television monitor contained no r-f or i-f stages; therefore, the tests were confined to measuring the gain and frequency response of the video- and synchronizing-signal amplifiers which it contained. Visual tests like those conducted for the camera and receiver permitted evaluation of picture quality.

Prior to the design of the TX-1511 Video Sweep Oscillator, the frequency response of video amplifiers in the television units was measured by using an oscilloscope or vacuum-tube voltmeter, and an oscillator capable of producing sine output over the band to which the amplifier was expected to respond. With the oscillator output fed to the amplifier to be tested, and the oscilloscope or voltmeter connected to measure the output from the second detector (or from an external detector), tests were made at various "spot" frequencies over the video band. The TX-1511 Video Sweep Oscillator was specially-developed to avoid the need for spot frequency checking. It produced a sweep signal from approximately 50 kilocycles to 12 megacycles, swept at 60 cycles per second. The frequency characteristics of the video amplifiers in the camera and receiver could be examined, and the circuits could be adjusted, with the aid of an oscilloscope.

FACILITIES
for
TESTING MILITARY ELECTRONIC EQUIPMENT

Television, radar and radio-communication apparatus for military use was custom-built equipment. In normal applications, particularly in aircraft, it was subjected to unusual conditions of vibration, shock, changes in temperature, and variation in atmospheric pressure and humidity. Therefore, tests and apparatus were formulated to simulate these conditions in the manufacturing plant, in order to insure the equipment operating satisfactorily under virtually any battle or climatic condition existing anywhere on the globe. Tests of this nature became known in the manufacturing plant as "type" tests.

Whether or not a particular electronic equipment was subjected to all of the type tests depended on the type of service for which it was designed. Airborne equipment, for example, was usually put through all the tests. Ground equipment, on the other hand, was not required to pass a test for the low atmospheric pressure encountered at high altitudes. Test specifications, set up by the armed forces, dictated the type as well as the severity of the test to be administered to each piece of electronic apparatus.

Heat and Humidity Chamber: The moist heat of the tropics was created in a heat and humidity chamber set up in Building 8 of the Camden plant. In this Chamber (Figure M), electronic equipment was exposed to humidified air, heated to temperatures as high as 140 degrees Fahrenheit and having a relative humidity of approximately 95 per cent. During the tests, the panel meters or display tubes of radar, television and radio-communication equipment were closely watched through windows in the chamber for any indications of change in performance. Heated moisture-laden air, a deadly enemy to most electrical installations, was allowed to seep around capacitors and into r-f coils and transformers to determine if adequate protection had been given these components against leakage of current, rust, and corrosion from electrolytic action.

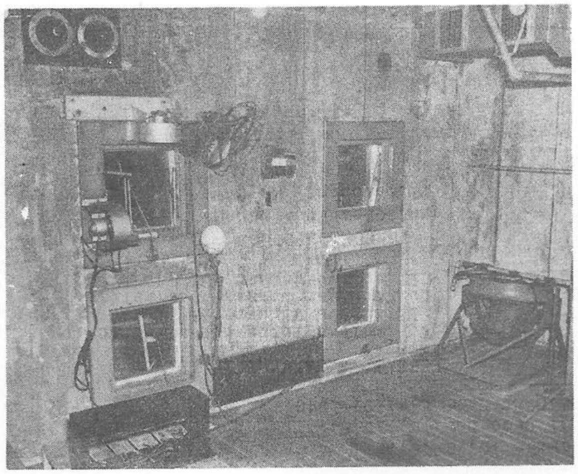
The test chamber is a room 13 feet wide and 17 feet long. The ducts by which heat and moisture are introduced into the room are hung on the wall approximately two feet below the ceiling. Along one side of the chamber are four small windows which permit meters and other indicators resting on narrow shelves inside the room to be read from the outside. Electrically-driven fans assure continuous movement of air within the room.

Cold Chamber: The frigid temperatures encountered in the arctic regions or in the substratosphere, thousands of feet above the earth, were duplicated in the cold chamber, where electronic equipment was chilled to temperatures as low as 25 degrees below zero. This intense cold sometimes produced serious changes in electrical adjustments, or froze electrolytic capacitors and other parts, thus disclosing components not suited to such low temperatures. Occasionally, tuning controls and mechanical linkages would stick, and sensitive relays would jam. These problems were often solved by substituting parts; in other instances, partial redesign of the equipment was necessary. The cold chamber is shown in Figure N.

Mechanical Shock Test: A different and rather severe test was that provided by the mechanical-shock testing apparatus. Receivers, transmitters or other electronic units that could withstand this test were unlikely to falter under the shock of collision or rough handling, or under the acoustic vibration dealt out by heavy guns in battle. For the test, a heavy sledge hammer suspended in pendulum fashion delivers blows against the back of a plate to which the receiver or transmitter is fastened. A typical apparatus is illustrated in Figure O. A heavy sponge-rubber mat is clamped between the plate and the unit under test. a few blows with the sledge quickly divulges any loose hardware or components. Also, falty construction, poor electrical connections, "cold" solder, poor welding and fragile components are disclosed. A subsequent operational test exposes poor stability of circuits and adjustments.

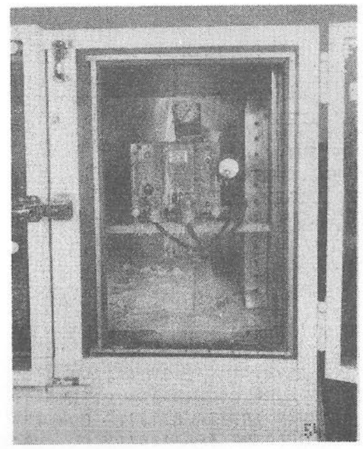
Inclination and Vibration: Also, there were elaborate mechanical type-testing machines such as the inclination and vibration machine and the shaker table, illustrated in Figures P and Q. The inclination and vibration equipment, which accommodates large and heavy units like those of radar and sonar equipments, is designed to simulate the pitch and toss of vessels at sea. The steel platform upon which the unit is securely mounted for the test is vibrated at rates between 4 and 40 cycles per second, at an amplitude of approximately 1/16 inch. During vibration, the platform can be slowly inclined, first to one side then to the other, to an angle of 45 degrees from horizontal. The shaker table is capable of vibrating smaller units at higher rates. Vibration takes place in both vertical and horizontal planes, and at rates of 10 to 60 cycles per second.

High Altitude Chamber: Aircraft equipment was subjected to even further type testing, a high altitude chamber, evacuated to provide the low pressures encountered at altitudes of 50,000 feet, housed the equipment to be tested. Every part of the mechanism under test was observed through glass windows in the test chamber. Defects in design, details of faulty construction that would remain hidden until actual high-altitude flight tests were found before the equipment left the factory. The chamber is a heavily-insulated box 5 feet long, 3 feet wide, and 4 feet high.



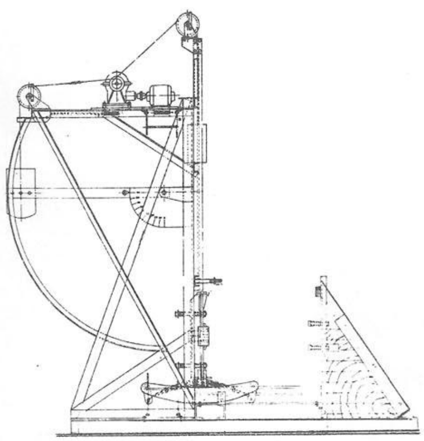
Heat-humidity Test Chamber

Figure M



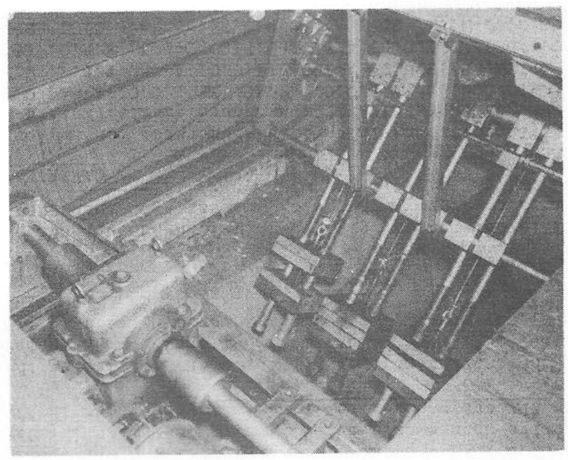
Cold-test Chamber

Figure N



Shock-testing Machine

Figure O

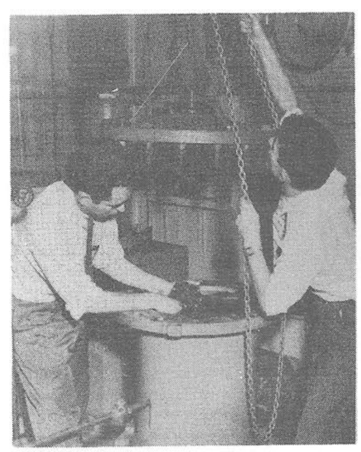


Vibration-inclination Table—Undergearing

Figure P

Three-way Vibration Table—One-man Operation

Figure Q



Deep-sea-pressure Test Tank—To 600 Feet (100 Fathoms)

Figure R

Deep-Sea Pressure Tank: Similarly, RCA equipment destined for underwater duty was submerged in the deep-sea pressure tank (Figure R). This tank, cylindrical in shape, with walls of steel 5 inches thick, provided in the factory the heavy pressures to which electronic equipment was subjected when submerged at sea.

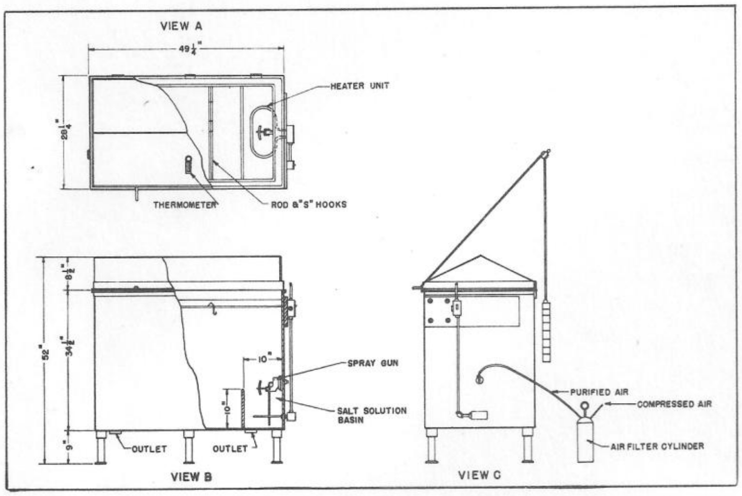
Salt-Spray Test Tank: Another important testing device is the salt-spray test tank shown in Figure S. This apparatus was set up to assure that electronic equipment, particularly the mechanical components, installed in coastal areas and on sea-going vessels would operate unhampered by the action of the salt air and spray. A 20 per cent salt solution, heated to a temperature of 90 degrees, was evaporated continuously, throwing off a cloud of salt spray which enveloped every item hung in the vapor-tight tank. Components were often subjected to this salt bath for as long a period as 200 hours, after which tests were made to determine if any changes in characteristics had taken place.

RCA's X-Ray Laboratory: A unique X-ray laboratory, located in in Building 4 of the Camden plant, is used for regular radiographic examination of materials. The complete laboratory consists of three rooms: The actual test chamber, a darkroom, and an office. The test chamber, a room approximately 9 feet wide and 14 feet long, is interlined on walls, floor and ceiling with 1/8-inch lead sheathing sandwiched between plywood panels.

In the test chamber are two X-ray units, differing in size and slightly as to function. The larger of these units, with its tube mounted on a three-way boom, is illustrated in Figure T. The electrical connections and the feed lines from the oil cooler to the tube are shown. Figure U shows the operations control stand and panel, which is located outside the test room. The larger X-ray unit, which has a rating of 150 kilovolts at 15 milliamperes, is a non-destructive testing apparatus enabling critical examination of material of a thickness penetrable by the machine. This thickness is, for steel, approximately one inch; for brass or copper, approximately 3/4 inch; for aluminum, 6 inches; and for most plastics, 8 inches. The penetrability of glass varies, and hence a close approximation cannot be given; however, penetration of 2 to 5 inches is possible.

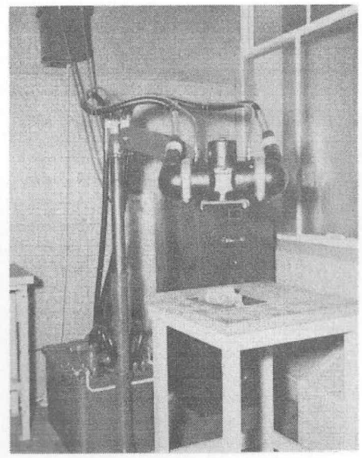
The primary use of this X-ray unit is to detect flaws inherent in materials, or faulty workmanship after fabrication or assembly. For example, steel or aluminum bars or castings can be tested before they are machined. Flaws such as gas pockets, sand holes, cold flow and tears are disclosed by use of the X-ray unit. Other applications are the checking of fabricated parts and the alignment of subassemblies. Ceramic materials can be tested for quality, and coaxial cables tested for the maximum safe degree of bend. An illuminator permits film made by the X-ray unit to be easily read.

The smaller X-ray unit, illustrated in Figure V, has a rating of 50 kilovolts at 15 milliamperes. This unit is used to identify materials. It also provides a quick check of chemical constituents, the temper and magnetic qualities of metals, and the purity of gases. Figure W shows the control stand and operations panel of the small X-ray unit.



Salt-spray Test Tank

Figure S

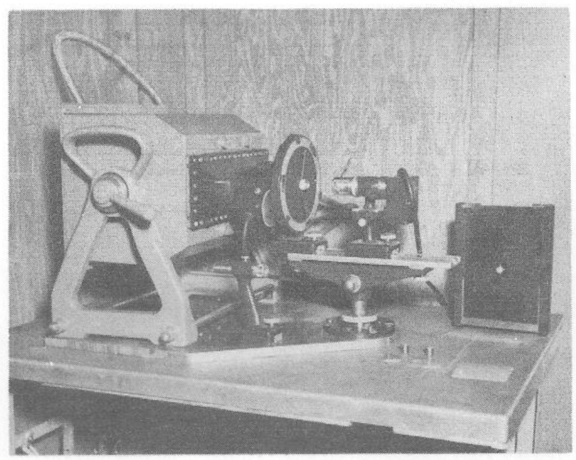


Industrial X-ray Testing Unit

Figure T

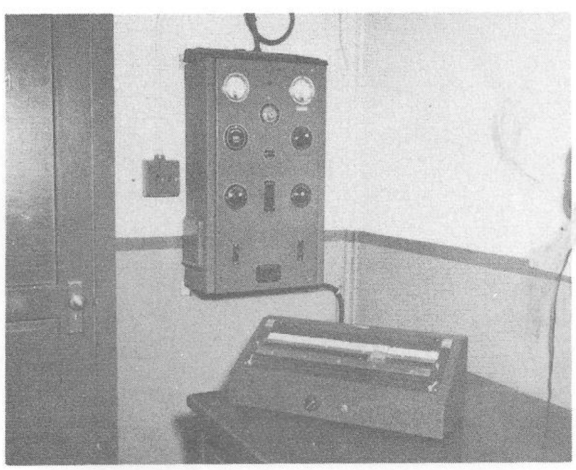
*Control Stand and Operations Panel (Large Unit)—
Illuminator at Left*

Figure U



X-ray Testing Unit (Small)

Figure V



*Control Stand and Operations Panel (Small Unit)—
Illuminator at Right*

Figure W

This book was prepared by the Editorial Group of Standards Engineering Section, A. N. Curtiss, Manager.

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