WAR DEPARTMENT
WASHINGTON

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INTRODUCTION TO RADIO COUNTERMEASURES

WITH DIRECTORY OF EQUIPMENT USED BY THE ARMY AIR FORCES

(SHORT TITLE: SIGCLA-1)

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THIS IS A REGISTERED DOCUMENT

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WAR DEPARTMENT
WASHINGTON 25, D. C., 1 AUGUST 1944.

Introduction to Radio Countermeasures with Directory of Equipment Used by AAF (Short Title SIGCLA-1) is published for the information and guidance of all concerned.

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G. C. MARSHALL,
Chief of Staff.

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PREFACE

The purpose of this manual is to present brief descriptions of radio countermeasure equipment used by Army Air Forces, now classified as confidential or restricted--equipment in development being omitted. In addition, introductory sections are included that seek to provide some of the background and some of the philosophy that is basic to the successful use of countermeasure equipment and devices. Obviously, in a book of this size only the highlights can be covered.

To specialists in countermeasures, the Introductions may serve as reminders of some of the factors that should always be considered. To those who are approaching the subject for the first time and to whom countermeasures may be one of many responsibilities, it is hoped that the text material will be found sufficiently complete, and not too technical, to serve its purpose.

The listing of an item of equipment herein should not be used as a basis for requisition. Information on which to base requisitions should be secured through normal supply channels.

It is important to note the suggestions on the next two pages before using the manual. This will insure against any possible misunderstandings of the data that have been presented.

HOW TO USE THIS MANUAL

(On these facing pages is shown the layout of the writeup for a typical piece of catalogued equipment. This, with the accompanying comments, should aid in the understanding of each presentation.)

OFFICIAL TITLE OF EQUIPMENT (Code Name in Parenthesis)

PICTURE OF TYPICAL INSTALLATION

The picture shows only one of several possible modes of installation. Permissible variations in details are suggested in Appendix II.

PURPOSE Statement covers the chief purpose for which the equipment is designed. It does not imply that the equipment may not be used for other purposes or under other conditions.

DESCRIPTION Statement gives a brief and general description, omitting many details.

PERFORMANCE Estimate of what equipment can do, including probable performance against specific enemy installations.

OPERATION Outline of some main features of operating procedure.

HOW TO USE THIS MANUAL

(On these facing pages is shown the layout of the writeup for a typical piece of catalogued equipment. This, with the accompanying comments, should aid in the understanding of each presentation.)

PICTURE OF MAIN COMPONENTS

The picture does not necessarily include all possible antennas, test equipment, nor detailed parts.

INSTALLATION A listing of a few important features, particularly any unusual factors, with regard to the installation problem for specific equipment.

PERSONNEL "A trained operator" means an officer or enlisted man who has been specially trained in the use of the specific equipment mentioned. "Special training" for maintenance personnel is usually brief.

SPECIFICATIONS Nominal values, representing minimum performance characteristics.

TECHNICAL FEATURES Salient design points not mentioned elsewhere.

STATUS "Light production", up to 250 units; "moderate production", up to 2000 units; "heavy production", above 2000 units. Delivery is usually made several months after production orders are placed. Following the "classification" is a listing of available Instruction Books on Operation and on Maintenance, in the order given. All data in write-ups are as of 15 July 1944.

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RECORD OF CORRECTIONS

CHANGE OR MEMORANDUM NO.	DATE ENTERED	SIGNATURE OF OFFICER MAKING CORRECTION

WHAT CAN RADIOCOUNTERMEASURES DO?

The important role Radio Countermeasures (RCM) can play in modern war is easily appreciated when it is visualized what would happen to an Army if the enemy could at critical moments wipe out its radio communications, its radio navigational aids, and its radar. As a practical matter, such a complete stroke is unlikely. A vital advantage can often be won, however, by partially successful countermeasures. RCM, although one of the newest weapons of war, has already been used to reduce the effectiveness of the enemy's radio communications and the enemy's radar. Three of the best-known examples:

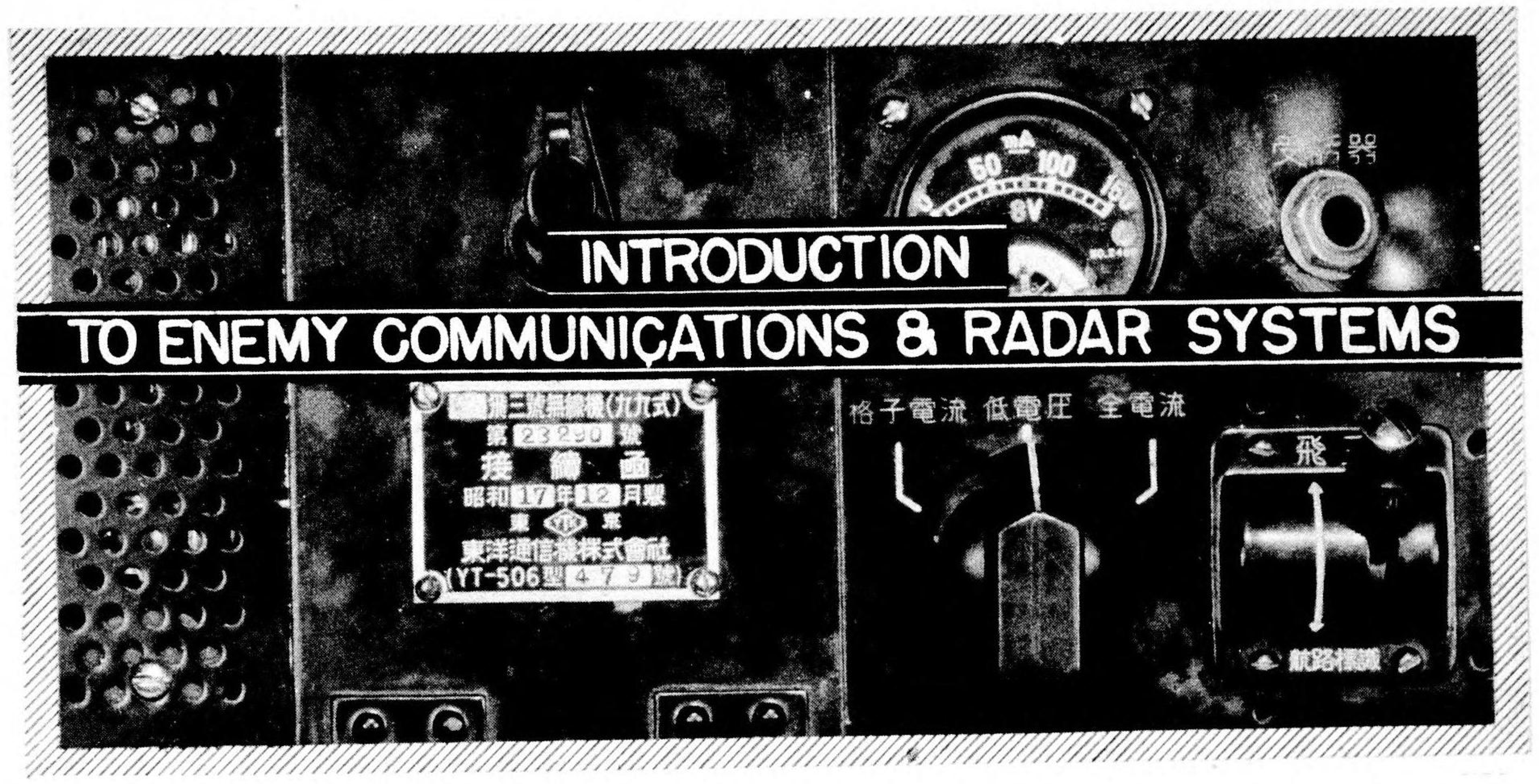
JOSTLE ► This British communications jammer, similar to the Jackals listed in this book, was used to disrupt German tank communications previous to and during the decisive Battle of El Alamein. A number of authorities attribute part of the success of that battle to the fact that the German armored forces were never able to group themselves effectively from one day to the next --this being in part a result of their inability to make proper use of their communications equipment.

CARPET ► This transmitter (AN/APT-2) for jamming German radars that direct anti-aircraft fire, searchlights and fighter-interceptor planes was first installed in one combat wing of the Eighth Air Force in October 1943. After ten missions, the Eighth Air Force Operational Research Section reported that the losses in the Carpet-equipped wing were considerably less than in the non-Carpet-equipped wings that took part in the same missions. Considering the number of planes used, Carpet was credited with saving 21 bombers and 210 men. In those raids when heavy overcast made radar the only means the enemy had for directing AA fire, the benefit of Carpet was even greater.

WINDOW ► This deception device was first used by the British on the large raids beginning 24 July 1943, that destroyed the greater part of the city of Hamburg. The average British bomber losses on the first Window-protected raids were reduced by as much as one-half, as compared with similar raids before the use of Window. The RAF estimated that in 2 months Window saved 200 planes and 1200-1500 men.

ENEMY USE OF RCM

The effectiveness of Window has been further confirmed by the Germans themselves in that they are also using it --the first confirmed case being at Bizerte on 6 September 1943. German and Japanese use of radio countermeasures must always be reckoned with, and knowledge of our own RCM program will aid in combating the enemy's RCM activities. To a considerable extent, the successful escape of the warships Scharnhorst and Gneisenau up the English channel on 12 February 1942 was made possible by German jamming of British coast-watching radar. The Germans had done little jamming for some time before the escape, but were able to do an extensive job when occasion demanded. This example shows how RCM of a particular type can be used with little warning, and gain in effectiveness thereby.



INTRODUCTION TO ENEMY COMMUNICATIONS & RADAR SYSTEMS

The use of radio countermeasure equipment to reduce the effectiveness of enemy radar and communication systems requires having as complete a knowledge as possible of the victim systems. Only on the basis of this knowledge can the intelligent planning and efficient practice of radio countermeasures be done.

In general, the enemy employs his radar and communication equipment for much the same purposes as does the U. S. Army, although there are many differences in both the methods of use and in the operating characteristics of the equipments. It is the purpose of this section to summarize those characteristics which are of particular interest from a countermeasure point-of-view.

The information about enemy equipment can be presented most concisely in tabular form, and this is done at the end of this section. Some of the more pertinent facts that may not be necessarily evident from the charts will be presented first.

GERMAN INFANTRY RADIO COMMUNICATIONS

The exact organization of the radio communications system used in the field will depend upon the particular tactical operation involved, the nature of the surrounding terrain and the equipment that is available. For this reason it is to be expected that individual systems will vary somewhat. In general, however, German infantry Divisions appear to use the various frequency ranges in the following manner:

1. 200 to 1200 kc:

   a. Division to higher formations and flanking Divisions (Division Rear Echelon).

2. 950 to 3100 kc:

   a. Division to headquarters of units immediately below it (Division Forward Echelon).

   b. Lateral communications between such lower headquarters.

3. 3000 to 7500 kc:

   a. Anti-tank, motor cycle, Artillery and Engineer Headquarters and their respective sub-units.

4. 24 to 50 mc:

   a. Tank-to-tank communications.

   b. Air-to-ground cooperation.

The specific equipment used for these (and other) German Army applications is listed in the tables following this introduction. The frequency range, output power, probable range, antenna polarization, and other facts pertinent to the practice of radio countermeasures also are detailed in the charts.*

In planning countermeasures against these communication systems it must be borne in mind that, wherever possible, the enemy will undoubtedly supplement radio channels with extensive wire networks and other means of communication. Countermeasures against these systems, aside from their destruction, is, of course, virtually impossible.

GERMAN ARMORED DIVISION COMMUNICATIONS

The organization of the radio communications system used in the German Armored Divisions, like that of Infantry Division System, will depend upon the particular operation, the terrain, and the available equipment. The general division of frequency bands is similar to that used by German Infantry Divisions.

The equipment that is available to the Armored Divisions, together with detailed information concerning its operating characteristics, is also tabulated in the charts.

*Where even more detailed information is desired, reference may be made to the Signal Communication Directory, Axis Nation Section, issued by the Intelligence Branch of the Chief Signal Officer.

JAPANESE RADIO COMMUNICATIONS

The Japanese radio communication frequency allotments do not conform to the system of frequency allotments such as that given for German frequencies according to the latest information obtainable. It seems to be true that Japanese frequencies are allotted in direct accordance with the transmission range desired so that the upper frequency limit for communications during an actual engagement is about 5 mc and the upper range for island-to-island communications is 20 mc. Detailed information concerning the operating characteristics of known Japanese Ground and Air Force equipment is tabulated in the accompanying charts. Further information may also be obtained fron the Signal Communications Directory, Axis Nations Section.

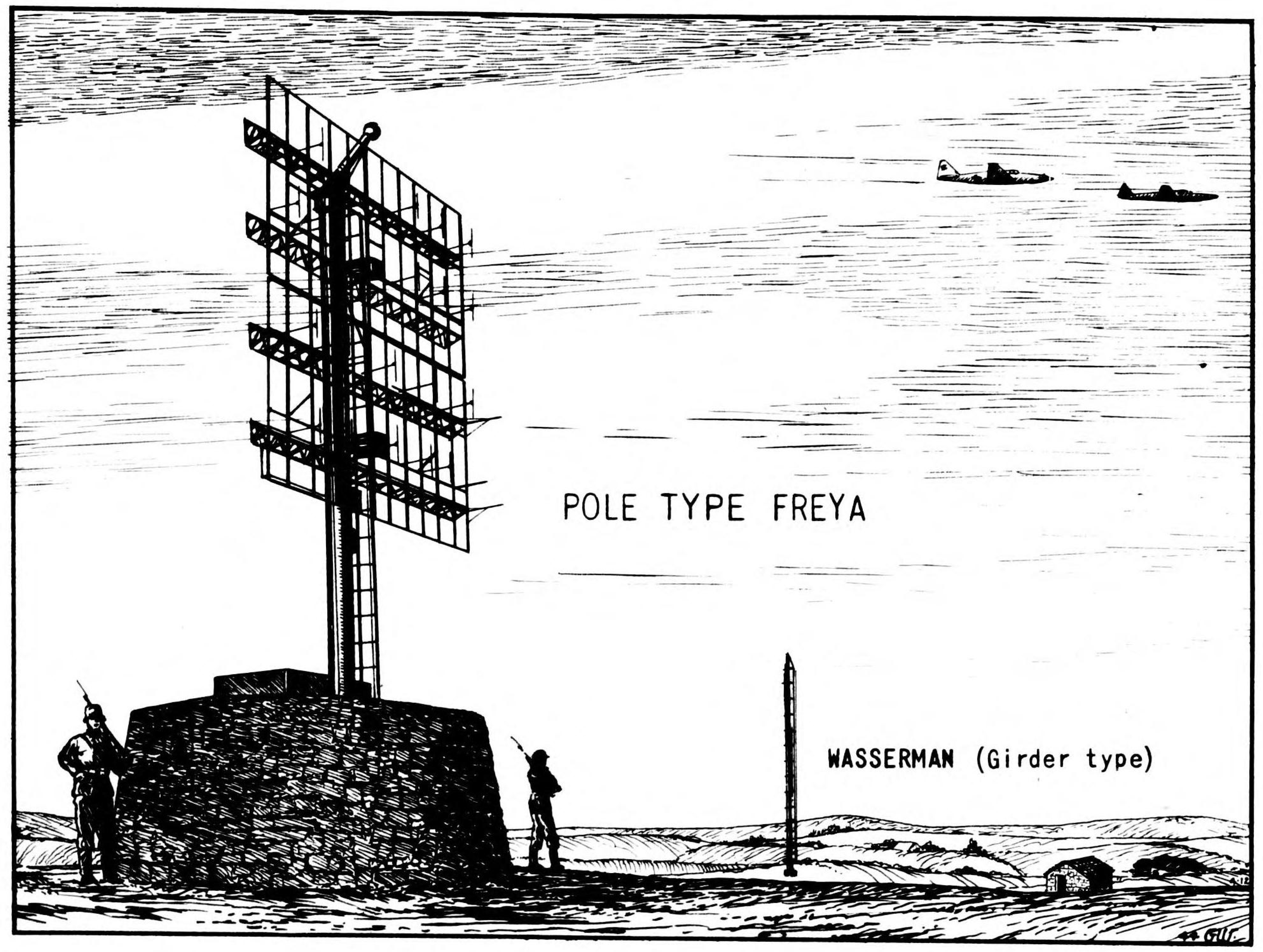
GERMAN RADAR APPLICATIONS

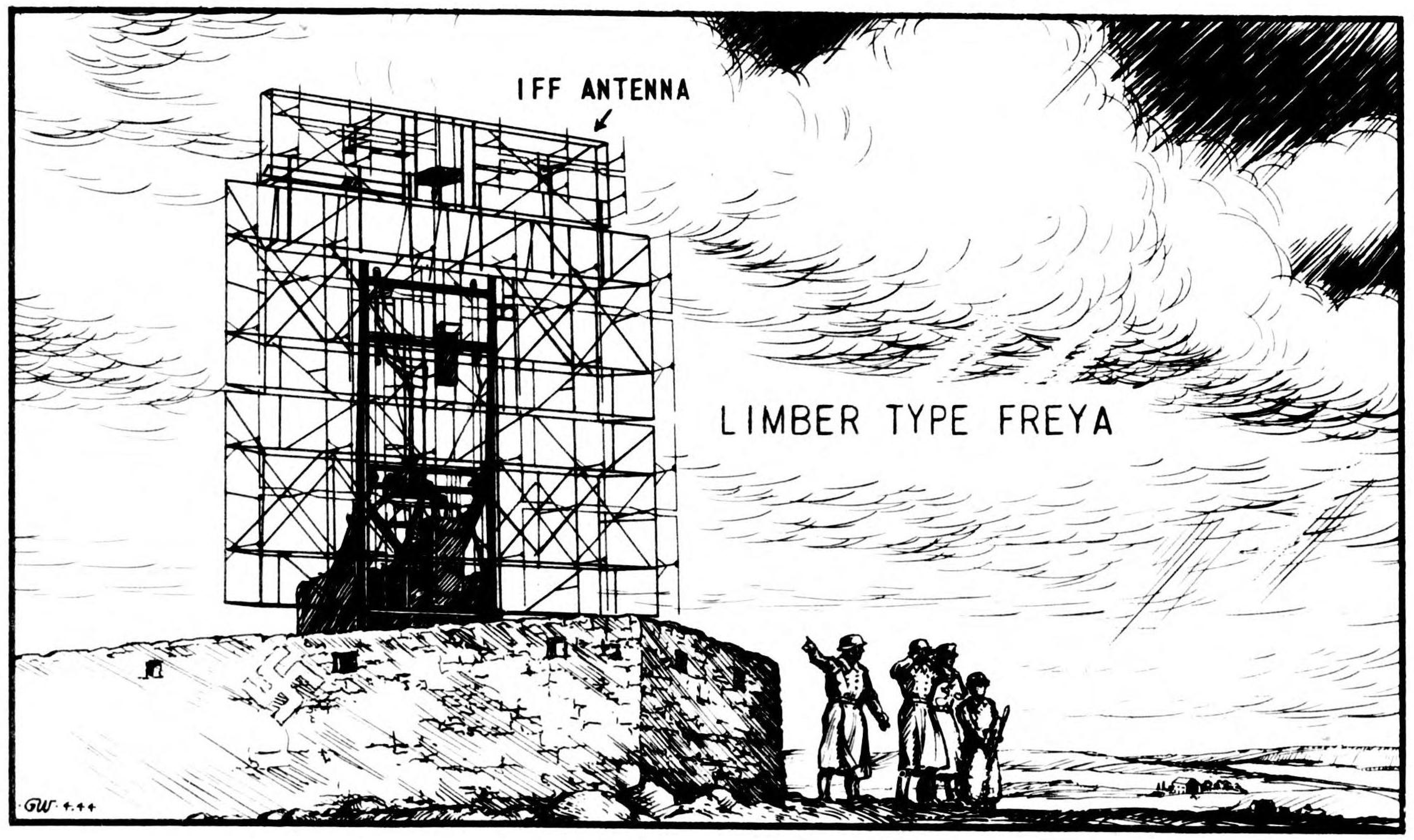
The Germans use radar extensively for early-warning (EW), ground-controlled-interception (GCI), search-light-control (SLC), gun-laying (GL), air-interception (AI) and allied applications. Elaborate radar networks have been installed on the Continent for defensive purposes, the various types of sets mentioned being closely associated with one another in order to provide a completely integrated system.

When an aircraft (or several aircraft) approaches enemy territory it is first detected by the early-warning equipment, presumably at a considerable range. As a rule, this equipment is capable of determining the bearing and the range of the airplane, but not its height. When the aircraft has approached close enough, it comes under the scrutiny of a tracking set that is able to determine the height of the aircraft, as well as its bearing and range. The resolution of these tracking sets is greater than that of the early warning equipment and the data is used for gun-laying, for search-light-control, or for directing a fighter to the vicinity of our plane (ground-controlled interception). When the fighter is close enough to the target, it will make use of airborne radar equipment to complete the interception.

GERMAN EARLY-WARNING RADAR

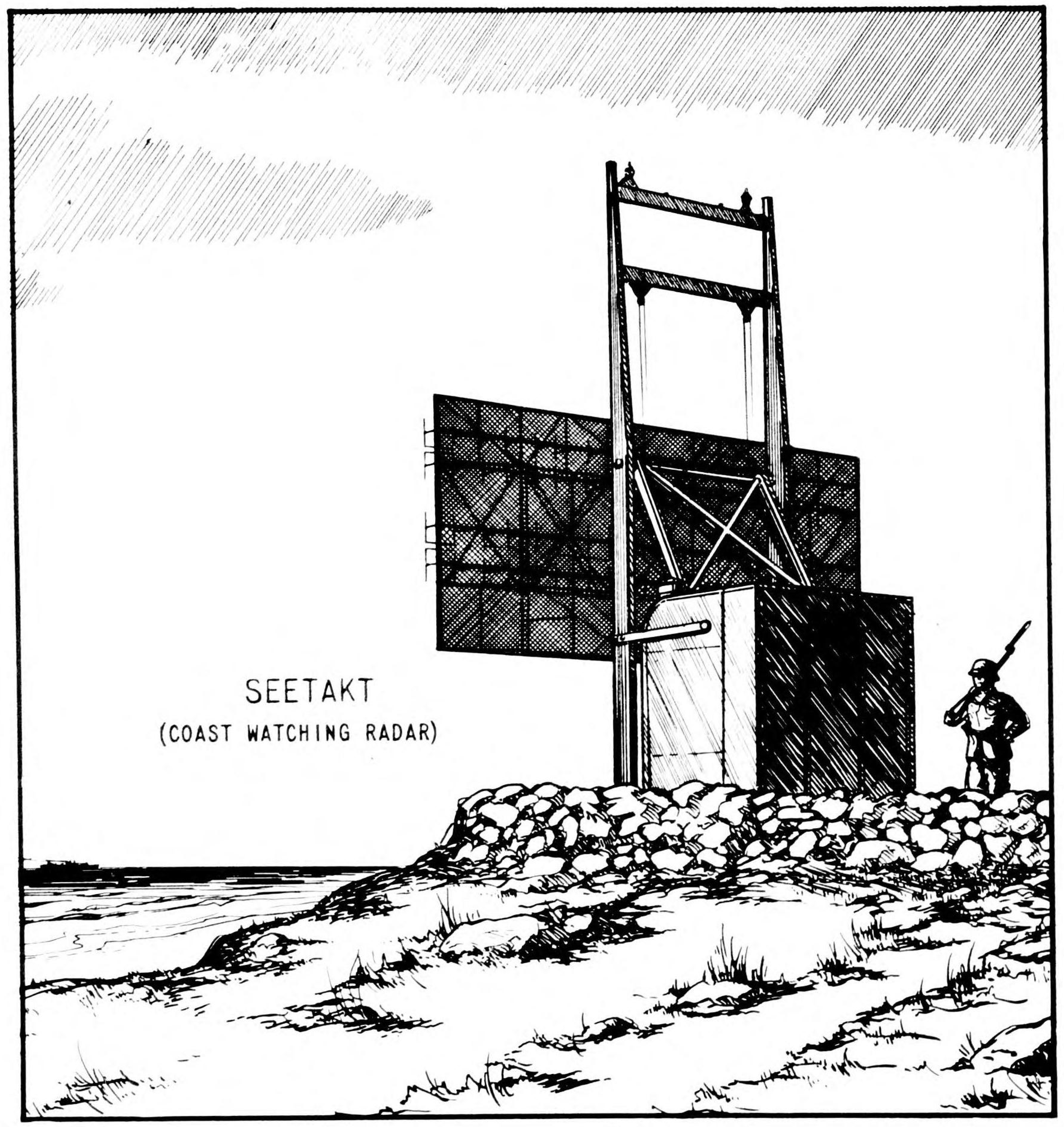
The backbone of the German aircraft reporting system is the Freya set. The older models (39G and 40G) are set up in trailers and are transportable where roads are available. This type is referred to as the "limber type", as it is mounted on an 88-mm gun chassis. The latest type (LZ) is demountable for air transport. It is known as the "pole type", since the antenna arrays hang on a vertical pole. The principle uses of these sets are to provide range and bearing data on aircraft and to put the Wurzburgs (see p. 7) at GCI sites onto the target. A chain of Freyas covers the over-water approaches to enemy-held Europe.

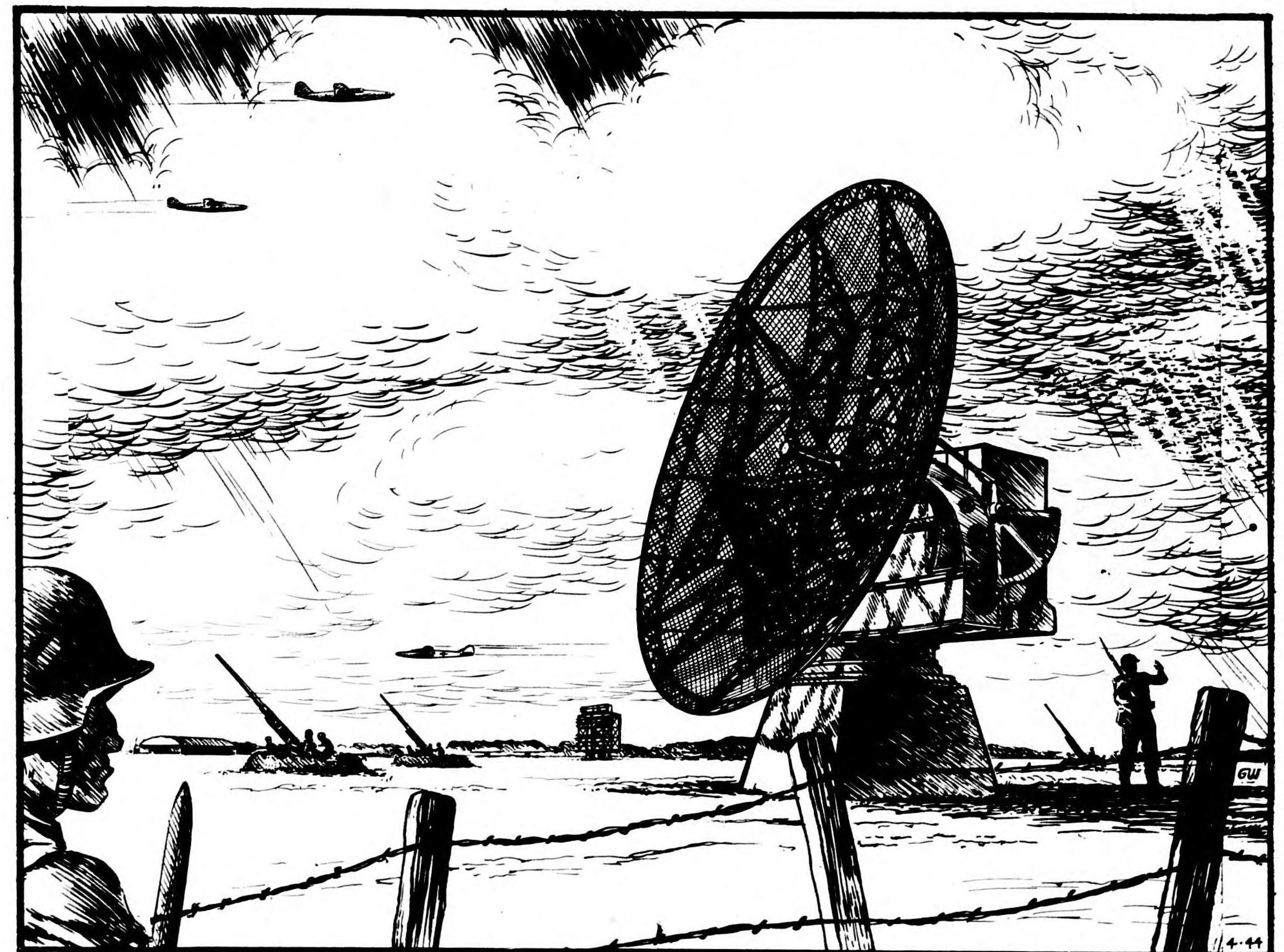




A second type of EW set is the Wassermann (Chimney). Only a small number appear to be in operation and these installations seem to be located only along the coast. This type of set is apparently used to supplement the Freya chain at key points. The Wassermann is believed to differ essentially from the Freya only in the antenna system, whose tall, thin shape explains the name "Chimney".

A third type of German EW radar is the Mammut (Hoarding). These sets are also limited in number and appear to supplement the Freya chain at key points. The Mammut seems to differ from the Freya essentially only insofar as the antenna is concerned. The antenna consists of a large, fixed array resembling a billboard or British "Hoarding".



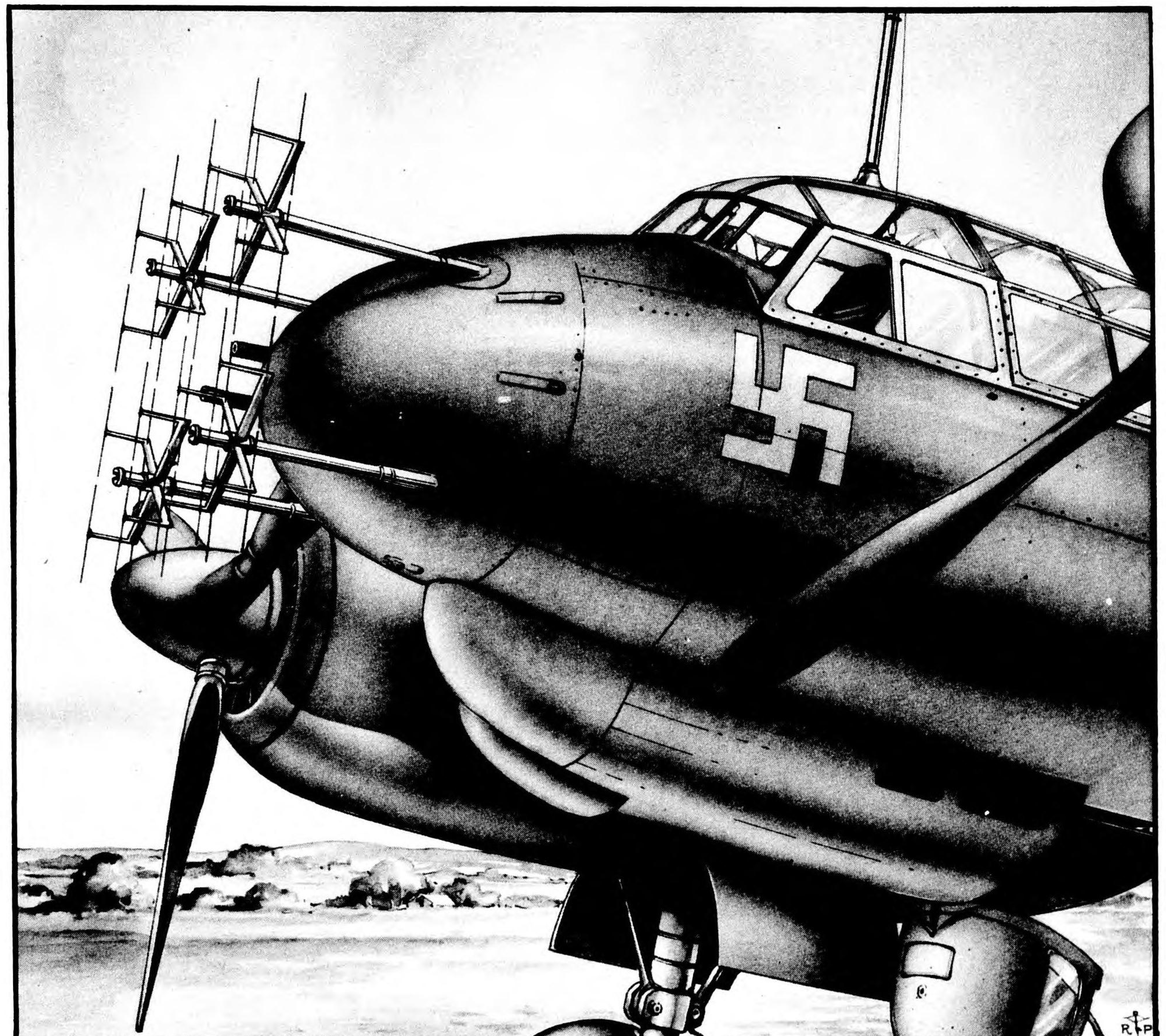


The standard German Ground-Controlled-Interception (GCI) site employs two Giant Wurzburg tracking radars (one is shown in foreground of above illustration) and a Freya early-warning radar (shown in background). The directivity or resolution of the Wurzburg being high, its field of view is small and consequently a Freya is used to put the Wurzburg onto the target.

GERMAN TRACKING RADAR

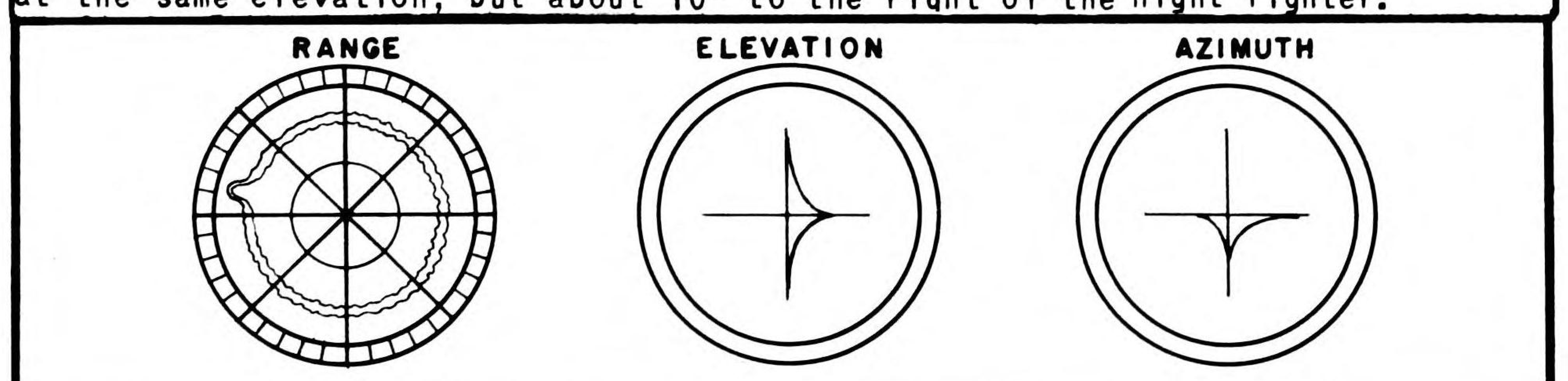
The basic radar used for GL, SLC and GCI purposes is the Wurzburg. This set is characterized by its parabolic antenna which appears in two sizes, the Giant (Basket) and the Small (Bowlfire). The former is a fixed installation, whereas the latter is mounted on a mobile 88 mm gun carriage. Originally, the Giant was used only for GCI but it now appears to be used also for GL and SLC. The small Wurzburg, however, is the basic GL/SLC radar. As the latest models become available for this purpose, the older ones are put to use as height-finders supplementing the early-warning chain of Freyas.

The Giant Wurzburg (Basket) derives its name from the large perforated circular paraboloid antenna, which is approximately 24 feet in diameter. It has evolved from the small Wurzburg (Bowlfire) which has an antenna approximately 10 feet in diameter made of solid metal and resembles a bowl. The larger antenna gives higher gain, thereby providing the range that is needed for GCI and, in addition, sharpens the beam, making possible accurate height-finding at the low elevations involved.



Shown above is the antenna array of the German FUG 202 Lichtenstein Gerat (also known as Emil-Emil) air-interception radar on a Ju 88 night fighter. The antenna is vertically polarized and consists of four sections, each comprised of four dipoles with reflectors. The equipment operates in the frequency band from approximately 480 to 500 Mc and has a useful range of about 2 miles. This equipment has been used by the Germans in both the European and Mediterranean Theaters.

Shown below are the three scopes used by the German radio operator. The direction of flight is obtained by the comparative size of the pip on either side of the time base on the scope. The drawings indicate the target is 1.5 kilometers away, at the same elevation, but about 10° to the right of the night fighter.



The standard German GCI site has two Giants plus a Freya "putter-on". Originally one Giant was used to follow the foe and the other the friend. Where the fighter Benito system is in operation, however, the second Giant is available for tracking another intended victim. Since a neighboring Freya is required to put either type of Wurzburg onto the target, it is evident that the jamming of the EW Freya will seriously reduce the effectiveness of the Wurzburg.

The standard German GL/SLC installation consists of a small Wurzburg. The range accuracy is said to be better than that of existing optical range-finders at all practical ranges. However, German flak is apparently most dangerous when it can use range data from the Wurzburg together with optical angular data. This method of gun-laying, which is used whenever possible, requires the use of searchlights at night. The master searchlights are, when possible, controlled by Wurzburgs. Where low visibility prevents optical direction-finding, complete radar control is used. The accuracy of firing then appears to be poor.

JAPANESE RADAR APPLICATION

The Japanese are beginning to use radar for all of the usual functions. Strong evidence is being obtained daily that the Japanese are using radar for early warning (EW), searchlight control (SLC), for gun laying (GL), and for airborne searching for surface vessels. Recent information from the Pacific indicates that the Japanese have been engaged in 10 cm radar work for the past two years, obviously being much more advanced than the Germans in this respect, as no evidence is available concern- the use of similar German radar equipment. Quite an extensive chain of early warning radars are being used from land based installations, which operate in the 43 to 215 Mc frequency band.

There appears to be a continued tendency on the part of the Japanese to improve their radar equipment. Such evidence has already been obtained in their early warning radars and in the ASV applications.

The standard Japanese radars are the following:

Mark I (Several models) -- Land based E.W. Several of these sets have been captured on the various islands in the Southwest Pacific area. These radars may be in the stage of being adapted for searchlight and gun control.

Mark II (Several models) -- Naval surface search and possibly fire control. Although none of these sets have been captured, there is definite evidence of their existence.

Mark IV (Not definite) -- Naval and land based fire control. This is not confirmed.

Air Mk VI -- Airborne radar sets of several types. These are being found more often in bombers; both two-engine and four-engine types, for ASV work.

An early model, termed Model 2, has recently been superseded by Model 4. Furthermore, Model 4 has been adapted for ground uses where necessary.

Submarine Radar -- Although a set of this type has not been captured, it appears certain that such equipment does exist in a limited number of submarines now active in the Pacific areas.

A NOTE ON THE CHARTS

The charts of enemy equipment characteristics are based upon the best information that is currently available. The data have been obtained from examinations of captured equipment, from intelligence reports and from RCM intercept operations.

It must be borne in mind that the state of development of enemy equipment is always progressing. Data that are correct today may not be correct tomorrow. New equipment and modifications of existing facilities will be encountered continually. As information on such facilities becomes available the following charts should be revised accordingly.

GERMAN EQUIPMENT

Recent evidence indicates the probable use of German airborne radar at 1150 Mc and at 1500 Mc. Ground based gun laying radar at 1000 to 1150 Mc with a pulse repetition frequency (PRF) of 3720-3920 cps is also suspected.

AN	switching from "A" to "N"	MIN	minimum
BL	blind landing	MOD	modulated
CIRC	circular	μs	microseconds
CM	centimeter	μv	microvolt
COMM	Communications	PROD	production
FMCW	freq. mod. CW	R, REC	receiver or reception
H	horizontal	RCN	reconnaissance
IND	indicator	SP	spacing
LW	long wave	SW	short wave
M	meter	T, TR, TRANS	transmitter
MAX	maximum	V	vertical
MCS	megacycles per second	W	watt
MED	Mediterranean		

ABBREVIATIONS

(Other than these given in Glossary)

GERMAN SEARCH AND WARNING RADAR

NAME	FREYA 39 G (LIMBER TYPE)	FREYA 40 G (LIMBER TYPE)	FREYA-LE (POLE TYPE) (DETA GERAT)	WASSERMAN L (SMALL) (GIRDER TYPE)
FREQUENCY COVERAGE (MC.)	90-148	90-148	90 - 148	116-146
PRF (CPS)	1000	490 TO 510	490 TO 510	485 TO 510
PULSE WIDTH (μS)	2-3	2-3	2-3	2.5
POLARIZATION	V	V	V	V
FUNCTION	EARLY WARN. AND GCI "PUTTER-ON"	EARLY WARN. AND GCI "PUTTER-ON"	EARLY WARN. AND GCI "PUTTER-ON"	LONG RANGE EARLY WARN.
RANGE (MILES)	90	120-MAX. 0.6-MIN.	120-MAX. 0.6-MIN.	180-MAX (?)
PEAK POWER (KW)	15-20	15-20	15-20	20
TYPE OF INSTALLATION	MOBILE SET MOUNTED ON 88mm FLAK GUN CHASSIS	MOBILE SET MOUNTED ON 88mm FLAK GUN CHASSIS	DEMOUNTABLE FOR AIR OR VEHICULAR TRANSPORTATION	FIXED
METHOD OF PRESENTATION	3 CRT TUBES (STRAIGHT TRACE) (DOUBLE BEAM) GEN. OBSERV., APPROX. AND PRECISION RANGE	3 CRT TUBES (STRAIGHT TRACE) (DOUBLE BEAM) GEN. OBSERV., APPROX. AND PRECISION RANGE	3 CRT TUBES (STRAIGHT TRACE) (DOUBLE BEAM) GEN. OBSERV., APPROX. AND PRECISION RANGE	
QUANTITY IN SERVICE	STILL USED ON SOME SITES SAY, 40	VERY WIDELY USED SAY, 180	WIDELY USED SAY, 80	ONLY A FEW SAY, 20
APPROXIMATE LOCATION	FOUND IN COASTAL CHAIN AND INLAND GCI SITES	FOUND IN COASTAL CHAIN AND INLAND GCI SITES	FOUND PRIMARILY IN MED. THEATRE	FOUND PRIMARILY IN MED. COASTAL SITES
REMARKS	RECEIVER IF STAGES-15 AND 7 MCS.	IFF PRESENTATION ON ALL FREYAS ARE PARALLEL TRACES ON TUBES IN "SPLIT" AND MAIN PRESENTATION UNITS		CAN TAKE CARE OF HIGH COVER BY MOTOR DRIVEN PHASING UNIT WHICH CHANGES BEAM ELEVATION FROM HORIZONTAL TO $2\frac{1}{2}^{\circ}$
ANTENNA STRUCTURE	VERTICAL STACK OF THREE RECTANGULAR WIRE NETTING FRAMES, 20 FT. WIDE x 8 FT. HIGH APPROX. BOTTOM FRAME FOR TRANS. MIDDLE FOR RECEIVER, TOP FOR IFF (?)	SAME AS FREYA 39G EXCEPT FOR SPACING BETWEEN FRAMES	SAME AS FREYA 40G ANTENNA EXCEPT ARRAYS ARE MOUNTED ON A HEAVY POLE INSTEAD OF THE USUAL FRAMEWORK	SAME TYPE OF ARRAY AS CHIMNEY RADAR EXCEPT IS 20FT. WIDE AND MOUNTS ON STEEL TOWER OF TRIANGULAR CROSS SECTION
ANT. GAIN	40	40	40	
HOR. BEAM WIDTH AT 1/2 LOBE AMP.	20°	20°	20°	20°
LOBE SWITCHING OR SPLIT	USUALLY PRESENT ON RECEIVER	USUALLY PRESENT ON RECEIVER	USUALLY PRESENT ON RECEIVER	(?)
METHOD OF SCANNING	ENTIRE ARRAY ROTATES ABOUT VERTICAL AXIS (MAX-6°/SEC)	ENTIRE ARRAY ROTATES ABOUT VERTICAL AXIS (MAX-6°/SEC)	ENTIRE ARRAY ROTATES ABOUT VERTICAL AXIS (MAX-6°/SEC)	ARRAY ROTATES ABOUT VERTICAL AXIS

GERMAN SEARCH AND WARNING RADAR

CHIMNEY (LARGE WASSERMAN) (CYLINDER TYPE)	MAMMUT (HOARDING)	GERYNEN (U BOAT RADAR)	SEETAKT (COAST WATCHER)	DETE TYPE (NAVAL RADAR)
116-146	116-146	355-395	360-390	360-390 (?)
490 TO 510	490 TO 510	500	500 OR 1000 (FEW)	
2-3	2-3		2-3	
V	V	V	V	
LONG RANGE EARLY WARN. HEIGHT FINDING	LONG RANGE EARLY WARN.	DETECTION OF AIRCRAFT AND RANGE OF SHIPS	DET. OF SHIPS COASTAL GUN RANGING	DET. OF SURFACE VESSELS GUN RANGING VS. VESSELS
180-MAX (?)	160	5-10	30-MAX. 0.6-MIN.	
20	20	3	5-10	
FIXED	FIXED	ON U-BOAT NEAR CONNING TOWER	MOUNTED ON 88mm FLAK GUN CHASSIS	
		TYPE "A"	GEN. OBSERV. TUBE; HIGH SPEED TRACE TUBE FOR PRECISION RANGING	
ONLY A FEW SAY, 25	ONLY A FEW SAY, 20	IN USE	IN USE. SAY, 200	
COASTAL SITES IN N.W. EUROPE AND MED. THEATRES	COASTAL SITES IN N.W. EUROPE		COASTAL SITES EUROPE AND MED.	
PROBABLY USES PHASING OF ARRAY WHEN OBTAINING AIRCRAFT HEIGHTS. THIS SET APPEARS TO BE A VERTICAL HOARDING. IFF ANTENNA IS 22 FT. EXTENSION ON TOP OF ARRAY	PROBABLY USES PHASING TO SWING BEAM, AS AERIAL ARRAY IS FIXED	RECEIVER IF STAGES-15 AND 7 MCS, (SAME AS FREYA DESIGN (?)) RANGE ACCURACY 100 TO 200 YDS. (PROBABLE) BEARING ACCURACY 5 TO 10° (PROBABLE)		ADAPTATION OF SKEETAKT FOR NAVAL USE (?)
COMMON T AND R. BROADSIDE ARRAY-FULL WAVE DIPOLES. 45 FT. WIDE-90 FT. HIGH ON 120 FT. TOWER (8 FT. DIAMETER)	BROADSIDE ARRAYS LIKE FREYA EXCEPT LARGER (98 FT. LONG AND 36 FT. HIGH). ONE IN FRONT - ONE BACK	3 FT. SQUARE WIRE MATTRESS CONTAINED IN SPECIALLY CONSTR. BLISTER ON PORT SIDE OF CONNING TOWER. FOUR 5" DIPOLES IN SQUARE	TR. AND REC., EACH, BROADSIDE OF 16 VERT. FULL WAVE DIPOLES. BOTH ARRAYS ARE BACKED BY A WIRE NET REFLECTOR	
160	200			
7 TO 10°	ABOUT 5°		ABOUT 10°	
(?)	NONE OBSERVED		NONE OBSERVED	
ARRAY ROTATES ABOUT VERTICAL AXIS	SWEEPING-120° OR FRONT AND BACK (PHASE-CONTROL)	MANUAL SWEEP	ARRAY ROTATES ABOUT VERTICAL AXIS MANUAL OR MOTOR DRIVE)	

GERMAN AIRBORNE RADAR

TYPE	FUG 213 (LICHENSTEIN "S" GERAT)	FUG 216 (NEPTUN "R" GERAT)	ROSTOCK-GERAT	FUG 214 (GERMONICA LICHTENSTEIN "R" GERAT)	FUG 202 (LICHTENSTEIN GERAT) (EMIL-EMIL)	FUG 200 HOHENTWEIL-GERAT)
FREQUENCY COVERAGE (MC)	81 (?)	150-182 POSSIBLE 164-171 OBSERVED	176	335-362	TR. 410-540 POSSIBLE REC. 479-497 POSSIBLE OBSERVED 480-500	550 to 570
FUNCTION	ASV (?)	TAIL WARNING	ASV	TAIL WARNING	AI	ASV NAV. AID + BLIND BOMBING
TRANSMITTER P.R.F.		1450 TO 1650	400 TO 600	2500 TO 2700	1900 TO 4780 PEAK 2700	600 (?)
PULSE WIDTH (μS)			2.8	1	1	
RANGE (MILES)		5	5	2	1.5-2.5 (LIMITED BY ALTITUDE)	CALIBRATED UP TO 60 MILES
ANTENNA SYSTEM	REC.-TWO COLINEAR HALF WAVE DIPOLES END FED. TR.-NO INFORMATION AVAILABLE	VERTICAL YAGI UNDER EACH WING. SAME AS FOR FUG 214 EXCEPT DOUBLE LENGTH	FOUR SETS OF AERIALS (ON LEADING EDGE OF EACH WING.) EACH SET CONSISTS OF TWO 1 FT. DIPOLES	ONE VERTICAL YAGI UNDER EACH WING, EACH HAS FOUR ELEMENTS	COMMON TR. & REC. FOUR SECTIONS EACH OF 4 DIPOLES WITH REFLECTORS	THREE AERIAL ARRAYS EACH CONSISTING OF FOUR COLINEAR FULL WAVE RADIATORS EACH SEPARATED BY HALF WAVE LENGTH
POLARIZATION	H	V	H	V	V	H
LOBE SWITCHING		NO SPLIT. RANGE ONLY	SOME EVIDENCE OF SPLIT	NO SPLIT. RANGE ONLY	SPLIT 19-32 CPS	ON RECEIVER
ANT. GAIN					13-14	13-14
EFFECTIVE BEAM WIDTH		60°		35°	35°	40°
TR. POWER OUTPUT (WATTS)		½-1 KW - PEAK	5 KW - PEAK	200 TO 450 PEAK	200 TO 450 PEAK	
METHOD OF INDICATION	2-CRT (RANGE, D/F) RANGE IS CIRCULAR TRACE	SINGLE-SIDED DEFLECTION GIVES RANGE ONLY.	ONE CRT WITH SEMI-CIRCULAR RANGE INDICATION	ONE CRT RANGE ONLY (LINEAR)	INDICATOR UNIT WITH 3 CRT. ONE CIRCULAR TIME BASE-FOR RANGE. OTHERS FOR AZIMUTH + ELEVATION	ONE CRT - TWO CALIBRATIONS FOR COARSE RANGE (60 MILES) AND FINE RANGE (6 MILES)
RECEIVER SENSITIVITY (μ VOLTS)		20 (SUPERHET)		ABOUT 30	30	
RECEIVER SELECTIVITY		1.25 TO 1.5 MCS. BANDWIDTH		SUPER-GENERATIVE RECEIVER	3MC-3DB: 4.5MC-5DB (SUPER-REGENERATIVE	
QUANTITY IN SERVICE	ON JU 88 AND DO217K	INTRODUCED IN OCT. 1943 FOUND IN JU 188		USED IN OLDER BOMBERS. BEING SUPERSEDED BY FUG 216 *	NORMALLY INSTALLED IN NIGHT FIGHTERS LIKE JU 88. ME-110.	FOUND IN HE 111 AND DO 217. FUG 200. ALSO IN JU 188. HE 111. FW 200
APPROX. AREAS OF OPERATION		EUROPE AND MED.	USED IN MED. & EUROPEAN THEATRES		IN USE OVER BELGIUM, GERMANY, HOLLAND AND MED. THEATRES	USED IN MED. & EUROPEAN THEATRES
REMARKS	USUALLY FOUND WITH FUG 203E IN CONTROL OPERATION ON GUIDED MISSILES	LONGER RANGE, GREATER COMPACTNESS, BETTER PRESENTATION THAN FUG 214. RECENT EVIDENCE OF THIS SET ON PRF FROM 150-400 CPS MAY LEAD TO LIGHT-WEIGHT GROUND EARLY-WARNING RADAR	COPY OF BRITISH ASV MK II ONLY FEW.	ADAPTION OF FUG 202.	COMPARABLE TO BRITISH MK IV AI FROM OPERATIONAL VIEWPOINT	USUALLY FOUND WITH FUG 203D IN CONTROL OPERATION ON GUIDED MISSILES

*Rewired model now being installed in many bombers.

GERMAN TRACKING RADAR

NAME	FMG 39T (A) (SMALL WURZBURG) (BOWL FIRE)	FMG 39T (C) (SLC-GL)	FMG 39T (D) (FUSE 62 "W")	FMG 39T (GIANT) (LARGE WURZBURG) (RIESEN WURZ.) (FUSE 65 "R")	COAST WATCHER (GIANT WURZBURG)
FREQUENCY COVERAGE	520-590	520-590	520-590	520-590	550-580
P.R.F. (cps)	3745 TO 3755	3745 TO 3755		1875	1500
PULSE WIDTH (μS)	1-2	1-2	1-2	1-2	1-2
POLARIZATION	V	ROTATES	ROTATES	ROTATES	H
FUNCTION	HEIGHT AND BEARING FOR GCI	GUN LAYING, SLC, HEIGHTS FOR GCI	GL, SLC AND HEIGHTS FOR GCI	GL, SLC AND BEARING FOR GCI	TRACKING OF SHIPPING. GUN RANGING
RANGE (MILES)	24-MAX. 1.0-MIN.	24-MAX. 1.0-MIN.	24-MAX. 1.0-MIN.	45-50	
PEAK POWER (KW)	7-11	7-11	7-11	7-11	7-11
ANTENNA STRUCTURE	9 FT. PARABOLOID OF SHEET METAL. HAS ADJUSTABLE TUBULAR DIPOLE FIXED IN THE VERTICAL PLANE, WITH SHEET METAL REFLECTOR	SAME AS FMG 39T (A) EXCEPT NEW BROADBAND DIPOLE IS MOUNTED ON ROTATING SHAFT FOR SPLIT. DIPOLE 16 OR 18 CM. LONG	SAME AS FMG 39T (C)	24 FT. DIAMETER PARABOLIC MIRROR. MIRROR IS MOSAIC OF SHEET METAL PRESSINGS WITH SQ. HOLES. OTHERWISE ARRAY IS SAME AS FMG 39T (D)	24 FT. DIAMETER PARABOLIC MIRROR [SAME AS FMG 39T (GIANT) - BUT NO SPLIT]
ANT. GAIN	120 (?)	120 (?)	120 (?)	900	
HOR. BEAM WIDTH AT 1/2 LOBE AMP.	(ABOUT 15° IN VERT. PL.)	ABOUT 18° WITH SPLIT	ABOUT 18° WITH SPLIT	ABOUT 8° WITH SPLIT (9° IN VERT. PLANE)	ABOUT 5°
LOBE SWITCHING OR SPLIT	NO SPLIT	SPLIT-25 CPS 4° SPLIT ANGLE	SPLIT 20 CPS TO 25 CPS	SPLIT-25 CPS 1.5° SPLIT ANGLE	NONE
TYPE OF INSTALLATION	LIGHT FOUR WHEEL TRAILER WITH OUTRIGGERS	MOBILE	MOBILE	FIXED	
METHOD OF PRESENTATION	CIRCULAR TIME BASE	CIRC. TIME BASE AND STROBE TUBES FOR BEARING AND ELEVATION	CIRC. TIME BASE AND STROBE TUBES	CIRC. TIME BASE AND STROBE TUBES	
QUANTITY IN SERVICE	WIDELY USED. SAY.500. NOT IN PRODUCTION	VERY WIDELY USED. SAY, 1000. (NOT IN PRODUCTION)	VERY WIDELY USED. SAY, 500 & 100 MONTHLY PRODUCTION	VERY WIDELY USED. SAY,750 & 20/MONTH PROD.	
APPROXIMATE LOCATION	COASTAL AND INLAND SITES EUROPE AND MED.	COASTAL AND INLAND SITES EUROPE AND MED.	COASTAL AND INLAND SITES EUROPE AND MED.	COASTAL AND INLAND SITES EUROPE AND MED.	
REMARKS	IFF-APPROX. 155 MCS, 5000 CPS. 1.5 μS PULSE WIDTH, IFF ANTENNAE-2 DIPOLES WITH D/F FACILITIES AT SIDES OF PARABALOID. IF BAND WIDTH-0.5 MCS (6 DB DOWN)	MINIMUM ANGLE OF ELEVATION FOR INLAND SITES IS: FOR COVER, 5° ABOVE OPTICAL HORIZON. FOR HEIGHT FINDING 10° ABOVE OPTICAL HORIZON	HAS MODIFIED UNIT GIVING MORE ACCURATE RANGE DATA. EQUIPPED WITH SELSYN DATA TRANSMISSION	ONLY DIFFERENCE FROM FMG 39T (D) IS PARABOLA AND HOUSING	PROBABLY IS EARLIER VERSION OF THE SPLIT-TYPE GIANT WURZBURG

GERMAN AIRBORNE V.H.F. NAVIGATION AND CONTROL EQUIPMENT

TYPE	FULANDE GERAT I	FULANDE GERAT 2H	FUG 16 E + ZVG 16	FUG 17E + FUG 28A (Y-GERAT)	FUG-203D (KEHL-EINRICHTUNG GERAT)
FREQUENCY COVERAGE (MC.)	EBL-1: 28.5-35 EBL-2: 38.0	EBL-3H: 30.0-33.3 EBL-2: 38.0	38.5-42.3 (TR. USUALLY 1.9 MC. BELOW REC.)	42.1-47.9 (TWO REC.+ ONE TR.)	48.3-50.0
FUNCTION	STANDARD BLIND APPROACH APPARATUS	NAV. AID (KNICKEBEIN)	FIGHTER BENITO (GCI Control)	BOMBER BENITO (BLIND BOMBING)	RADIO CORRECTION OF FRITZ "X" OR FX 1400 BOMB.
RANGE (MILES)		250	100 (A/C AT 10,000 FT)	UP TO 200	
MODES REC. AND TRANSMIT	RECEIVERS ONLY. AM.	RECEIVERS ONLY. AM. (KNICK-KEYED 60 C/S. AT 1170 C/S)	REC. -MCW (3000 CPS) OR PHONE TR.- PHONE	MCW INFO. ON RANGE BY R/T	SAME AS FUG-203E (?)
METHOD OF INDICATION	AURAL + VISUAL LEFT-RIGHT AND MARKER BEACON IND.(METER)	SAME AS FULANDE GERAT I	HEADSET (INFO. FROM GROUND)	METER AZIMUTH LEFT-RIGHT IND. FUG 17E RANGE BY R/T	WATCH BOMB VISUALLY
TR. POWER OUTPUT (WATTS)		GROUND STA.-1KW RECEIVER ONLY ON A/C		FUG 17E-10 GROUND EQUIP. 800 WATTS	
RECEIVER SENSITIVITY (μVOLTS)	EBL-1: 25 FOR 1 MW. EBL-2 : 1.4μV FOR ½ MW.	EBL-3M 6μ V-1 MW.	4		
RECEIVER SELECTIVITY	EBL-1 6DB-50KC	EBL-3H 45KC-6DB.	25KC-6DB	25 KC-6DB	ABOUT 80KC - 6 DB 170 KC - 12 DB RF 47.2-50.5 - 6 DB 46.0-52.0 - 20 DB
ANTENNA SYSTEM	MAIN BEACON REC.-EBL-1 HAS SHORT FIXED AERIAL. MARKER BEACON REC.-EBL-2 HAS DIPOLE AERIAL.	SAME AS FULANDE GER. I EXCEPT ANTENNA MATCHING DIFFERENT	16Z: SINGLE FIXED WIRE OR T AERIAL ZVG - 16: D/F LOOP SINGLE TURN	ON A/C Rx RETRACTABLE 2' 11" Tx 39" ROD BENEATH A/C	TR. ANT. ON DO 217 K2. TWO 11FT. WIRES, TAIL TO FUSELAGE.
POLARIZATION		V	V	V	
QUANTITY IN SERVICE	STANDARD FOR FIGHTERS + BOMBERS	SUPERSEDES FULANDE #1 WHERE POSSIBLE			FOUND IN HE 177'S AND DO 217K2
APPROXIMATE AREAS OF OPERATION		ETO	ETO	ETO	ETO AND MED. THEATRE
REMARKS	1150 CPS - MAIN BEACON 700 CPS - INNER MARKER 1700 CPS - OUTER MARKER	DIFFERS FROM FULANDE GERAT I IN THAT TUNEABLE RECEIVER IS SUBSTITUTED	THIS SYSTEM GIVES RANGE ONLY. BEARING OF THE FIGHTER IS DONE BY TORNADO GERAT (D/F SYSTEM FROM GROUND)	COURSE RECEIVER - FUG 28A; IND. RANGE SYSTEM - FUG 17E (RETRANSMISSION)	RECEIVER ON BOMB E230. FX 1400 IS 3000 LB. BOMB FOR HIGH ALTITUDE (20,000 FT.) USE

GERMAN AIRBORNE V.H.F. NAVIGATION AND CONTROL EQUIPMENT

FUG-203E (KEHL-EINRICH-TUNG GERAT)	"X" GERAT (RUFFIAN)	HYPERBEL-GERAT BRITISH GEE MK II	FUG 25A	FUG 25	FUG 101 FUG 101A (F-GERAT)	FUG 103
48.3-75.0	66.5 - 75.0 (TWO RECEIVERS)	20-60	INTERROG: 120 - 130 RESPOND: 150 - 160	INTERROG: 550 - 580 RESPOND: 150 - 160	351 - 389 SPOT FREQ. 370	351-389 SPOT FREQ. 370
RADIO CONTROL OF HS - 293 GLIDER BOMB (JET PROPELLED)	NAV. AID +BL. BOMB.	AIR TO GROUND NAV. AID.	IFF FOR EW RADARS	IFF FOR WURZBURGS	LOW RANGE ALTIMETER	ALTIMETER,
	250	250	150	40	10 - 150 METERS	10-750 METERS
1000 AND 1500 ALTERNATELY ABOUT 10 TIMES PER SEC. AND 8000 AND 12.000 ALTERNATELY.	AM - 2000 CPS	MASTER STATION 500 CPS. SLAVE STATION 250 CPS.	REC. PULSES OF 500 PRF AND 2 μS	REC. PULSES UP TO 5000 PRF AND 1 TO 2 μS; TR.- MCW- 1000 CPS	FMCW	FMCW
WATCH BOMB VISUALLY	STEADY TONE ON COURSE R/L METER	CRT DISPLAY INFO. TRANSFERRED TO CHART	TWO CRT'S		METER CALIBRATED IN METERS	METER CALIBRATED IN METERS
30-40(?)	GND. 800 WATTS	GND. 400 KW PEAK	300 TO 440 PEAK	APPROX. 0.2	3	3
(TYPE E-230)	1μVFOR 50 MW.		150 - 180	20 AT 30% MOD.		
IF-6DB, 50 KC. ACTUAL IF=2.94 MC.	226 KC 40 DB 75 KC	1 MC-6DB	500 KC - 6 DB			
REC. ON GLIDE BOMB, L-SHAPE, 82 INCHES TOTAL LENGTH. TR. ANT. ON DO-217E-TWO 11-FT. WIRES, TAIL TO FUSELAGE.	$\frac{h}{4}$ VERTICAL ROD EACH Rx		14" STUB - COMMON TR. AND REC.	"SPIKE" - 14" LONG FOR REC. AND TR. CAN D/F ON MINIMUM	2 HORIZONTAL DIPOLES 5'5" APART	2 HORIZONTAL DIPOLES 5'5" APART
	V	V	V	V	H	H
FOUND IN DO-217E. FW-200. HE-177	USED ON SOME HE 111	EXPERIMENTAL (?)	STANDARD	STANDARD FOR FIGHTERS	IN MOST PLANES UNTIL FUG 103 MORE AVAILABLE	INTRODUCED IN AUG. 1943
ETO AND MED. THEATRE	NEARLY OBSOLETE	ETO	WIDELY USED IN MED. AND EUROPEAN THEATRES	USED IN MED. AND EUROPEAN THEATRES	ETO MTO	
GLIDER - 10 FT WING SPAN 12FT. OVERALL LENGTH. RELEASED AT 3000-5000 FT. HEIGHT. CONTROL FOR AILERONS AND ELEVATORS.	X-CLOCK+FUG 200+FUG 103 RELIABLE FOR BLIND BOMBING	GERMANS NAVIGATE BY BRITISH SYSTEM TYPE 7000	NOW USED FOR BLIND BOMBING WITH 2 FREYAS	SIGNALS PICKED UP ON TWO VERTICAL DIPOLES ON TOP OF WURZBURG PARABOLA	ALSO USED IN BLIND BOMBING	IMPROVEMENTS OVER FUG 101 AND 101A

GERMAN AIRBORNE COMMUNICATION AND STANDARD D/F EQUIPMENT (PART I)

TYPE	PEILGERAT 6	PEILGERAT 7	PEILGERAT 5	PEILGERAT 4	FUG -3.3A AND 3 AU
FREQUENCY COVERAGE (MCS)	0.15-0.3 0.3-0.6 0.6-1.2	0.15-0.3 0.3 -0.6 0.6 -1.2	0.165-0.4 0.4 -1.0	0.25-0.4	0.3-0.6 3.0-6.0
FUNCTION	D/F FOR MULTI ENGINE PLANES	D/F FOR MULTI ENGINE PLANES	EARLY TYPE D/F FOR MULTI ENGINE PLANES	D/F FOR SINGLE SEAT FIGHTERS	EARLY COMM. SET OF BOMBERS
MODES REC. AND TRANSMIT.	REC.-CW, MCW & PHONE (TWO CRYSTALS)	REC.-CW, MCW & PHONE	REC.-CW, MCW & PHONE	REC.-CW, MCW & PHONE	TR.-CW, PHONE & IMPULSE REC.-CW, MCW & PHONE
RANGE (MILES)	DEPENDS ON TR. STRENGTH	DEPENDS ON TR. STRENGTH	DEPENDS ON TR. STRENGTH	DEPENDS ON TR. STRENGTH	
ANTENNA SYSTEM	HAND OR MOTOR DRIVEN DUST CORED OVAL LOOP -4"x3"x13"	PROBABLY SAME AS FOR PEILGERAT 6	HAND ROTATED DUST CORED OVAL LOOP- 4"x3"x13"	FIXED METAL CORED OVAL LOOP - 3½" DIA. x 13" LONG	FIXED 90-135 CM TRAILING 180-300 CM
TR. POWER OUTPUT (WATTS)					L.W. - 70 S.W. - 40
TRANSMITTER CIRCUIT					TRIODE OSCIL-LATOR AND TETRODE AMP-LIFIER
METHOD OF INDICATION	AURAL D/F .... ORDINARY RECEPTION .... USUAL D/F METER	AUTOMATIC DIAL INDICATION INSTEAD OF AURAL D/F	AURAL TO INTERCOMM. .... VISUAL TO ONE OR TWO COURSE METERS	AURAL TO INTERCOMM. .... VISUAL TO METER	
RECEIVER SENSITIVITY (µ VOLTS)			15 FOR 4 MILLIWATTS	1 FOR 5 MILLIWATTS (CW)	
RECEIVER SELECTIVITY			-26 DB - 9 KC -40 DB -22 KC	-20 DB - 2 KC -60 DB - 3.5 KC	
FREQUENCY SHIFTING CAPABILITY	MANUAL TUNING		MECHANICAL TUN-ING BY REMOTE CONTROL	TWO PRESET FREQ.-REMOTELY TUNED BY MOTOR. FINE TUNING - BY PILOT	FUG 3 - SAME TR. AND REC. FUG 3A & 3 AU HAVE SWITCHING OF ANTENNA
QUANTITY IN SERVICE	STANDARD D/F. EQUIPMENT IN HE 177. DO 217, ETC.	PROBABLY INCREASING FROM SMALL NUMBER	REPLACED AS STANDARD BY PEILGERAT 6	ORIGINALLY FOR LIGHT BOMBERS IN MIDDLE EAST	PROBABLY FEW
APPROX. AREAS OF OPERATION	EUROPEAN & MED. THEATRES	EUROPEAN THEATRE	OBSOCELESCENT IN MED. THEATRE	SINGLE SEATERS LIKE JU 87 - IN MED. THEATRE	
REMARKS	USED TO OBTAIN BEAR-INGS ON BROADCAST STATIONS AND HOMING BEACONS AND TO PRO-VIDE COMMUNICATION RECEPTION IN THE 0.3 TO 0.6 BAND (TO SUBSTITUTE FOR THE FUG 10 LONG WAVE RECEIVER)	IT CAN BE NOTED THAT PEILGERAT 6 HAS LATE-LY BEEN IMPROVED BY ADDING AN AUTOMATIC DIAL INDICATOR ATTACH-MENT FOR D/F. PEIL-GERAT 7 IS THE FINISH-ED MODEL CONTAINING THIS ADDITION PLUS OTHERS.	USED TO OBTAIN BEARINGS ON BROAD-CAST STATIONS AND HOMING BEACONS. NOTE: AN KEYING NOT USED IN THIS EQUIPMENT	10 YEAR OLD, USED TO OBTAIN BEARINGS ON MOBILE AERO-DROME BEACONS	FUG-3 RANGE LIMITED AND NO IMPULSE, FUG-3 AU IMPROVED MAINTENANCE FEATURES AND GENERATOR AND IMPULSE TR. FUG-3A- HAS AERIAL TUNING AND IMPULSE

GERMAN AIRBORNE COMMUNICATION AND STANDARD D/F EQUIPMENT (PART I)

FUG -5,5A	FUG-8	FUG-10 AND 10P	FUG-2	FUG -1	FUG-4
0.3-0.6 3.0-6.0	0.3-0.6 3.0-6.0	0.3-0.6 3.0-6.0	TR.-0.31-0.6 REC.-0.31-1.67	TR.-0.6-1.67 REC.-0.31-1.67	2.5-3.75
EARLY COMM. SET FOR BOMBERS AND SEAPLANES	EARLY COMM. SET FOR BOMBERS (LIMITED USE)	STANDARD COMM. SET FOR BOMBERS (FUG 10P ST'D)	EARLY COMM. SET FOR BOMBERS	EARLY COMM. SET FOR BOMBERS	COMMUNICATIONS RECEIVER ONLY
TR.-CW, PHONE & IMPULSE REC.-CW, MCW & PHONE	L.W. - CW S.W. - CW & PHONE REC.- CW, MCW & PHONE	L.W. - CW S.W. - MCW & PHONE REC.- CW, MCW & PHONE	TR.- CW REC. - CW, MCW & PHONE	TR.- CW REC.- CW, MCW & PHONE	CW, MCW & PHONE
		300-500			
FIXED 90-135 CM TRAILING 180-300 CM	FIXED 90-135 CM TRAILING 180-300 CM	FIXED AND TRAILING ANTENNAS, SIMILAR TO FUG 3, 5 AND 8	TRAILING AERIAL -240 CM	FIXED AERIAL -140 CM	FIXED AERIAL -140 CM
L.W. - 70 S.W. - 40	L.W. 40 S.W. 20	L.W. 65 S.W. 40	20 - 100	20-100	
	HARTLEY OSCILLATOR CLICK TUNING			TRIODE OSCILLATOR INTO TWO TRIODE AMPLIFIERS	
		1 FOR 2.4 MILLIWATTS			
		L.W.-6 DB - 2 KC S.W.-6 DB - 27 KC -30 DB - 240 KC			
	CAN OPERATE ON BOTH L.W. AND S.W. CHAN-NELS SIMULTANEOUSLY	4 CLICKSTOPS MANUAL TUNING	SINGLE FREQUENCY SET MANUAL TUNING	SINGLE FREQUENCY SET; MANUAL TUNING	PARTLY REMOTE CONTROLLED
MODERATE NUMBERS SHOULD BE AVAILABLE	LIMITED NUMBER IN SERVICE	FUG 10 P IN EXTEN-SIVE USE IN BOMBERS SUCH AS DO 217 M	VERY EARLY SETS-PROBABLY FEW	VERY EARLY SETS PROBABLY FEW	VERY EARLY SETS PROBABLY FEW
		MED. AND EUROPEAN THEATRES			
DIFFER FROM FUG 3 SERIES BY AD-DITION OF EMER-GENCY TRANSMIS-SION MEANS. FIT-TED AS ALTERNATE TO FUG 3.		FUG 10P HAS IM-PROVED D/F AND BLIND APPROACH AS PART OF THE SET. (PEILGERAT 6 AND FULANDE GERAT 2 H). FUG 10 HAS PEIL-GERAT 5 AND FULANDE GERAT 1 CARRIED ALONG LOOSE.	REPLACED BY FUG 3	REPLACED BY FUG 3	THIS IS RECEIVER USED IN FUG 6

GERMAN AIRBORNE COMMUNICATION AND STANDARD D/F EQUIPMENT (PART 2)

TYPE	FUG-6 AND 6A	FUG - 7 AND 7A	FUG 7C	FUG-11	FUG-10-K-2
FREQUENCY COVERAGE (MC)	2.5 - 3.75	2.5 - 3.75	3.0 - 5.0	3.0-6.0 6.0-12.0 12.0-24.0	6.0-12.0
FUNCTION	EARLY COMM. SET FOR SINGLE ENGINE PLANES	COMM. IN SINGLE SEAT FIGHTERS AND DIVE BOMBERS (SINCE 1935)	COMM. IN SINGLE SEAT FIGHTERS AND DIVE BOMBERS	COMM. SET FOR BOMBERS	COMM. SET FOR BOMBERS
MODES REC. AND TRANSMIT	TR. - CW, PHONE REC.. - FUG 4	TR.- CW, PHONE REC.- CW, MCW & PHONE (PHONE ONLY IN SINGLE SEAT FIGHTERS)	TR.- CW, PHONE REC.- CW, MCW & PHONE	TR.- CW & PHONE REC.- CW, MCW & PHONE	TR.-MCW & PHONE REC.- CW, MCW & PHONE
RANGE (MILES)		ABOUT 15. (MAY BE LESS DUE TO PRESET REC.)			
ANTENNA SYSTEM	FIXED AERIAL - 140 CM	FIXED ANTENNA IN FIGHTER AIRCRAFT (TAIL TO MAST). TRAILING ANTENNA IN DIVE BOMBERS (MANUALLY REELED)	FIXED AND TRAILING ANTENNAS SIMILAR TO FUG 7A	AERIAL TUNED AUTOMATICALLY WITH MAIN TUNING	
TR. POWER OUTPUT (WATTS)	20	20	20	70-80	
TRANSMITTER CIRCUIT	XTAL CONTROLLED OSCILLATOR			AM EVENTUALLY ALSO FM	
METHOD OF INDICATION					
RECEIVER SENSITIVITY (µ VOLTS)		50-95 FOR 1 MILLIWATT			
RECEIVER SELECTIVITY		-20 DB - 20 KC			
FREQUENCY SHIFTING CAPABILITY	MANUAL TUNING OF XTAL OSCILLATOR	SET ON ONE FREQUENCY ON THE GROUND FOR USE IN SINGLE SEAT FIGHTER WHEN USED IN DIVE BOMBERS SET IS ACCESSIBLE		SIX PRESET FREQ. POSSIBLE REMOTE CONTROL	
QUANTITY IN SERVICE	VERY EARLY SET PROBABLY FEW	SUBSTANTIAL NUMBERS SHOULD BE AVAILABLE ME109, JU87, HS129	PROBABLY VERY FEW JU87	REPLACES FUG-10	REPLACES FUG 10 IN HE 177 INSTALLATIONS
APPROX. AREAS OF OPERATION		EUROPEAN AND MED. THEATRES	MED. THEATRES	HAS NOT APPEARED YET	EUROPEAN THEATRES
REMARKS	FUG 6A HAS IMPROVED DYNAMOTOR PLUS CONTROLS OF RECEIVER AND POWER	FUG 7A IS THE SET ACTUALLY USED IN INSTALLATIONS AS FUG 7 HAS NEVER BEEN FOUND IN GERMAN PLANES ACCORDING TO AVAILABLE INFORMATION	FUG 7C IS OBVIOUSLY AN ATTEMPT TO INCREASE THE FREQ. COVERAGE OF SINGLE SEAT FIGHTER AND DIVE BOMBERS FOR AIR TO GROUND COOP AND AIR TO AIR (WITH FUG 10P IN BOMBERS)	IN PROTOTYPE STAGE END OF 1942. EVIDENCE BASED ON ITALIAN DATA	

GERMAN AIRBORNE COMMUNICATION AND STANDARD D/F EQUIPMENT (PART 2)

FUG-15	FUG-16	FUG-16Z	FUG-17	FUG-17Z	FUG-141
37.8-47.7	38.5-42.3	38.5-42.3	42.1-47.9	42.1-47.9	53.5-61.0
COMM. SET FOR BOMBERS	VHF-MULTI ENGINE STANDARD SINCE 1941	VHF SINGLE ENGINE STANDARD	ARMY COOP. AND TWIN SEATER CLOSE SUPPORT COMM. AND TO SUBSTITUTE ON LONG RANGE AIR TO GROUND WORK	CAN THIS BE A MOD. OF FUG 17 SIMILAR TO FUG 16 Z ?	D/F SET FOR SEARCHING AIRCRAFT LOOKING FOR LOST PLANES
MCW & PHONE	PHONE	MCW & PHONE .... ANY TYPE OF SIGNAL FOR D/F	PHONE & MCW	PHONE & MCW .... ANY TYPE OF SIGNAL FOR D/F	
	20-100 (AT APPROX. 10,000 FT)	20-100 (AT APPROX. 10,000 FT)	30-185 (AT 25,000 FT - 20 W GROUND STATION)	30-185 (AT 25,000 FT)	GREATER THAN 40
SEMI-FIXED AERIAL	SINGLE WIRE ANTENNA WITH A LENGTH OF 3.3 OR 6.7 FT VARYING WITH INSTALLATION	SINGLE WIRE 5' 11" LONG TO TAIL OR "T" TYPE AERIAL WITH 2'8" LEADER INTO CENTER OF 5' 11" HORIZONTAL WIRE	VERTICAL ROD ABOUT 39" LONG		
10	5-10	5-10	5-10		
FM	PENTODE MASTER OSCILLATOR AND FREQUENCY DOUBLE FEEDING PENTODE POWER AMPLIFIER	PENTODE MASTER OSCILLATOR AND FREQUENCY DOUBLER FEEDING PENTODE POWER AMPLIFIER	TUNED PLATE - TUNED GRID OSCILLATOR		
	VOICE	TONE FOR GROUND D/F .... VOICE .... D/F HOM. ON GROUND D/F	TONE FOR GROUND D/F .... VOICE		
	9-10 FOR 1 MILLIWATT	30 FOR 50 MILLIWATTS	30 FOR 50 MILLIWATT	30 FOR 50 MILLIWATT	
	-3 DB - 23 KC -40 DB - 73 KC	-6 DB - 23 KC -40 DB - 73 KC	-6 DB - 25 KC	-6DB-25KC	
100 FREQUENCY CHANNELS SINGLE CONTROL TUNING	FOUR CLICKSTOPS. TUNED TO ONE FREQ. ON GROUND	FOUR CLICKSTOPS. PRE-TUNED ON GROUND. PILOT CAN OPERATE REMOTE 2 OR 4 POSITION SELECTOR	FOUR CLICKSTOPS - MANUALLY TUNED	4 CLICKSTOPS	
TO REPLACE FUG-16 (?)	ON ALL FRONT LINE BOMBERS	ON ALL FRONT LINE FIGHTERS	STANDARD FOR LONG RANGE BOMBERS	FOUND IN HE 177 FW 200	
		IN MED. & EUROPEAN FW 190 AND ME 109G	IN MED. AND EUROPEAN THEATRES	IN MED. THEATRES	
IN PROTOTYPE STAGE END OF 1942. EVIDENCE BASED ON ITALIAN DATA		RECEIVER IF = 3.1 MCS. A 20 CM, SINGLE TURN LOOP IS USED FOR D/F PURPOSES. FUG 16ZE IS THOUGHT TO INCLUDE RETRANSMISSION FACILITY FOR "DUMMY PLANE" FIRE CONTROL.	FUG 17 OFTEN BENCH MOUNTED FOR GROUND LINK. IN GROUND LINK WITH ARMY COOP-C20W IS MOSTLY USED. THE C20W IS OBVIOUSLY A 20 WATT SET	DIFFERS FROM FUG 17 IN THAT AN EXTERNAL LOOP IS ADDED FOR HOMING (ON TARGET)	D/F ON GERMAN SEA RESCUE TRANSMITTER NS-4. NS-4 HAS 60 MILLIWATTS OUTPUT AND TRANSMITTER ON SINGLE FREQUENCY

GERMAN GROUND COMMUNICATION AND STANDARD D/F EQUIPMENT (PART I)

TYPE	D/F REC. 6/315	1.5 KW TR. a REC. LW.E. a	100 W.S. REC. TORN. E. b	30 W.S. REC. TORN. E. b	5 W.S/24 b REC. TORN E.b	1 KW TR. b REC. KW.E. a
FREQUENCY COVERAGE (MCS)	0.075-3.62	TR.-0.1-0.6 REC.-0.075-1.53	TR.-0.2-1.2 REC.-0.1-7.0	TR. - 0.95-1.67 REC. - 0.1-7.0	TR.-0.95-3.15 REC.-0.1-7.0	TR.-1.09-6.67 REC.-1.0-10.2
FUNCTION	PORTABLE D/F	ARMY TO CORPS SET	CORPS RADIO SET	ARMORED COMMAND SET	SIG. AND RCN SET	STAFF TO ARMY SET
MODES REC. AND TRANSMIT.	PHONE & CW	CW, MCW & PHONE	CW & PHONE	CW & PHONE	CW & PHONE	CW, MCW & PHONE
RANGE (MILES)	DEPENDS ON TR.	200-625	25-78	6-70	4-50	300-625
ANTENNA SYSTEM	GONIOMETER CROSS LOOPS	75 FT. WINCHMAST	24-30 FT. UMBRELLA		AERIAL WIRES 15 M. LONG AND COUNTERPOISE WIRES 25 M. LONG	TELESCOPING ANTENNA MAST
TR. POWER OUTPUT (WATTS)		1500	100	30	5	1000
TRANSMITTER CIRCUIT		MASTER OSCILLATOR			SELF EXCITED OSCILLATOR WITH INDUCTIVE REACTIVE COUPLING	
RECEIVER SENSITIVITY (μ VOLTS)			20-100	20-100	20-100	
FREQUENCY SHIFTING CAPABILITY		CHANGE POSSIBLE IN ABOUT 30 SEC.			MANUALLY ADJUSTABLE	
QUANTITY IN SERVICE		MODERATE	STANDARD	REPLACED BY 30 W.S.a.		STANDARD
APPROX. AREAS OF OPERATION		EUROPEAN AND MED. THEATRES	EUROPEAN AND MED. THEATRES	EUROPEAN AND MED. THEATRES	EUROPEAN AND MED. THEATRES	EUROPEAN THEATRES
REMARKS	IF = 0.056 MC.	ALSO HAS PROVISION FOR TELETYPE AND TELEPHOTO TRANSMISSION	POWER OUTPUT CAN BE REDUCED TO 10 WATTS IF DESIRED. RECEIVER IS PACK SET.			ALSO HAS PROVISION FOR TELETYPE AND TELEPHOTO TRANS.

GERMAN GROUND COMMUNICATION AND STANDARD D/F EQUIPMENT (PART I)

30 W.S. a REC. MW.E. c	80 W.S. a REC. MW.E. c	TORN FuC	TORN FuG	TORN FuBl	15 W S/R a	70 W.S.
TR-1.12 - 3.0 REC.-0.84-3.0	TR - 1.12-3.0 REC.-0.84-3.0	TR-1.5-2.3 REC.-1.45-2.6	2.5 - 3.5	TR - 3.0-6.0 REC.-3.0-6.7	3.0-7.5	3.0-16.7
ARMORED COMMAND SET	ARMORED COMMAND SET	ARTILLERY OBSERVATION SET	MAY REPLACE FuF FOR ARTILLERY	PACK SET FOR ALL BUT INFANTRY	ARTILLERY FIRE CONTROL COMM.	REPLACES 1 KW TR b AT TIMES
CW AND PHONE	CW AND PHONE	CW AND PHONE	CW AND PHONE	CW AND PHONE	CW AND PHONE	CW ONLY
10-150	25-45	6-15	7-18	7-18	20-60	LONG
24 FOOT WINCH MAST	24 FOOT STAR MAST	ROD AERIAL SINGLE WIRE	STATIONARY-SECTIONAL ROD; MARCH-WHIP	ROD AERIAL SINGLE WIRE	24 FOOT MAST	SINGLE WIRE 8-12 M. LONG
30	80	0.65		0.65	15	70
			MOPA (NO PRE-SET FREQ.)			
				100		
				TWO PRESET FREQ.		
REPLACED BY 80 W.S.					STANDARD	FEW
EUROPEAN AND MED. THEATRES	EUROPEAN AND MED. THEATRES	EUROPEAN THEATRES	MED. THEATRE	EUROPEAN AND MED. THEATRES	EUROPEAN AND MED. THEATRES	MED. THEATRE
			SIMILAR TO U.S. ARMY WALKIE TALKIE	IF = 1.0 MCS.	THIS IS LORENZ TRANSCEIVER	LORENZ TRANSMITTER

GERMAN GROUND COMMUNICATION AND STANDARD D/F EQUIPMENT (PART 2)

TYPE	SHORT WAVE D/F REC. C	TORN FuF	R/T SET F (FUSPRECH f)	R/T SET H (FUSPRECH h)	R/T SET A (FUSPRECH a)	20 W.S. b
FREQUENCY COVERAGE (MCS)	3.5-15.4	TR-4.5-6.7 REC.-3.0-6.7	20.0-21.5	23.0-24.95	24.0-25.0	25.0-27.2
FUNCTION	PORTABLE ADCOCK-D/F	ARTILLERY COMM. SET		COMM. BETWEEN INFANTRY AND MOBILE TROOPS	RECONNAISSANCE CAR INTER-COMM.	ARTILLERY SOUND RANGING SET
MODES REC. AND TRANSMIT.	CW AND PHONE	CW AND PHONE	PHONE	PHONE	PHONE	MCW
RANGE (MILES)	DEPENDS ON TR. STRENGTH	6-15		2-4	1-2	6-10
ANTENNA SYSTEM	ADCOCK ANTENNA	ROD AERIAL, SINGLE WIRE		6½ FT. ROD	ROD - 6½' AERIAL	ROD AERIAL 6½' HIGH
TR. POWER OUTPUT (WATTS)		0.65		10	8	20
TRANSMITTER CIRCUIT						
RECEIVER SENSITIVITY (μ VOLTS)		100				
FREQUENCY SHIFTING CAPABILITY						2 CLICKSTOPS
QUANTITY IN SERVICE						
APPROX. AREAS OF OPERATION	MED. THEATRE	MED. THEATRE	MED. THEATRE	MED. THEATRE	MED. THEATRE	MED. & EUROPEAN THEATRES
REMARKS	THIS D/F SET PLUS THE D/F REC. 6/ 315 PROVIDES FOR D/F COVERAGE FROM 75 KC TO 15.4 MC.	IF = 1.0 MC				

GERMAN GROUND COMMUNICATION AND STANDARD D/F EQUIPMENT (PART 2)

10 W.S. c	20 W.S. c REC.- UKw. Ee	FUSPRECH "a"	TORN FuD 2	20 W.S. d REC. UKw. E.f1	120 W.S.	FIELD R/T SET B
27.2-33.3	27.2-33.3	27.5-29.8	33.8-38.0	42.1-47.9	42.1-54.0	90 - 110
TANK SET	TANK SET	TANK TO TANK	PARATROOPER COMM.	AIR TO GROUND COOP TANK SET	ARTILLERY SET	INFANTRY PACK SET
CW, PHONE	CW, PHONE	PHONE	CW, MCW & PHONE	CW & PHONE	PHONE	PHONE
5-10	6-14	2-8	2-10	30		0.8
ROD	ROD		VERTICAL 6'	6' ROD AERIAL	SMALL ROD ON 60' MAST	ROD AERIAL
10	20	6	1	20	120	0.15
			MASTER OSCILLATOR POWER AMPLIFIER			
		38				
REPLACED BY 20 W.S. c.	QUANTITY	FEW	QUANTITY			FEW
MED. THEATRE	MED. THEATRE	MED. THEATRE	MED. THEATRE	MED. THEATRE	MED. THEATRE	MED. THEATRE
		IF=3.1 MC.	IF=2.1 MC.		TELEFUNKEN DEVELOPMENT	PROVISIONAL MODEL

GERMAN GROUND COMMUNICATION AND STANDARD D/F EQUIPMENT (PART 3)

TYPE	FIELD R/T SET A-1	FIELD R/T SET C	DMG 4K	SEG 2T	DMG 5K
FREQUENCY COVERAGE (MCS)	120-156	130-158	500-560	500-600	502-554.2
FUNCTION	INFANTRY PACK SET	INFANTRY PACK SET	SPECIAL PURPOSE	SPECIAL PURPOSE	SPECIAL PURPOSE
MODES REC. AND TRANSMIT.	PHONE	PHONE	PHONE AND TELEPHOTO	MCW AND PHONE	PHONE AND TELEPHOTO
RANGE (MILES)	0.8	0.3	30-60 (LONGER BY RELAYS)	OPTICAL RANGE ONLY	30-60 (LONGER BY RELAYS)
ANTENNA SYSTEM	ROD AERIAL	ROD AERIAL	SPECIAL DIPOLE ARRAY BEAMED	DOUBLE DIAMOND ARRAY WITH REFLECTOR	SPECIAL DIPOLE ARRAY BEAMED
TR. POWER OUTPUT (WATTS)	0.15	0.15			
TRANSMITTER CIRCUIT					
RECEIVER SENSITIVITY (μ VOLTS)					
FREQUENCY SHIFTING CAPABILITY					
QUANTITY IN SERVICE	FEW	REPLACES TORN FuD2	FEW	SEVERAL ALREADY FOUND	
APPROX. AREAS OF OPERATION	MED. AND EUROPEAN THEATRES	MED. THEATRE	MED. THEATRE	MED. THEATRE	MED. THEATRE
REMARKS			AUTOMATIC TUNING ± 5 KC. USES HEADSET CRT (?)		USES HEADSET CRT (?)

JAPANESE EQUIPMENT

CBI	China, Burma, India	OSC	oscillator
COMM	Communications	REC	receiving
H	horizontal	ST'D	standard
μs	microseconds	SWPA	Southwest Pacific
μv	microvolts	TR	transmitting
MCW	modulated CW	V	vertical
MOPA	master oscillator power amplifier	XTAL	crystal

ABBREVIATIONS

(OTHER THAN THOSE GIVEN IN GLOSSARY)

JAPANESE GROUND, NAVAL AND AIRBORNE RADAR

NAME	MARK VI MODEL I (?)	MARK I MODEL 3 (?)	MARK I MODEL I	MARK I MODEL I MODIFICATION I	AIR MK VI MODEL 2	AIR MK VI MODEL 4	
FREQUENCY COVERAGE (MCS)	42.9-60	67-82	TR. 97-103 REC.-89-115	TR. 93-109 REC.-90-110	110-118	141-163	
FUNCTION	ARMY TARGET DESIGNATOR	LAND-BASED E.W.	E.W.	E.W.	ASV	ASV & GROUND EW	
RANGE (MILES)			55	93	22-31	25-50 ON GROUND	
PRF (CPS)	150 to 210	400 to 525	600 TO 1080	600 TO 1200	750 TO 1000	1000 to 1200	
PULSE WIDTH (US)		25 to 35	15 TO 18	15 TO 20		5 to 10	
PEAK POWER (KW)			3	5.0	4 TO 5	3 TO 6	
ANTENNA STRUCTURE			SAME AS MARK I MOD I TWO STER-BAS ONE ABOVE OTHER 8λ/2 RODS 16λ/2 RODS FOR EACH	TR ANTENNA MOUNTED ABOVE REC. ANT. ON SAME FRAMEWORK AND ROTATED TOGETHER. EACH IS CENTER FED STERBA ARRAY. 5λ/2 WIDE X 2 ROWS HIGH (λ/2 59")			
POLARIZATION		H	H	H		H	
LOBE SWITCHING OR SPLIT			NONE	NONE 5° BEARING ACCURACY		NONE 10° BEARING ACCURACY	
METHOD OF SCANNING			MANUAL. ROTATES ON STEEL TURNTABLE FULL 360°	MANUAL. ROTATES ON STEEL TURNTABLE FULL 360°			
METHOD OF PRESENTATION			5 "TYPE A" WIDE LINE SWEEP SCOPES (BLANK SPACES)	5 "TYPE A" WITH 5 RANGE MARKERS BELOW BASE LINE. ECHO ABOVE BASE LINE		TYPE "A" SCOPES	
TYPE OF INSTALLATION			ON FIXED HUT ON GROUND	DEPENDS ON SITE. USUALLY ON WOODEN SHACK MOUNTED ON STONE PIER	AIRBORNE		
ESTIMATED QUANTITY IN SERVICE	APPEARS TO BE INCREASING	INCREASING IN NUMBER	EARLY VERSION OF MK I, REV. I. SAY 50	PRODUCTION INITIATED IN LATE 1942. SAY 350 NOW ON HAND		PROBABLY FEW	
APPROXIMATE LOCATION	SEVERAL IN CBI AREA	SWPA, CBI & NORTH PACIFIC AREAS	SOME IN SWPA. THIS SET CAPTURED ON GUADALCANAL	THROUGHOUT SWPA AND CBI SET CAPTURED ON ATTU AND MAKIN ISLANDS	BEING USED ON "BETTY", "EMILY" AND "MAVIS" BOMBERS *	SWPA & NORTH PACIFIC	
REMARKS	MAY BE COPY OF BRITISH GL OR MRU	APPEARS DEFINITE	MK I REVISION I HAS BETTER PERFORMANCE AND MAINTENANCE FEATURES. ANT. BEAM WIDTH ABOUT 18°	MAYBE MODIFIED TO VERT. POL. RECEIVER SENSITIVITY, 7μv. ANT. BEAM WIDTH ABOUT 20°-25°.		CAPTURED DOCUMENT, REC. & IND.	

* "EMILY" IS A PATROL BOMBER) 4-ENGINE
"MAVIS" IS A PATROL BOMBER)

JAPANESE GROUND, NAVAL AND AIRBORNE RADAR

MARK III	MARK I MODEL 2	MARK II MODEL I	MARK II MODEL I MODEL 3	MARK V (?)	MARK IV MODEL SI (?)	MARK II MODEL 2	MARK II MODEL 2 MODIF 2
165-180	187-214	190-210	225-270	342- 350	740-760	APPROXIMATELY 3000	3000
ALARM SYSTEM	LAND-BASED E.W. (PORTABLE)	SHIP E.W.	NAVAL E.W.	SUB RADAR SEARCH	NAVY FIRE CONTROL ON GROUND & SHIP	SHIPBORNE SURFACE SEARCH	SHIPBORNE G.L. (?) & SEARCH
100	60	60			31		11-22
CW (?)	1000-1200	APPROXIMATELY 1000	330-575	30-50	350 TO 500		APPROXIMATELY 2500
	25	5	2-8				APPROXIMATELY 6
0.5	5 (EST.)		5		30	2	2
	FRAME ANTENNA 14" x 8' ON METAL CAB; BOTH ROTATE 360° B.W. 25°	8' X 10' BEDSPRING TYPE ROTATES				USES E-M HORN TYPE RADIATOR OR DIPOLE WITH PARABOLIC REFLECTOR	2 OR MORE HORNS 3° TO 4°
	H	H					DEP. OR REL. POSITION
	NONE	46/SEC (?)	NOT CERTAIN		1° BEARING ACCURACY		SPIT & NULL FOR FIRE CONTROL 2.4° ACCURACY
	360° AT. 1/3 OR 1 RPM.		SWEEPING SEARCH	ABOUT 8° EITHER SIDE OF HEAD OF SUB			HORNS ROTATE
	TYPE "A" SCOPE	TYPE "A" SCOPE			TYPE "A" SCOPE		TYPE "A" SCOPE WITH EXPANDED SCALE
	TRAILER 3 TON					SUBS, DESTROYERS, COAST DEFENSE (?)	
	INCREASING, SAY 50		MAY BE SEVERAL SETS	SEVERAL SETS INSTALLED SUPERSEDED BY 10 CM SET	NO DEFINITE EVIDENCE	ORIGINATED IN LATE 1942	
SWPA INTERCEPTS	CBI SWPA AND FORMOSA	SWPA	SWPA & CBI		SWPA (CAPT. DOC.)	SWPA	
PROBABLY "HITCH-HIKER" SYSTEM TR. & REC. SEPARATE	CONFIRMED. IT MAY BE OF INTEREST TO GUESS THAT THIS SET MAY BE DEFENDING JAPAN. SL CONTROL	ADAPTATION OF MARK I FOR MODEL 2 SHIPBOARD	PROBABLY BEING REPLACED BY 10 CM SETS	CONTROL OF TORPEDOES PROBABLE. SWPA APPEARS DEFINITE	ALSO ARE S_2 AND S_3 MODELS OF THIS SET	CAPTURED DOCUMENTS	CAP. DOC.

JAPANESE GROUND COMMUNICATION AND STANDARD D/F EQUIPMENT (PART I)

TYPE	SERIES - 92 TYPE-3	SERIES - 87 TYPE-1	SERIES -94 TYPE-2B	SERIES - 94 TYPE-1
FREQUENCY COVERAGE (MC.)	0.05-0.6	0.1-1.0	0.14-1.5 0.95-1.75 1.75-3.2 3.2- 6.67	0.2-0.5
FUNCTION	COMM. FOR DIV. & ARMIES	COMM. FOR GHQ, ARMY CORPS & DIV.	PORTABLE SET FOR CORPS & DIV.	COMM. FOR DIV. & ARMIES
MODES REC. AND TRANS.	CW, PHONE	CW, PHONE	CW	CW, PHONE
RANGE (MILES)	150-300	150-300		
TR. POWER OUTPUT (WATTS)	1000	2000	80-200	1000
TRANSMITTER CIRCUIT	SELF EXCITED OR XTAL OSC.	SELF EXCITED OSC.	XTAL CONTROL OR MOPA	
ANTENNA SYSTEM	UMBRELLA & COUNTERPOISE	UMBRELLA & COUNTERPOISE	6' ROD	UMBRELLA & COUNTERPOISE
REMARKS	SEVERAL CAPTURED ON MAKIN ISLAND SERIAL #92 FOUND	SEVERAL CAPTURED ON TARAWA	FOR .14-1.5 MCS. THE REC. IF = 100 KC. FOR 1.05-15 MCS. THE REC. IF = 400 KC.	LATER VERSION OF SERIES 92-TYPE 3 (?)

SERIES - 15 TYPE-2,3	SERIES - 94 TYPES-3A,B & C	SERIES - 92 TYPE-5		SERIES - 15 TYPE-4
0.33-0.6	0.4-5.7 REC.-0.3-6.0	0.4-5.7 REC.-0.4-7.0	0.5-3.0 1.5-10.0	0.53-1.0
COMM. FOR CORPS, DIV., REG'T AND GROUND TO AIR	DIV., CAVALRY, REG'T. PACK SET	INFANTRY HQ. PACK SET	D/F	CAVALRY SET
CW, PHONE	CW	CW	CW, MCW, PHONE	
GROUND TO GROUND 25 GROUND TO AIR 190	30	5-6	DEPENDS ON TRANS. STRENGTH	5
20 (?)	10 (?)			
	XTAL CONTROL OR MOPA			
	OPEN WIRE AND COUNTERPOISE			

JAPANESE GROUND COMMUNICATION AND STANDARD D/F EQUIPMENT (PART 2)

TYPE	SERIES-94 TYPES-4A,B,C,D	SERIES-15 TYPE-5	SERIES-95 TYPE-4	SERIES-(?) TYPE-2
FREQUENCY COVERAGE (MC.)	0.9-5.3	2.5-4.5	3.3-8.0	3.38-14.0 (GAP-10.4-12.2)
FUNCTION	ARTILLERY ARMORED CORPS AND REG'T. SETS	INFANTRY & ARTILLERY PACK SET		VEHICULAR SET
MODES REC. AND TRANS.	CW, PHONE	CW, PHONE	CW, PHONE	CW
RANGE (MILES)				
TR. POWER OUTPUT (WATTS)	3-5		100	240
TRANSMITTER CIRCUIT				
ANTENNA SYSTEM				OPEN WIRE AND COUNTER-POISE
REMARKS			SEVERAL CAPTURED ON MAKIN ISLAND SERIAL #70 FOUND	

JAPANESE GROUND COMMUNICATION AND STANDARD D/F EQUIPMENT (PART 2)

TAMU SET NO.3	TYPE TM "A" (PORTABLE)	YT-189 (398)	SERIES-94 TYPE-6		
3.5-17.0	4.3-11.3	23-31	24.2-49.3	70-75	185-191
PORTABLE MARINE SET	PORTABLE TRANSCEIVER	WALKIE TALKIE	INFANTRY WALKIE TALKIE	VHF BEACON (?)	UHF BEACON
CW	CW ONLY	CW, MCW & PHONE	MCW & PHONE	CW	CW
	5		1-2		
400	12 TO 75 MILLIWATT	26	0.25-0.5		
XTAL CON-TROL OR MOPA	HARTLEY OSCILLATOR		ULTRA AUDION (TWIN TRIODE)		
	BUILT IN REEL WIRE		5' ROD		
RECEIVER-4 TUBE, ONE STAGE RF AND REGENERATIVE DETECTOR	RECEIVER SENSITIVITY 1100 TO 2000 MICROVOLTS OBSOLETE DESIGN.	AM, ONE TUBE (TWIN-TRIODE), NO CRYSTAL CONTROL.	RECEIVER SENSITIVITY 200 TO 900 μVOLTS. RECEIVER SELECTIVITY: 6 DB FOR 1.47 MCS., 20 DB FOR 0.85 MCS., 60 DB FOR 2.05 MCS.	SIGNALS HEARD IN WEWAK AREA -1000 CPS MODULATION AIR NAVIGATION (?)	INTER ISLAND BEACON FOR SHIPS (?) RADIO FENCE (?)

JAPANESE AIRBORNE COMMUNICATION AND STANDARD D/F EQUIPMENT (PART I)

TYPE	TYPE 0 KU. 4	TYPE I KU-3	TYPE 94 HI-1	TYPE 94 HI-2	TYPE 96 KU-3
FREQUENCY COVERAGE (MCS)	0.15-0.3 0.3 -0.5 0.45-1.2	0.165-0.4 0.4 -1.0	0.3-0.5 5.0-10.0	0.3-0.5 5.0-10.0	0.2-0.5 4.8-10.0
FUNCTION	TO OBTAIN BEARINGS ON BROADCAST STATIONS AND HOMING BEACONS	TO OBTAIN BEARINGS ON BROADCAST STATIONS AND HOMING BEACONS	EARLY BOMBER COMM.	COMM. FOR SOME ARMY MEDIUM BOMBERS	COMM. STANDARD FOR "BETTY" MEDIUM BOMBER STANDARD
MODES REC. AND TRANSMIT.	CW, MCW & PHONE	CW, MCW & PHONE	CW, PHONE	CW, PHONE	CW, PHONE
RANGE (MILES)	DEPENDS ON TRANSMITTER STRENGTH	DEPENDS ON TRANSMITTER STRENGTH			
ANTENNA SYSTEM	LOOP	LOOP	FIXED AND TRAILING WIRE		
TR. POWER OUTPUT (WATTS)			50-100	50-100	20-40
TRANSMITTER CIRCUIT			XTAL CONTROLLED OSCILLATOR	XTAL CONTROLLED OSCILLATOR	XTAL CONTROLLED OSCILLATOR
METHOD OF OF INDICATION	AURAL - HEADSET .... VISUAL - INTO COURSE METER	AURAL TO INTER-COMM. .... VISUAL TO ONE OR TWO METERS	HEADSET		
RECEIVER SENSITIVITY (μVOLTS)		15 FOR 4 MILLIWATTS			
RECEIVER SELECTIVITY		-26 DB - 9 KC -40 DB - 22 KC			
FREQUENCY SHIFTING CAPABILITY	MANUAL TUNING	MECHANICAL TUNING BY REMOTE CONTROL			
QUANTITY IN SERVICE	PROBABLY IS NOT STANDARD YET - BUT MAY BE SOON IN "BETTY" BOMBERS	IN FIGHTERS AND LARGE BOMBERS (NOT MANY) IN "JUDY"	IN EARLY "SALLY" BOMBERS	IN "SALLY" BOMBERS	IN "BETTY" BOMBERS AND "KATE" TORPEDO BOMBERS
APPROX. AREAS OF OPERATION	CBI AND SWPA AREAS	CBI AND CENTRAL PAC. AREAS	CBI	CBI	CBI AND SWPA
REMARKS	LISTED AS ONE SET ALTHOUGH IT PROBABLY EXISTS IN SEVERAL MODELS (COMMERCIAL FAIRCHILD AND LEARADIO MODELS). HOWEVER, SINCE STANDARDIZATION IS BEING EFFECTED BY JAPS, THESE MAY BE IT.	THIS IS A COPY OF THE GERMAN PEGE 5. CAN BE USED FOR BLIND APPROACH. JAPANESE HAVE NOT EMPLOYED D/F EQUIPMENT TOO EXTENSIVELY YET.	PROBABLY HAS BEEN REPLACED BY 94 HI-2 *	*	*

* "SALLY" - is twin engine low mid-wing monoplane - medium bomber with range of about 670 miles (loaded). Also called Mitsubishi Type 97MB.

* "BETTY" - is one of the latest of Japan's bombers. Same type as Sally, except for better range, maneuverability, etc.

* "JUDY" - Navy carrier borne reconnaissance plane (2 place).

JAPANESE AIRBORNE COMMUNICATION AND STANDARD D/F EQUIPMENT (PART I)

TYPE 96 KU-4	TYPE 96 KU-2	TYPE 99 HI-3	TYPE 99 HI-4	TYPE 96 KU-1	TYPE 96 HI-3 NO. 2
0.3-0.5 5.0-10.0	1.5-7.5	TR. 2.4-6.0 REC. 1.5-6.7	TR. 2.5-15.0 REC. 2.5-18.0	3.8-5.8	4.2-5.0
COMM. FOR "BETTY" BOMBERS	STANDARD COMM. FOR LIGHT AND DIVE BOMBERS (ARMY AND NAVY)	STANDARD FOR ARMY FIGHTERS AND RECONNAISSANCE BOMBERS	EXPERIMENTAL INCREASE OF FREQ. RANGE OF TYPE 99 HI-3 (?)	EARLY COMM. STANDARD FOR SINGLE SEATED FIGHTERS LIKE ZEROS AND OSCARS	EXPERIMENTAL VERSION OF TYPE 96HI-3 TO EXTEND FREQ.
CW, PHONE	CW, MCW, PHONE	CW, MCW, PHONE		CW, PHONE	CW, PHONE
		100 - 200			
	TRAILING OR FIXED ANTENNA OF T OR INVERTED L TYPE				
20-40		5-10	20	8-10	
	XTAL CONTROLLED OSCILLATOR	ANODE MODULATED XTAL POWER OSCILLATOR .... FIXED COILS IN TRANSMITTERS	XTAL CONTROLLED OSCILLATOR	XTAL CONTROLLED OSCILLATOR	
		HEADSET			
		5-17 FOR 20 MILLIWATTS			
		-6 DB - 7 KC -20 DB -13 KC -40 DB -17 KC			
	ALL TR. AND REC. ADJUSTMENTS MADE ON THE GROUND PRIOR TO TAKE OFF. NO REMOTE CONTROL PROVIDED	PRESET ON GROUND- BUT CAN BE REMOTELY TUNED IN PLANE	PRESET ON GROUND NOT CHANGEABLE IN FLIGHT		
REPLACES 96 HI-3 WHERE AVAILABLE	FOUND IN "DINAH" "VAL" AND "LILY" LIGHT AND DIVE BOMBERS	FOUND IN "OSCAR", "SONIA" AND "TONY" .... SUPERSEDES 96HI-1 AND HI-1		FOUND IN "ZEKE" "HAP", "OSCAR"	NEGLIGIBLE AMOUNT
CBI	CBI SWPA	CBI SWPA		CBI SWPA CENTRAL PACIFIC	
AN IMPROVED VERSION OF TYPE 96HI-3	IF - 400 KCS. *	*		* IF - 500 KCS	THIS SET PROBABLY SHOULD NOT BE LISTED, EXCEPT FOR HISTORICAL REASONS

* "OSCAR" - Army single seated fighter MKI (version of Zero).
* "SONIA" - Army light reconnaissance bomber - also coop plane.
* "ZEKE" - this is the famous Zero - Mitsubishi - Type 0 MKI single seated fighter.
* 'HAP" - this is Mitsubishi type 0 MK2 single seated fighter (2nd version of Zero).
* "KATE" - Navy monoplane bomber. Low wing radial engine.

* "DINAH" - new Army reconnaissance bomber.
* "VAL" - Standard Navy dive bombers.
* "LILY" - Army two engine light bomber.
* "TONY" - Single engine fighter.

JAPANESE AIRBORNE COMMUNICATION AND STANDARD D/F EQUIPMENT (PART 2)

TYPE	HI-1	HI-2	TYPE 98 KU-4	HI-3	HI-4 (FLYING MK.4)
FREQUENCY COVERAGE (MCS)	5.0-7.5	7.5-10.8	29.5-52.5	38.5-42.3 (?)	44-50
FUNCTION	EARLY COMM. SET FOR RECONNAISANCE PLANES	LATE MODEL FOR BOMBER COOP COMM.	MEDIUM BOMBER COOP SET AIR TO GROUND AIR TO AIR	JAP VERSION OF GERMAN FUG 16 (?)	LIGHT AND MED. BOMBER VHF SET
MODES REC. AND TRANSMIT	CW, PHONE	CW, PHONE	CW, MCW & PHONE		PHONE
RANGE (MILES)		300	25-60		
ANTENNA SYSTEM		TRAILING OR DOUBLE WIRE			VERTICAL OR HORIZONTAL DEPENDING ON INSTALLATION
TR. POWER OUTPUT (WATTS)	10-20	9-26	20-25		10
TRANSMITTER CIRCUIT	XTAL CONTROLLED OSCILLATOR	XTAL CONTROLLED OSCILLATOR	XTAL CONTROLLED OSCILLATOR		XTAL CONTROLLED CIRCUIT
METHOD OF INDICATION					
RECEIVER SENSITIVITY (μ VOLTS)		13			
RECEIVER SELECTIVITY					
FREQUENCY SHIFTING CAPABILITY		TWO PRESET FREQUENCIES	PRESET - NOT CHANGE-ABLE IN FLIGHT		
QUANTITY IN SERVICE	FOUND IN "DINAH"		FOUND IN "BETTY" AND "NELL"	ADAPTED FOR "OSCAR" ?	FOUND IN "LILY" AND "BETTY"
APPROX. AREAS OF OPERATION	CBI	CBI	CBI SWPA CENTRAL PACIFIC	CBI	SWPA CBI
REMARKS	REPORT THAT SPEECH CAN BE SCRAMBLED IN THIS SET	IF 628 KCS	IF 2.4 MCS	GERMAN FUG 16 REPORTED TO HAVE BEEN SOLD TO JAPANESE. THE HI-3 IS PROBABLY THIS SET	OF SAME GENERAL USE AS GERMAN FUG 17. IF TUNABLE .75 TO 2.5 MCS.

*"NELL" - two engine mid-wing monoplane used for high level bombing and torpedo attacks.

INTRODUCTION

TO

RCM

INTRODUCTION TO RADIO COUNTERMEASURES (RCM)

The neutralization of the effectiveness of enemy radio communication and radar systems by electronic or other means is known as Radio Countermeasures (abbreviated RCM). Radio Countermeasures also includes the problem of Radio Intercept but, since this is predominantly a tactical problem, it is not treated in this book, which is concerned mainly with technical matters.

Application of radio countermeasures requires careful preparation. The degree of success will usually depend upon the craftiness of those planning the operation, the speed of its application and the skill of its execution. The importance of planning, speed, and execution becomes obvious when one recalls that the enemy is "calling the tune". Whether communications, radar or radio-controlled devices are used, the enemy selects the frequencies, the output power, the location and amount of the equipment, and the operating procedures. The effectiveness of the enemy's activities will therefore depend upon our nimbleness in making use of available means to nullify these activities. By the same token, the enemy's continued success depends upon the speed with which he can shift frequencies, locations, etc., and start the cycle over again. The application of radio countermeasures thus can be described as a continual scramble or series of "emergencies".

To be sure, all activities of the Armed Services in the field may be thought of as involving the meeting of new and constantly changing conditions. In most instances, however, the enemy makes use of existing and known factors (men, guns, aircraft, tanks, etc.); only the numbers and the deployment in each situation are likely to be unique. In any event, the operational "countermeasure" likewise makes use of available men, guns, aircraft, etc.

In radio countermeasures, on the other hand, it may not be possible to cope with the situation by the use of existing equipment. It is often necessary to develop RCM equipment specifically for use against a particular radio device. Furthermore, until the characteristics of the enemy equipment are known, it may not be possible to develop the most efficient countermeasures devices for a given situation.

Since it is not feasible to equip every theater with jamming transmitters and other countermeasures devices for use against every possible type of radio equipment, those on-the-spot will have to make effective use of equipment on hand whenever the enemy turns up in unexpected places. As this point cannot be overemphasized, an attempt has been made here to include, not only a description of the actual equipments being developed for RCM purposes, but also to set forth some of the fundamental philosophy that is essential to the successful use of these devices.

Basically, the methods employed for communications, radar, and controlled-devices countermeasures are:

(1) straight-forward jamming
(2) use of deception devices
(3) methods that create confusion

Jamming may be considered a "brute-force" method of accomplishing the desired result while confusion and deception devices may be thought of as a more subtle method of attack.

Closely allied to these direct RCM methods are the use of homing and direction-finding receivers and, in the case of radar, of warning devices to advise when one is being scrutinized by enemy radar systems. Furthermore, in both communications and radar, various anti-jamming techniques may be applied. Finally, since the successful application of RCM implies an accurate knowledge of the disposition, operating characteristics, and habits of the enemy systems, it is essential that adequate search equipment also be available as a part of the complete RCM program. Thus, RCM facilities include:

(1) Search Receivers
(2) Direction-Finding Receivers
(3) Warning Receivers
(4) Jamming Transmitters
(5) Confusion and Deception Devices
(6) Anti-Jamming Techniques

Since the method of practicing RCM in the communications field is often different from that which is appropriate in the radar field (or allied applications such as radio-controlled devices) it is important to differentiate between the two fields. This is done in the following discussion and it is essential that this definite distinction always be kept in mind.

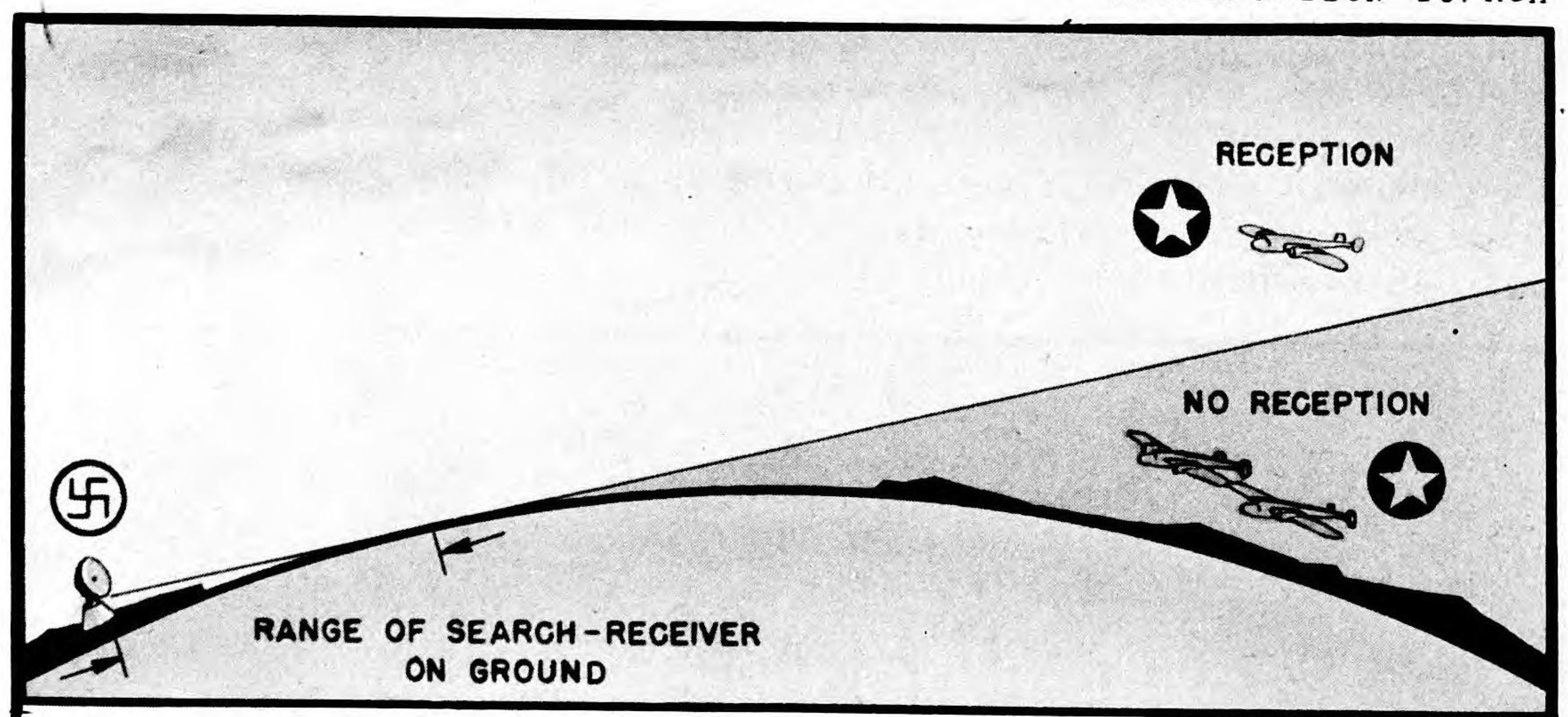
SEARCH RECEIVERS

Before the use of jamming transmitters or confusion and deception devices can be planned in detail, accurate information must be available concerning enemy communications and radar equipment and radio-control systems. In the preliminary stages of the planning it may be sufficient to make use of such generalized information as may be available concerning the probable numbers of enemy equipments, their disposition and the frequency band in which they operate. For a specific application, however, it is essential to know the exact frequencies employed by the systems to be neutralized, their methods of operation, what reserve facilities are available to the enemy, and the geographical locations of the systems involved. Such details are required because, in general, the jamming or deceptive means to be used must be accurately adjusted for the frequencies involved, and operated only when they are likely to be effective and in such a manner as to neutralize all enemy facilities (or at least as many as possible) whether they are regular or emergency systems.

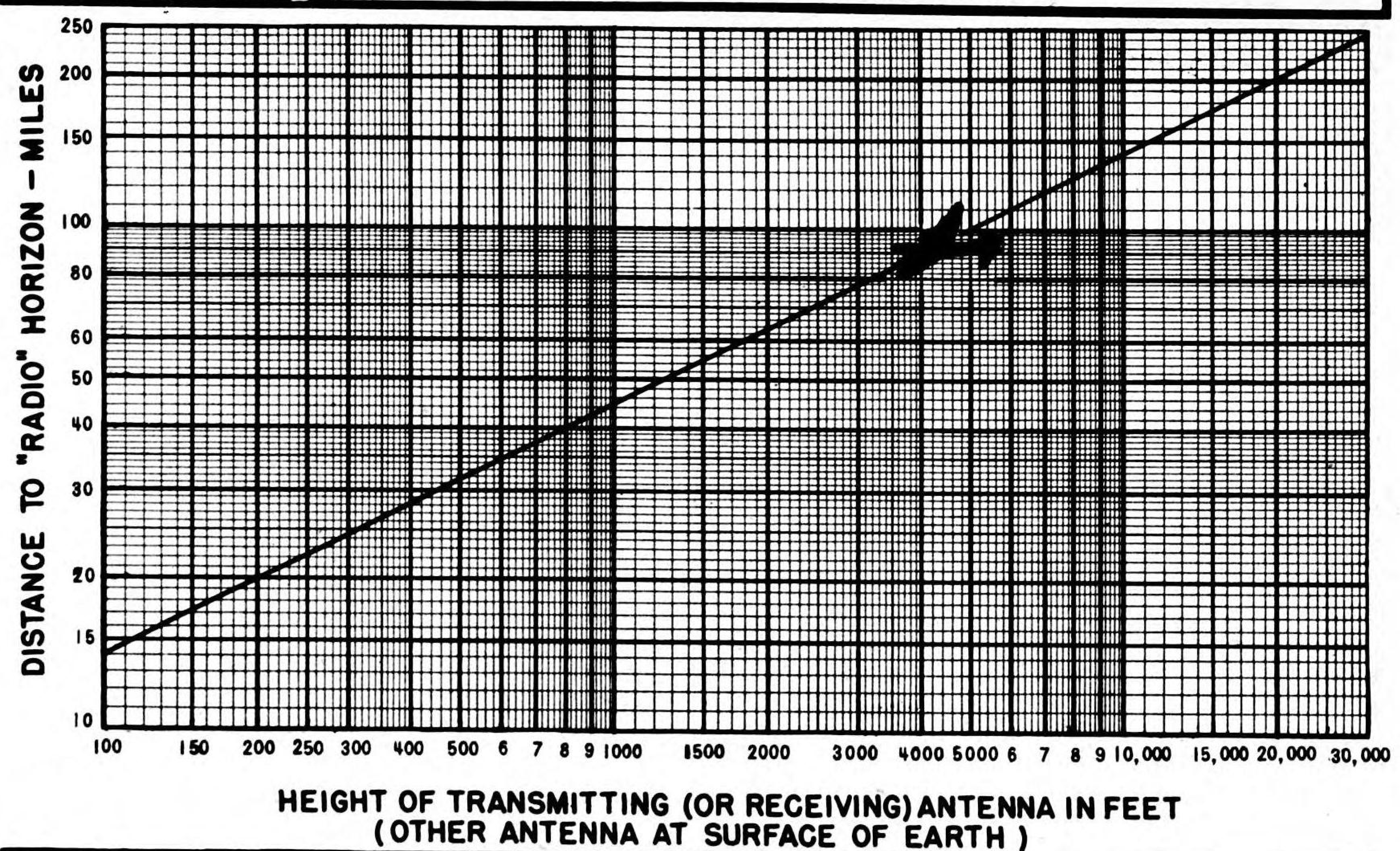
The equipment used for searching, analyzing, and direction finding on enemy communications channels is, for the most part, conventional in design and has been catalogued elsewhere (e.g. Signal Communication Equipment Directory prepared by Military Intelligence Branch, OCSigO). For this reason it is not covered in this book. Equipment operating at radar frequencies, however, is relatively new and is therefore covered in detail.

A properly equipped searching expedition, in addition to being used to determine the radio frequencies employed, can ascertain many other operating characteristics of the enemy radar set. A knowledge of these characteristics will not only considerably facilitate neutralization of the radar, but will also provide information that may be valuable from an intelligence standpoint. In lieu of the actual capture of an enemy system, such data permit an informed estimate to be made of the capabilities of the equipment.

Radar searching can generally be most readily accomplished by observations made from aircraft, since the emissions from such systems seldom extend appreciably beyond the "radio line-of-sight". Thus, unless the terrain is particularly favorable, only those radar equipments which are immediately adjacent to the fighting front will be observable by ground-based radar search receivers. This has been true in the European Theater of Operations between the British Isles and the Continent. In the Alaskan Theater the terrain was such that observations of the enemy radar

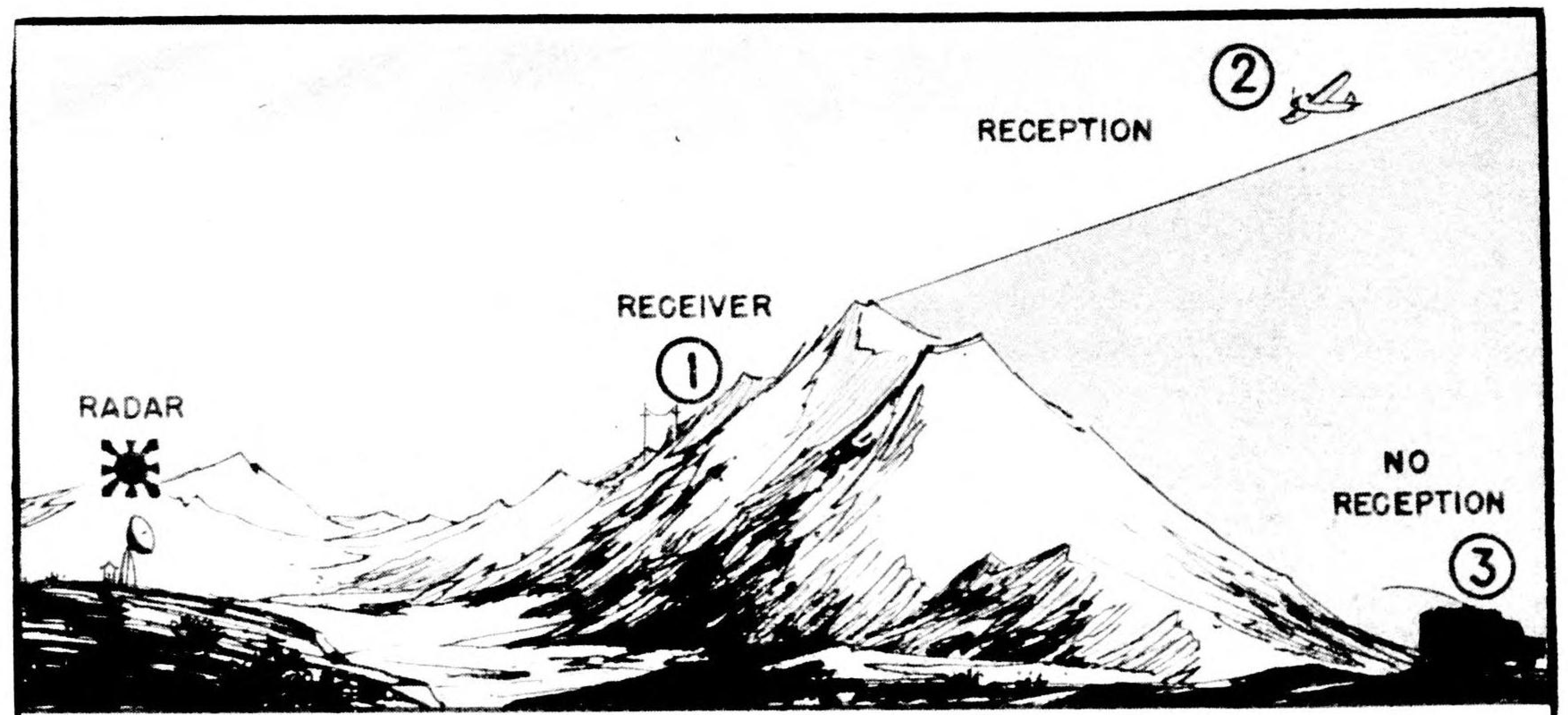


When searching for radar or v-h-f (very-high-frequency) communication transmissions, the reconnaissance plane must fly high enough to be within radio "line-of-sight" of the transmitter that is to be observed. The curvature of the earth (exaggerated in the above illustration), mountains and other major obstructions cast radio or radar "shadows" as shown.



The distance from a transmitter (or a receiver), elevated above the surface of the earth, to the "radio" horizon is shown in the above chart. Where both the transmitter and the receiver are elevated the maximum distance that can separate the two terminals, while still effecting communication, is the sum of the two distances, determined individually, for the respective heights of the transmitter and the receiver. Thus a v-h-f transmitter, 200 feet above the surface of the earth can transmit to points 20 miles away. If, however, the receiver is airborne to a height of 5000 ft., then transmission could be maintained for a distance of 20 + 100 = 120 miles.

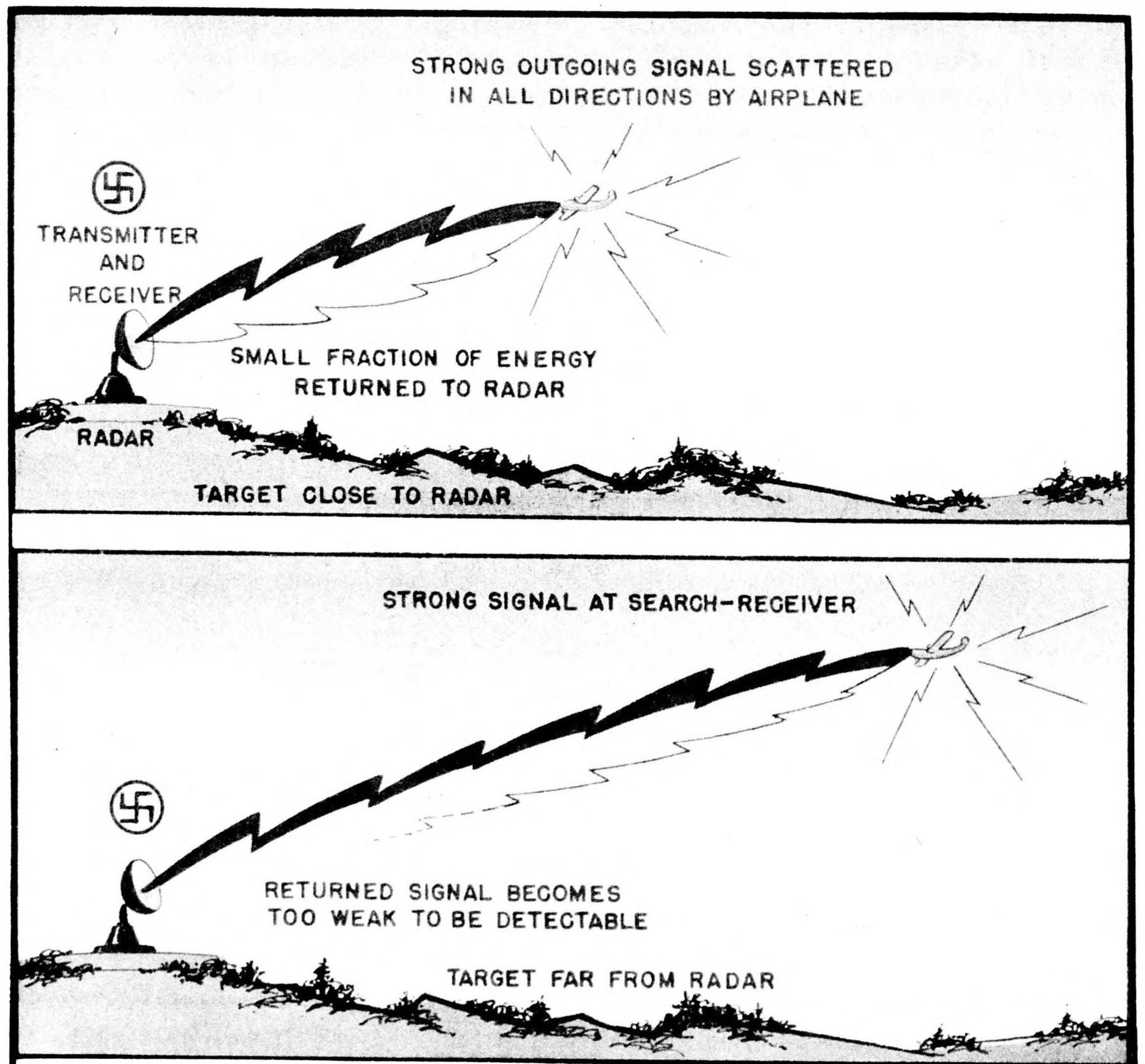
equipment on Kiska could be made from Amchitka. Thus, although airborne searching may be more common, the desirability of being prepared to undertake such operations with mobile, portable or ground-based equipment must be borne in mind. The search receivers described herein are primarily intended for airborne applications, but can be adapted to these other types of service.



Ground-based search receivers for radar or v-h-f communication transmissions can be used only when the terrain is favorable. A receiving site at (1) would be satisfactory to observe the radar shown, but location (3) is shielded by the intervening hills and will not be satisfactory. An airborne search receiver (2) will experience good reception as long as it remains at a high enough altitude to avoid the region where the radio "shadow" is cast.

In connection with airborne search it should be noted that radar emissions can be received at distances from the radar that are considerably beyond the maximum detection range of the radar system. Under these circumstances it is often possible to observe the operating characteristics of an enemy radar without coming within its field of view. (See picture at top of next page.)

Receivers for determining the characteristics of the control signals used for enemy radio-controlled devices (e.g., radio-controlled tanks or glide bombs), present a particularly difficult search problem. This arises from the fact that the signals are only observable for the few seconds (a minute, at the very most) during an actual attack while the vehicle is making the target run. Even within this short period of time the control signals may not be continuously radiated, since they may of necessity be intermittent. Furthermore, the control signals may be confined to a very narrow channel, located almost anywhere in the radio spectrum. Finally, false or decoy signals, on frequencies far removed from those actually used, may be transmitted by the enemy during the attack.



Radar emissions can be received at distances from the radar that are considerably beyond the maximum detection range of the radar system. The amount of energy at the target, resulting from the direct radar transmission, is tremendous compared to the amount that arrives back at the radar receiver. This is because the bulk of the energy is scattered by the target in all directions. Even when the target is so far away that the energy returning to the radar is too small to be detectable, there will generally be sufficient signal at the target to be heard by a good search receiver carried in the airplane.

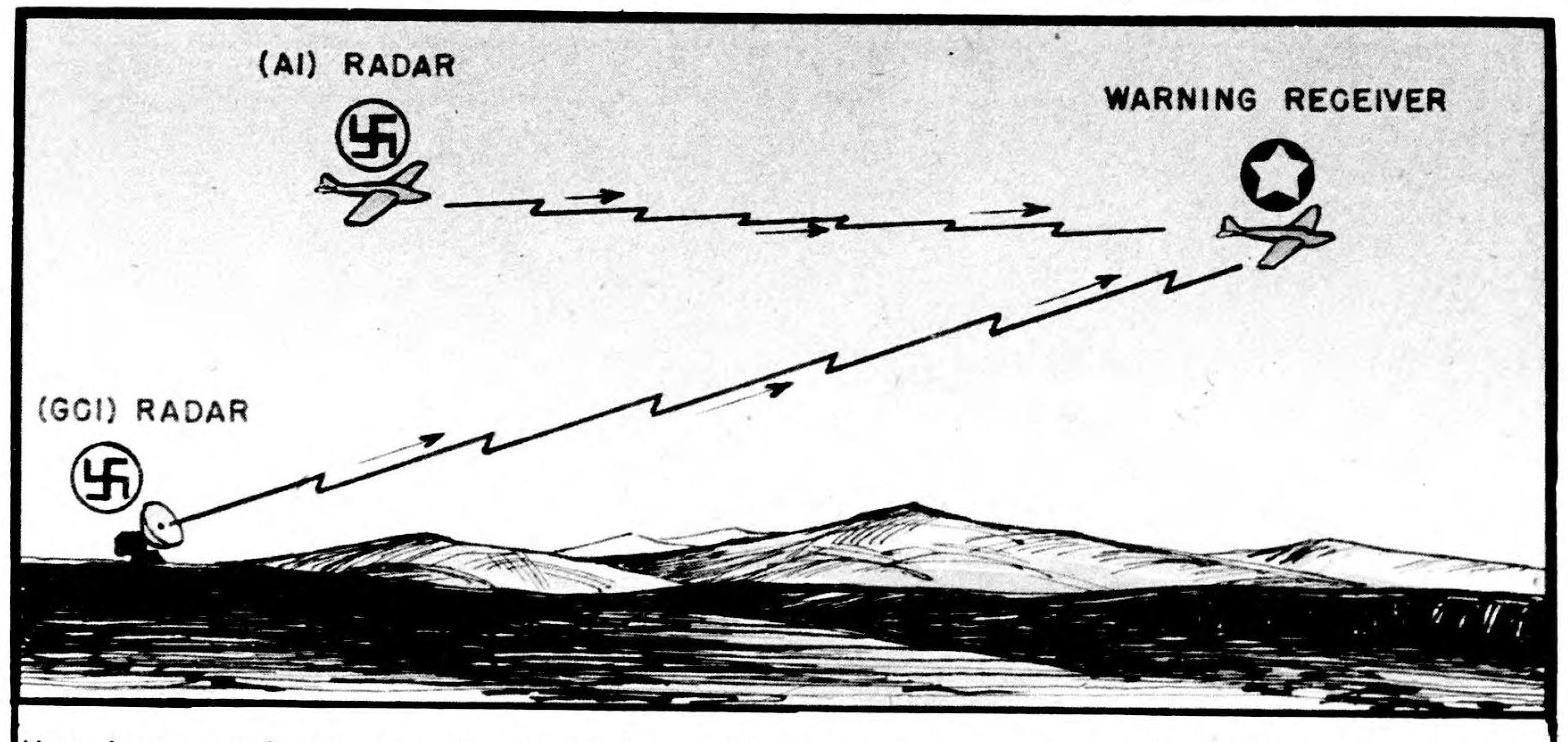
DIRECTION-FINDING & HOMING RECEIVERS

Direction-finding means are also a part of the search program since it is essential to ascertain the location of enemy radar installations. Because of the wide frequency range that is of interest, the various polarizations of the signal, and other factors, this is not a simple problem. Successful systems have been devised, nevertheless, and are described elsewhere in this volume.

Homing receivers are another important type of RCM equipment since they may be instrumental in making it possible to undertake a most effective counter-countermeasure --finding and destroying enemy jammer-equipped craft. Besides being useful for homing on the source of enemy jamming transmissions, such receivers can also be used to home on friendly or enemy communications and radar systems.

WARNING RECEIVERS

Radar warning receivers that are more or less automatic in operation are useful for advising when one comes under observation by enemy radar. For example, an aircraft interception (AI) warning system can be used to warn aircraft when attack by radar equipped enemy fighters is imminent. A gun laying (GL), search



Warning receivers may be used to advise when an aircraft is being observed by enemy search-light-control (SLC), gun-laying (GL), ground-control-interception (GCI) or aircraft-interception (AI) radar. In each case the warning need only be given when the situation becomes menacing and it is no longer advisable to postpone evasive action.

light control (SLC), or ground-controlled interception (GCI) warning receiver would advise when danger from these sources is likely. Experience has shown that the protection afforded by equipment of this kind is valuable for easing the inevitable tenseness that accompanies the possibility of attack without warning. In addition to its application to aircraft, such equipment is also useful, of course, for warning surface vessels or submarines of exposure to various types of radar.

JAMMING TRANSMITTERS

Jamming transmitters are usually designed for use against a specific type (or types) of communications or radar system. They may be classified as airborne, portable, mobile, expendable, shipborne, or ground-based, depending upon their intended method of

use. Because of wave propagation considerations, a given short-distance communications or radar channel can, in general, be jammed with the minimum of power, if the jammer is airborne. Airborne jammers are, however, faced with many limitations, such as limited primary power supply, antenna installation problems (particularly at the lower communication frequencies), difficulty of maintaining a continuous jamming operation, dependence upon weather, and vulnerability to attack. For these reasons the use of ground-based, mobile, or portable jamming equipment is indicated whenever practical.

The most important advantages of ground-based jamming transmitters are the relative ease of continuous operation (if required), the possibility of inconspicuous location, and the availability of greater amounts of primary power. Advantage may also be taken of available space to employ directive antenna systems in order to send a large percentage of the available power toward the victim and away from any friendly systems that may be operating in the same general region of the frequency spectrum. Unfortunately, however, the distances involved, the nature of the surrounding terrain and the amount of transmitter power that can be conveniently radiated do not permit the wide-spread practice of jamming from ground locations, particularly in the case of radar.

Expendable jammers are generally of the type that may be dropped by parachute or in a bomb casing close to the victim station. A desirable feature of this type of jammer is that it may be sowed in quantities near the victim where it will operate until located and destroyed, or until the power supply is depleted. Such jammers can be effective even though they have very low power. Expendable transmitters seem to offer more possibilities in the communications field than in radar and consequently their development in the latter field has not been exploited to any extent.

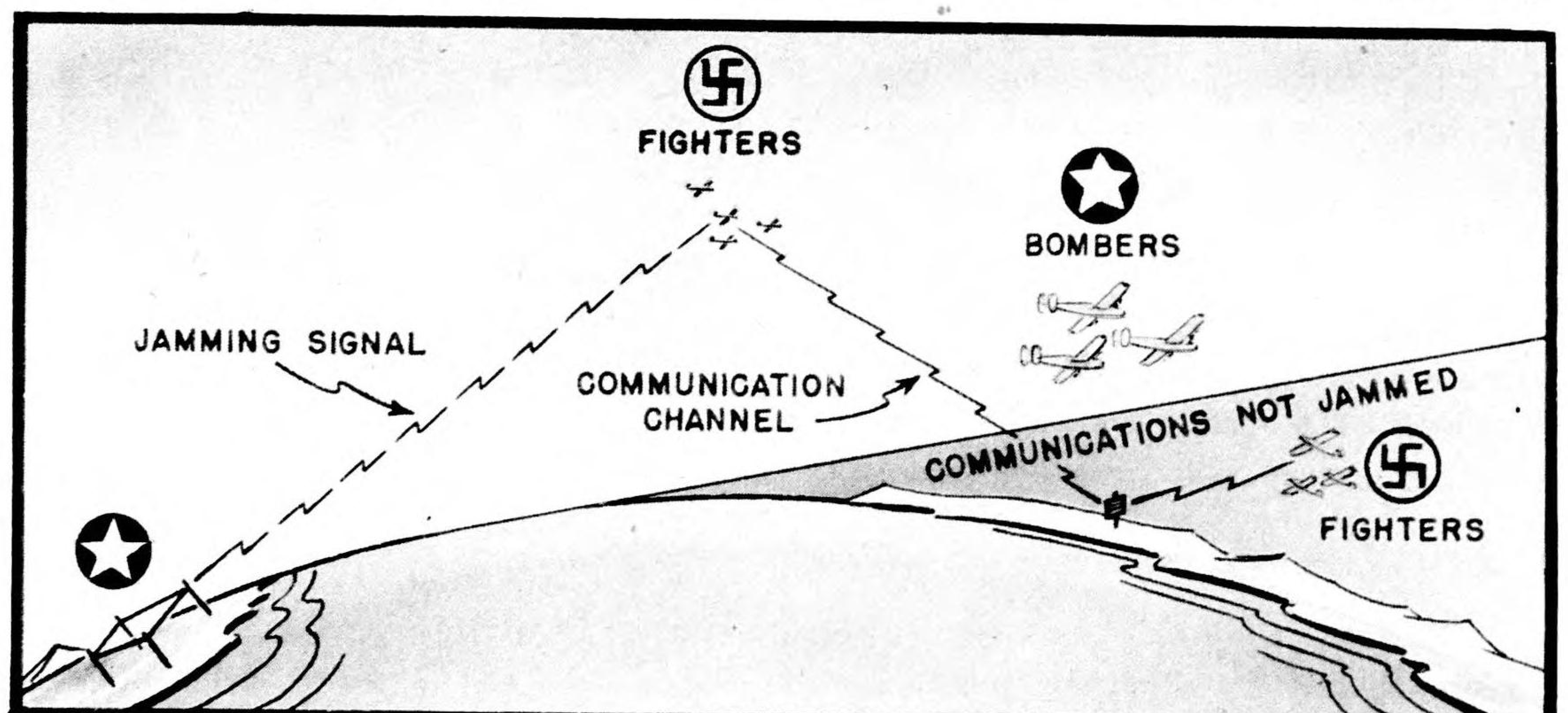
COMMUNICATIONS JAMMING

Communications jamming transmitters, if properly used, can be very effective against ground-force command-nets, armored-vehicle communication systems, walkie-talkie equipments, air-to-air and air-to-ground communications systems, and other relatively short-distance communications channels. Although it is possible, under favorable conditions, to attempt to jam long-distance point-to-point circuits, the success of such operations may be rendered unprofitable by the amount of power that may be needed, by the lack of suitable geographical locations for the jammer (which must blanket the terminal of the enemy channel with a frequency determined by the intended victim), by the large number of frequency channels that the enemy may have available for emergency use, and by the need for jamming all channels practically continuously if the "blockade" is to be effective.

In any event, the jamming of communication circuits of any kind must be coordinated with the activities of any intelligence services that may be using the channels to obtain information concerning enemy activities. The benefits to be gained by jamming must always be weighed against those to be obtained by monitoring the intended victim signal for information purposes.

Jamming of enemy ground-to-air communications channels may be a very effective means of neutralizing the effectiveness of enemy ground-controlled interception (GCI) radar systems. In fact, it is just as effective as jamming the radar itself since, if proper instructions cannot be transmitted to the interception fighter the usefulness of the GCI system is destroyed. The jamming of such ground-to-air circuits may be most readily accomplished by airborne jammers in the vicinity of the victim stations. Where an alternative exists, however, this may not be the best method since such airborne jammers may become the target of enemy action.

In favorable situations, high-powered, ground-based communications jamming equipment, using directive antennas, may be advantageously employed to send signals into the region where enemy GCI fighters are operating. This procedure will result in the jamming



A high-powered transmitter, located on the ground, can be used to jam the enemy ground-to-fighter communications channels, used for ground-controlled-interception (GCI) operations, provided the distances involved are not too great and the terrain is favorable. As the distance increases it is necessary for the bombers that are to be protected to fly at higher and higher altitudes in order to keep the fighters above the "shadow" area (wherein jamming does not occur). Reference to the radio line-of-sight chart indicates the relation between altitude and distance.

of only the ground-to-air link (and not the air-to-ground link). Since the ground-to-air link is the important link of the GCI system, however, its jamming should make GCI operations impossible or at least very difficult.

AIRCRAFT INTERCEPTION (AI) RADAR JAMMING

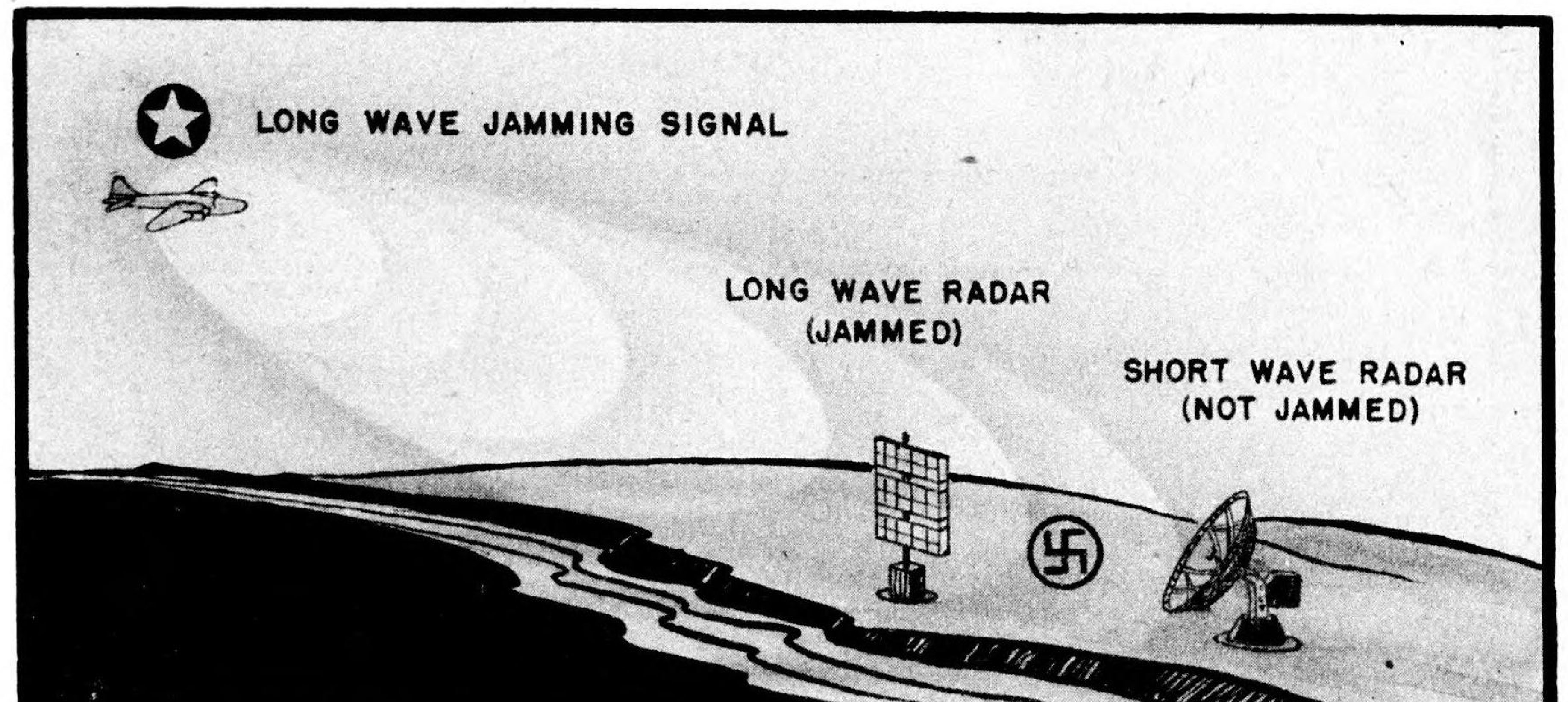
If the enemy fighters are equipped with AI radar it will be desirable to jam the AI system also. Again, this can be most effectively done with airborne jammers but they, in turn, may become the object of an attack guided by homing devices. In this case, also, if the distance and the terrain involved are favorable, use may be made of high-powered ground-based jamming transmitters operating at the enemy AI frequencies.

GUN LAYING (GL) AND SEARCH-LIGHT-CONTROL (SLC) RADAR JAMMING

In the jamming of GL and SLC radar (also GCI radar, if the radar itself is to be jammed) the jamming equipment must be airborne, generally by the target aircraft, since the resolution of these radar equipments will probably be such as to discriminate reasonably well against interference from directions other than that in which the radars are oriented. In daytime tight-formation flying, all jammers coming within the beam width of the radar will contribute to the overall effect but, at the same time, all targets within a pulse length will contribute to the size of the radar echo.*

EARLY WARNING (EW) RADAR JAMMING

Early-warning (EW) radar systems may be effectively jammed by airborne equipment or by ground-based transmitters where the geographical features of the situation are favorable. It is important to note that jamming operations must be carried out against all

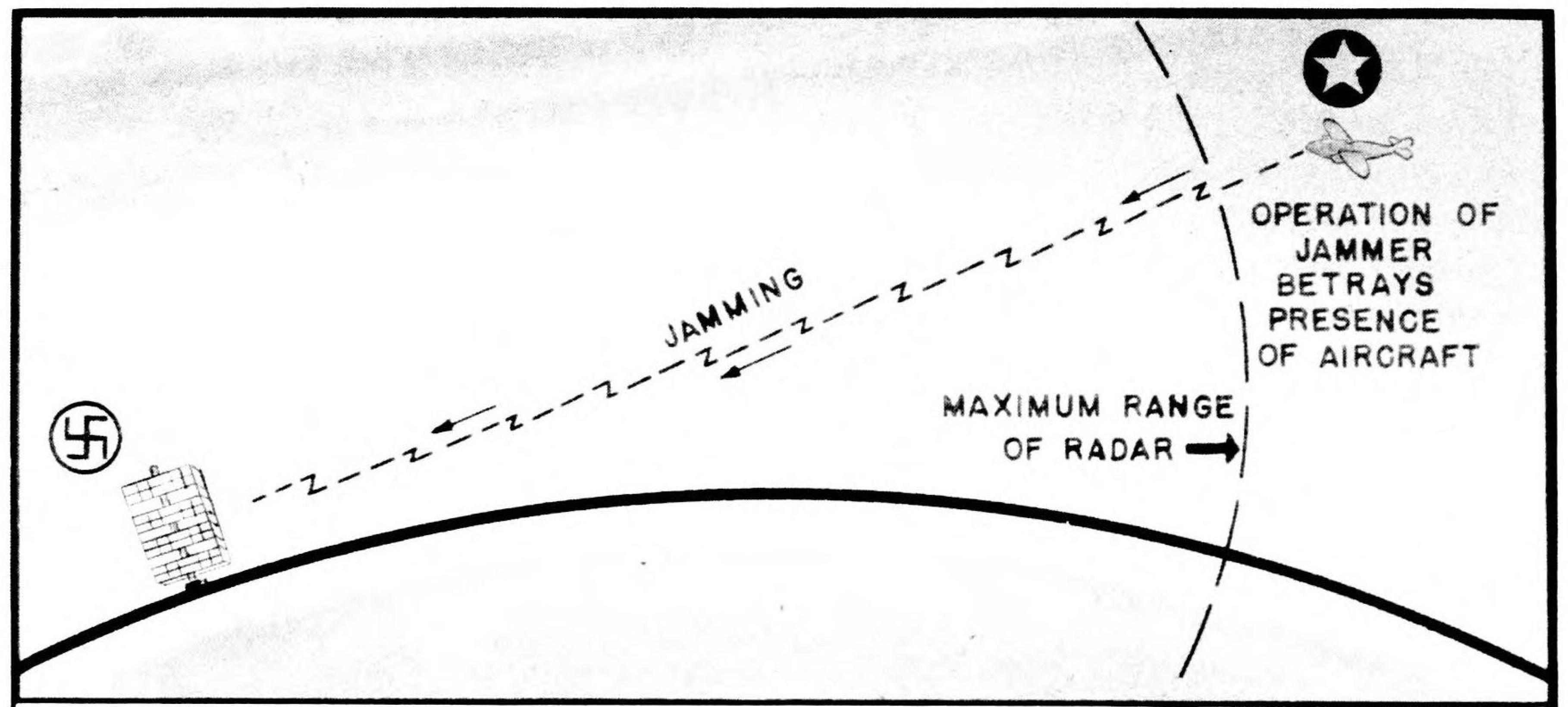


Jamming transmitters must be tuned to the frequency of the radar or communications system that is to be jammed. A jammer adjusted for use against a low-frequency (long-wavelength) early-warning radar will have no effect upon a high-frequency (short-wavelength) gun-laying radar or upon a radio communications channel.

*For further explanation see discussion of operational tactics in Jammer Transmitter Section.

existing systems, regardless of their frequency, if the over-all operation is to be successful. Also in some theaters of operation, such as the European one, the need for EW jamming must be carefully evaluated in view of the proximity of the fronts and the large concentration of other types of radar which, in such special situations, may be capable of supplying all the warning that is of practical value. Where EW radar is used to place GCI radar on the target, the jamming of the former (as well as the latter) may be of some value.

In any radar jamming operation it is important not to use the jamming transmitter before entering the field of view of the intended victim radar. If the jammer is used too soon, the jammer-

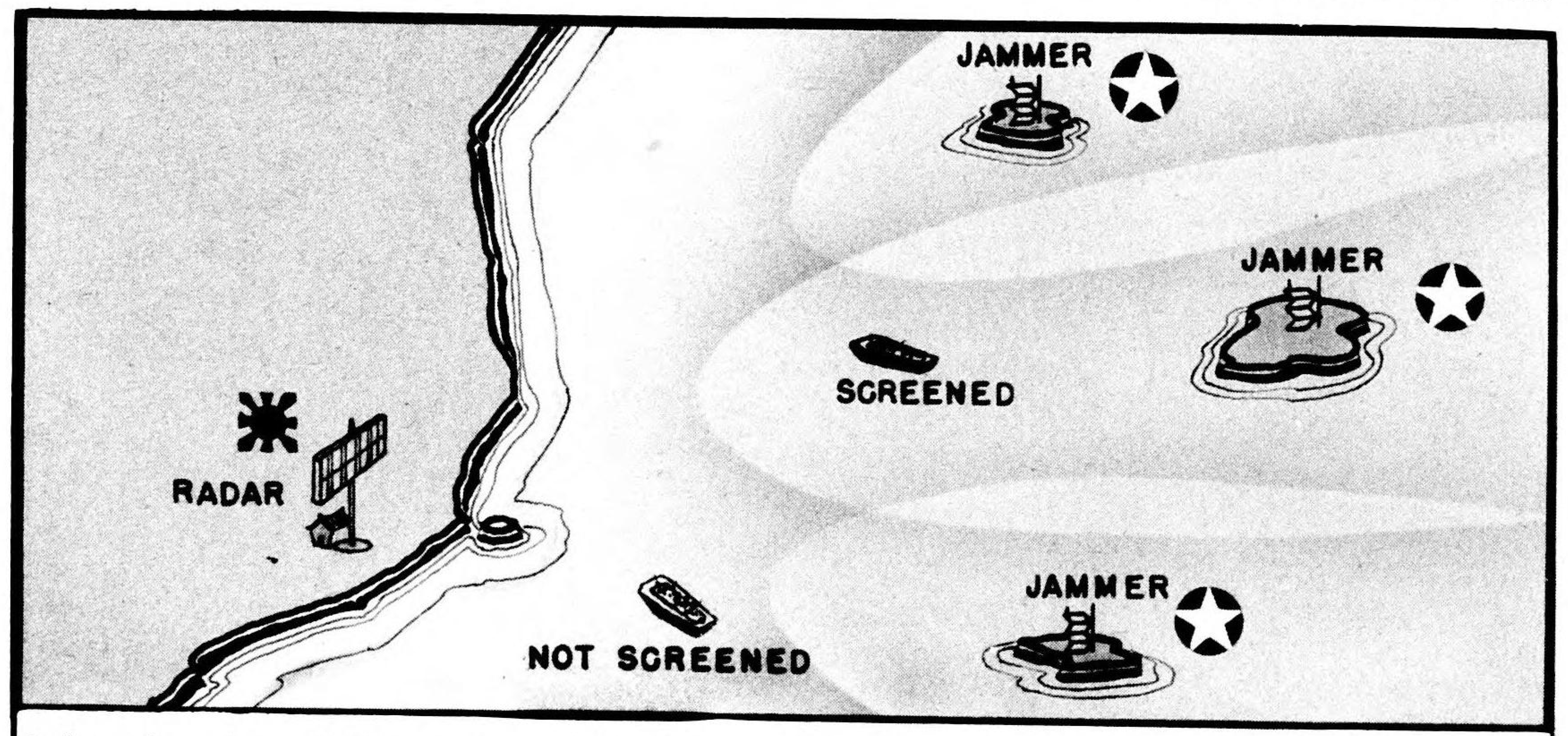


If a jammer is placed into operation before the jammer-carrying craft reaches the limit of detection of the enemy radar, it will forewarn the radar of the activity in the direction from which the jamming is being received. The radar will not be able to determine the range of the jamming-craft, nor the size of the target, but it will be able to determine the direction from which the jamming is being received.

carrying craft will advertise its presence to the enemy by indicating the bearing (but not the range) from which the jammer is approaching.

COASTAL-WATCH RADAR JAMMING

Coastal-watch radar may be jammed from transmitters carried on shipboard, on low-flying aircraft or, when a suitable location is available, from ground-based jammers. As with all radar jamming, it is important to note that the radar will be subject to jamming only when it is pointed toward the source of jamming signals. The resolution of the radar-receiving antenna determines the arc over which it is susceptible to interference. If jamming over a considerable arc is desired, it will be necessary to employ a number of jamming sites. (See picture at top of next page.)



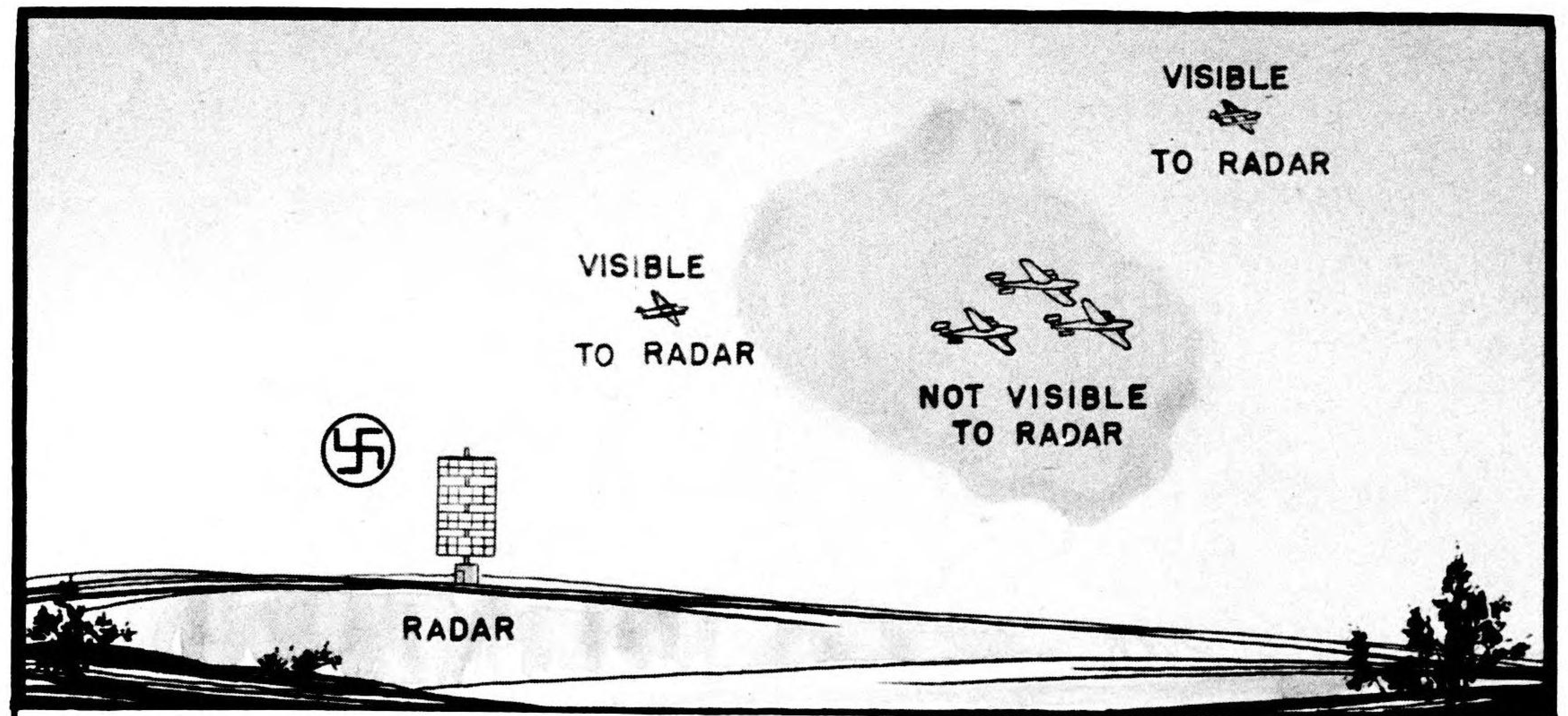
A jamming transmitter in a fixed location is able to screen a target from a radar only when that target stays within a certain area around the jammer. If the target approaches too close to the radar, the jammer is unable to screen it. A number of jammers, properly located geographically, are required if screening over a large area is required.

COMMUNICATIONS CONFUSION AND DECEPTION METHODS

The application of confusion and deception methods in communications channels does not, for the most part, require any special devices other than transmitting and receiving equipment operating on the proper frequencies. Such practices do require ingenuity on the part of the operator. They are not covered in this volume, which is primarily concerned with the application of equipment developed especially for RCM purposes.

RADAR CONFUSION METHODS

The method now in use of confusing enemy radar is by means of a "window operation." By this term is meant the sowing of radar echo producing reflectors to an extent that an entire volume of space becomes infested and the multiplicity of echoes of false targets will conceal a true target in this volume. The appearance of these false echoes is not greatly different from that of an aircraft except that their apparent speed (which depends upon the wind velocity) is very low. For complete protection the infestation must be sufficiently dense so that the false echoes are strong enough to conceal the echo from an aircraft flying through the infested volume. The material used by the Army Air Forces is chaff and rope, described on page 142 and 143 packed in bundles of convenient size for sowing from an aircraft, either by hand or by automatic ma-



Aircraft flying in an area which has been infested with a sufficient quantity of Window cannot be detected by radar, just as they cannot be seen optically, if flying within a cloud. However, aircraft that are beyond the Window-sown area can be detected by radar whereas in the optical analogy an airplane back of a cloud would not be visible.

chine. Other services have used reflectors sown from the surface by means of rockets, or suspended from a balloon or kite to simulate surface targets.

RADAR DECEPTION METHODS

Considerable attention has been paid in the RCM program to methods of deceiving radars. By this, it is meant, of course, that the enemy operator makes a false report not knowing that the echo received by his equipment is not a normal one. A window operation, may be so carried out as to fall into this category, particularly in areas where window has been in regular use and the enemy radar operator is used to seeing it as cover for a normal raid. A few aircraft carrying sufficient window may eject it at a high rate in a rendezvous area, if in view of enemy early warning radar, in order to alert his defense system on days when no raid is planned Another scheme, where there are several possible targets in one area, is to send a few special aircraft with sufficient window as a diversionary raid. Then if window is also dropped in the proper quantity by the main raid, there will be no way for the enemy radar operator to distinguish between the main raid and the diversion. Obviously, in using window to deceive early warning radars, the frequency coverage must include all radars which the enemy will use for this purpose.

ANTI-JAMMING METHODS

The use of jamming, confusion and deception methods may be thought of as offensive countermeasures while the development of anti-jamming (AJ) techniques may be considered a defensive one.

A number of AJ methods and devices have been developed for both communication and radar systems. In many instances these are incorporated in the basic design of the equipment involved. This is true of communications receivers, since it has been the general practice for some time to include features that would assist in segregating the desired signal from any interfering signals. As new methods become available, it is possible and worthwhile to supply modification kits for application to some types of existing equipment in the field. The best of these devices are of little value, however, if not properly used.

In both communications and radar, there is no substitute for experience in reading the desired signals through interference and for the will to do so. The importance of this fact cannot be overemphasized. Experience in the field has demonstrated that untrained operators do not take full advantage of every means available to receive the desired signal. A still more serious fact is that upon being exposed to novel forms of interference, untrained operators have even given up trying to operate their equipment or have taken it apart to find faults which were mistakenly thought to exist within the set. These tendencies can only be overcome by adequate training and frequent exercises during which the operator has an opportunity to familiarize himself with the various possible forms of interference that may be encountered and learns to carry on as well as possible in spite of the disturbances. The importance of this AJ method is evident when it is realized that by proper operator training it may be possible to force the enemy to use from 2 to 10 times as much jamming power to achieve a desired effect. At the frequencies involved this increase is sometimes difficult or even impossible to achieve.

Another potent AJ measure for both communications and radar is the making available of a number of alternate operating frequencies, together with means for rapidly changing from one to another. The range of available frequencies should, of course, be as wide as possible and the time necessary for making the shift should be as short as possible, preferably of negligible duration.

In some instances the incorporation of an AJ design feature will be possible only with an accompanying impairment in the performance of the equipment involved. In general, however, it is probably prudent to make some sacrifice in performance in order to combat jamming, since the finest system is entirely useless if it is successfully jammed.

A feature that generally improves the AJ properties of a system without impairing its performance is the use of high directivity or resolution. Systems having high directivity are more difficult to jam, as a rule, because of their discrimination against unwanted signals arriving from directions other than that in which they are oriented. Microwave sets lend themselves particularly well to improvements along these lines.

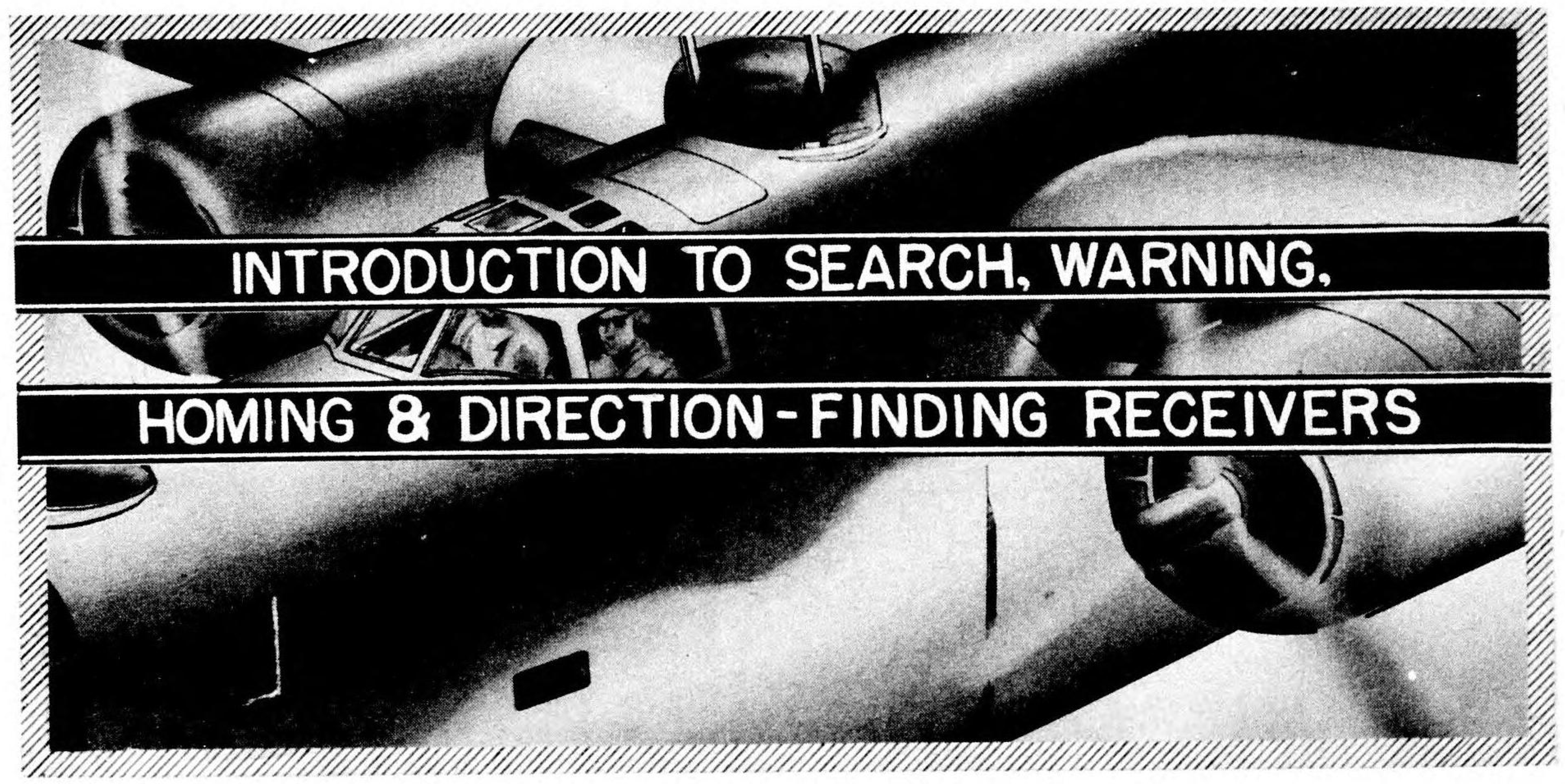
Radar equipment having directive antenna systems is capable of considerable discrimination against jamming signals. The greater the directivity of the radar, the better is its ability to work in directions differing only slightly from that of the source of interference. This feature is of considerable value as an anti-jamming measure.

SUMMARY

The above discussion has dealt with the relation between the four basic parts (Search, Jamming, Confusion and Deception, and Anti-Jamming) of the RCM program. The equipments that have been or are being developed in each category are described in detail on the following pages.

Each section of this book is preceded by a more detailed discussion of the application of the equipment involved than has been given above. In addition, a summary chart is included when possible, in order to present, in one tabulation, the pertinent specifications of all the equipment in a given class. This summary should be useful as a guide to the selection of a piece of apparatus for a specific service.

15 July 1944



INTRODUCTION TO SEARCH, WARNING, HOMING & DIRECTION-FINDING RECEIVERS

The need for search, homing and direction-finding receivers has been discussed in a general way in the preceeding section, *Introduction to RCM*. As mentioned there, the equipment used for communications search and direction-finding are, for the most part, of conventional design and have been covered in detail elsewhere. For this reason, most of the following, more detailed discussion concerns itself with receivers intended for radar countermeasures activities.

ANALYSIS OF ENEMY RADAR BY USE OF SEARCH RECEIVERS

Search receivers, when supplemented by suitable indicating and analyzing devices, can be instrumental in obtaining much valuable information concerning enemy radar equipment. Some of the operating characteristics that may be determined by searching,the reason for their importance from a countermeasures viewpoint, and the probable range of values that will be encountered are as follows:

(1) Carrier Frequency (About 100 Mc and higher)
In order to permit intelligent design and successful employment of countermeasures devices, it is important to know the exact operating frequency of specific radar systems and the band of frequencies over which the radar sets of a given type are spread.

(2) Antenna Polarization (Horizontal, vertical or rotating)
Since it is important that the transmitter power available for jamming purposes be used as effectively as possible, and the maximum possible sensitivity is gen-

erally desired in receivers, it is essential that the polarization of the enemy emissions be ascertained and the jamming transmitter and search, warning, or direction-finding receiver antennas be arranged accordingly.

(3) Lobe Switching Rate (From about ½ to 500 per second).
An accurate knowledge of the lobe switching (or split) rate of enemy systems is of importance in the design and application of certain types of deception devices. (e.g. Peter). This can be readily determined where lobe switching of the radar transmitter is practiced.

(4) Maximum Range (From a small fraction to hundreds of miles).
The maximum range for which a radar system is designed may be estimated from a knowledge of the pulse-repetition-frequency (prf ranges from about 20 to 5000 pulses per second). In the case of an oscillating or rotating searching beam the actual maximum range may be ascertained for a specific target when the beam stops searching and locks upon the target. A knowledge of the maximum range of a radar is important since, in general, it is not desirable to operate jamming transmitters until they come within range of the radar system.

(5) Minimum Range (From tens of yards to a few miles).
The minimum design range may be estimated from a knowledge of the pulse length (from about 0.1 to 25 microseconds) and the pulse shape. Information as to the minimum range of an enemy radar system is not of particular interest from an electronic countermeasures viewpoint but it may be of considerable value to other operational branches of the services and to the designers of our radar equipment. Information concerning the pulse shape, however, is of importance in the design of certain deception devices(e.g. Moonshine and Stardust).

(6) Equivalent Radiated Power
Field intensity measurements, coupled with information as to the distance from the radar at which the measurements were taken, will permit an accurate estimate to be made of the equivalent radiated power of the radar and of the necessary sensitivity of warning receivers.

(7) Rate of Rotation (From about 0.1 to 1.0 per minute).
The probable rate of rotation of a radar is of considerable interest in the design and application of automatic search receivers since it influences the selection of the rate at which the receiver scans the frequency spectrum. Furthermore, observations made on the rate of rotation are useful in determining whether a

PPI is used by the radar under surveillance.

(8) Resolution or Directivity
Information concerning the directivity patterns in the horizontal and vertical planes will indicate the resolution or directivity of the radar and provide an estimate of the antenna gain. Information concerning the vertical pattern may also reveal nulls or blind spots which may be used to advantage in approaching the radar in question.

ANALYZING AND INDICATING EQUIPMENT

It is evident from the foregoing that, in addition to the search receiver itself, there is need for various associated analyzing, recording and indicating equipment if full advantage is to be taken of the emission from a radar system in obtaining information relative to its operating characteristics. The auxiliary equipment includes frequency meters, pulse analyzers, cathode-ray oscilloscopes and audio oscillators.

The accuracy of frequency meters for the radar portion of the frequency spectrum is, in general, not sufficiently great to permit the setting of jamming transmitters by reference to the stated absolute frequency. It is preferable to set such transmitters on frequency by employing the same frequency meter as was used originally to determine the enemy radar frequency. Although the absolute calibration of such instruments may not be so accurate as desirable, their stability and relative calibration may be satisfactory if they are used first to determine the frequency to be jammed and then to set the jammer to this frequency.

AUTOMATIC SEARCH RECEIVERS

Radar reconnaissance, for reasons already mentioned, is usually done from aircraft. The task is not particularly simple even though the geography may be such that the searching craft is able to stay out of range of the radar under investigation. For example, in an area where there is only one radar (or very few) operating on an unknown frequency, it is necessary that there be a double coincidence if the signal is to be heard; that is, the search receiver must be tuned to the radar frequency at the instant the radar is oriented toward the search receiver.

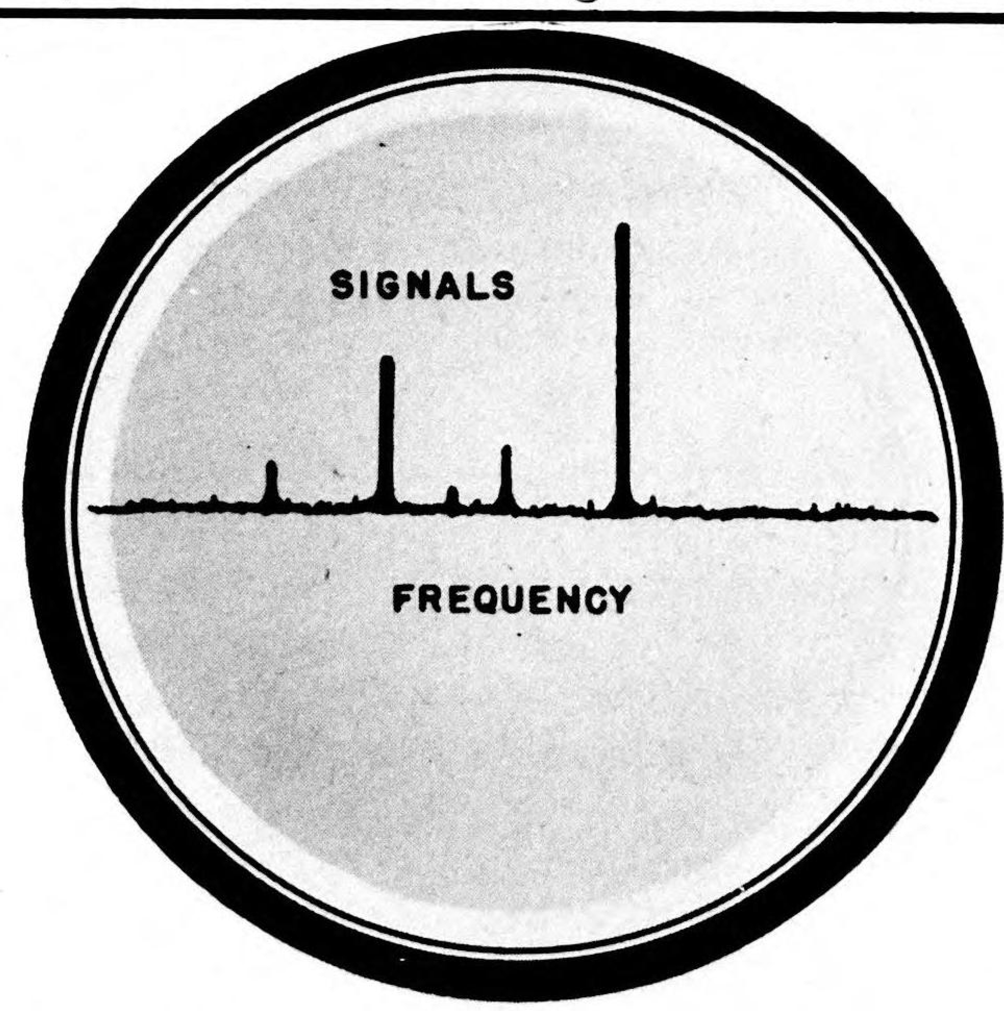
Since radar and similar types of emissions (such as for radio-controlled glide bombs or tanks) may take place anywhere in a very wide band of frequencies, searching becomes a very tedious job if it is undertaken in a thorough manner. At low radar frequencies this is not so serious a problem as at high frequencies since, in the former case, the directivity of the radar transmitting antennas is not so great as at high frequencies. Furthermore, at low

radar frequencies there are often spurious side lobes of radiation that emit sufficient power to permit reception on a sensitive receiver even though it may not be in the main beam of the radar.

At high radar frequencies the search problem is doubly difficult since, not only are the beams generally extremely sharp and possessed of only very minor spurious lobes, but also there is a much larger number of possible channels. On the other hand, if the reconnaissance is over an area where there are a large number of radars operating, it may be difficult because of the speed of flight and the number of radars involved, to record and distinguish between all the radar signals heard.

The various types of automatic tuning and recording means that have been devised to alleviate these difficulties are described on the following pages. In some instances these devices are such that they can be carried on regular bombing missions (operating without attention) and thus provide preliminary data concerning enemy radar. In general, however, automatic devices do not record the operating frequency of received emissions with sufficient accuracy for the pre-setting of jamming transmitters. Rather, they are useful for indicating the general whereabouts, both in frequency and geographical location (by comparing the time of signal reception with the flight log) of the radar stations heard. A detailed search with more precise measuring equipment can then be made with the minimum amount of effort.

For search operations involving radio-control devices, it is



One form of indicator that is used in the panoramic type of receiver displays all the signals within a given band of frequencies upon the face of a cathode-ray tube. The position of the signals along the baseline is an indication of their frequency while the height of the signals is a measure of their strength.

generally necessary to obtain all the information possible in an extremely short time. For this purpose, the panoramic type of receiver is by far the most useful, since all signals in a large frequency band can be indicated simultaneously. However, as the panoramic receiver indicates only the frequency of the received signal, further information must be obtained by means of other equipment.

In communications channels, because of the large number of signals that are practically always present and the need for identifying each signal individually, the use of automatic searching and recording equipment is not, in general, feasible. For communications searching, the regular receiver, packaged for the type of installation involved (airborne, mobile, etc.) and operated by skilled personnel, will usually fulfill all requirements. Although elaborate automatic search receivers for the communications bands can be designed, their complexity and bulk make them of questionable usefulness for the present purpose.

SENSITIVITY OF RADAR SEARCH RECEIVERS

It is not generally necessary that radar warning receivers have the extreme sensitivity which is desirable in communications receivers or in receivers that are a part of a radar system. This is true because of the extremely high field intensities that exist at the search receiver location when it is within range of a radar. This fact is obvious when it is recalled that only a small portion of the total energy intercepted by the target is returned to the radar and yet this echo must be sufficiently great to permit the reception of a discernible signal by the radar receiver. The warning receiver, on the other hand, is exposed to the intense field that exists at its location whenever the radar beam is oriented in that direction.

Sensitive radar search receivers are useful, however, since they will permit the reception of radar signals at maximum distances. Furthermore, with a sensitive receiver, radar emissions will be observable even though the radar involved may not be "looking" directly toward the receiver.

RADAR WARNING RECEIVERS

Although the basic idea of a radar warning receiver was that of a simple device, experience has shown that to be useful the receiver must be capable of rather complex operations. This is particularly true in the European Theater of Operations. In this area the enemy SLC, GL and GCI radar are all in a narrow band of frequencies (see previous section on enemy radar) and enemy AI and Coastal Watch equipment is similarly disposed in adjacent bands.

To be of maximum usefulness a warning receiver should be able to discriminate between these different types of radar since different evasive tactics are practiced against the various types.

The time that may elapse before evasive action must be undertaken is different for different types of radar. For example, evasive action against GL need not be taken until after the enemy radar has been centered exactly on the target for a period long enough to supply sufficient data to the AA predictors to permit accurate firing. Thus, GL warning devices might include means for determining when this centering takes place and in addition introduce a time delay of something less than a minute (since all predictors require a flow of uninterrupted information for a certain period of time) before giving a warning signal.

In the case of GCI, a warning need not be given until the target has been under surveillance for 5 minutes or thereabouts. For AI warning, however, the warning signal should be given whenever the AI-equipped aircraft is almost close enough to press home the attack. Unless arrangements are made to provide these distinguishing features, the warning equipment, at least in a congested area, will give almost continual warnings which, if heeded, would result in an intolerable amount of evasive action.

Warning receivers for the early warning (EW) radar frequencies are not required, as a rule, since attacking aircraft must fly over the EW radars in any event. However, in theaters where the location of every EW equipment has not been ascertained by prior search - i.e., in initial raids into new territory - the use of warning receivers for the EW bands may be useful in indicating when one first comes under scrutiny, and interception may be anticipated.

HOMING SYSTEMS

By providing a search receiver with suitable directional antennas, switching mechanisms and indicators, a system can be developed that will assist the craft carrying the equipment to orient itself toward a source of radio, radar or jamming signals. An installation of this type is known as a homing system, since it will indicate the course to be taken in order ultimately* to reach the source of signals. The use of equipment of this kind is more or less confined to airplanes since in larger, slower moving, and less mobile craft the use of direction-finding systems (see below) offers several advantages that more than offset their added size and complexity. Direction-finding systems are also applicable to aircraft. They bear a relation to homing systems similar to that which the turret guns bear to the fixed guns on the airplane. With

*Because of drift, a spiral course will actually be followed unless corrections are made.

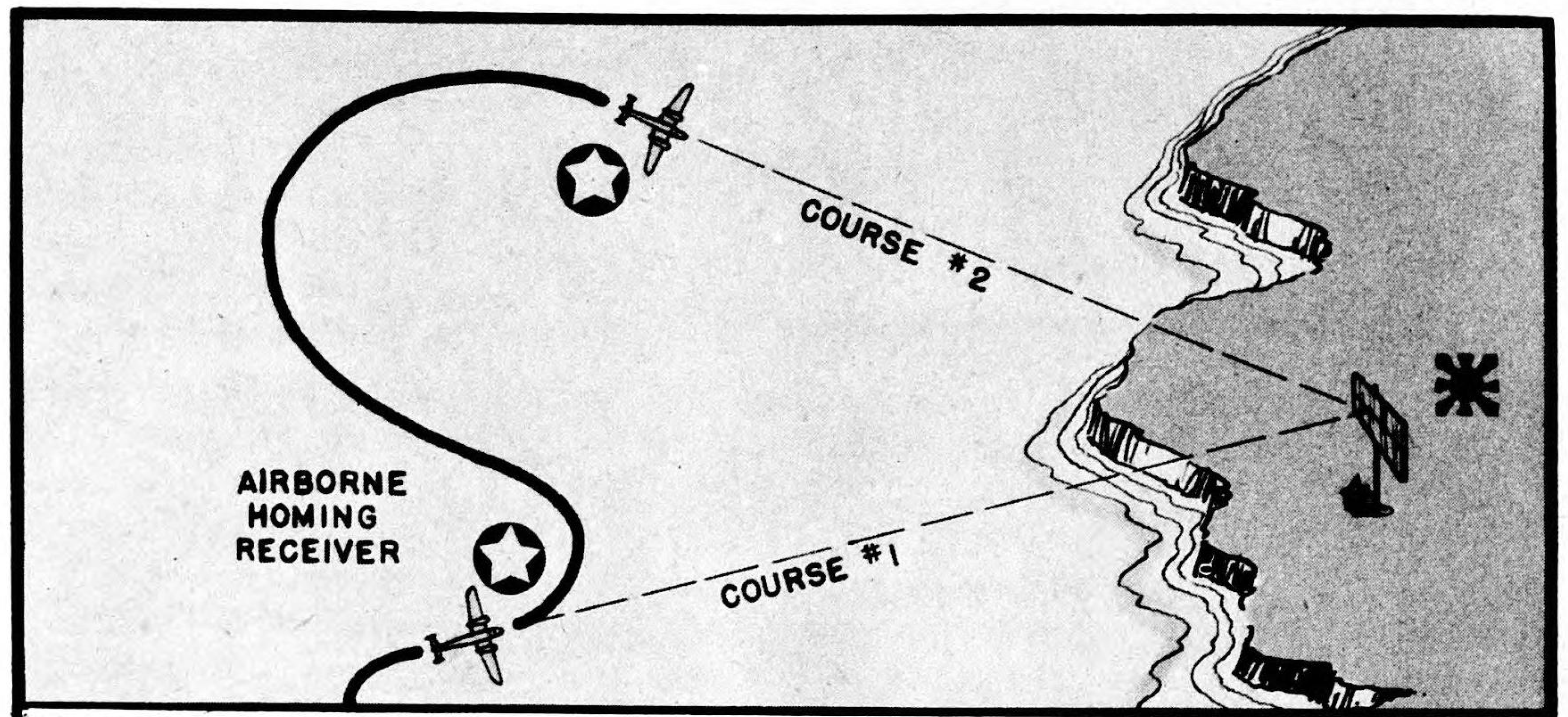
a homing system or with fixed guns the airplane must be turned toward the target, while with a direction-finding system or with turret guns the airplane may fly a chosen course while still coming to bear upon the target.

Homing systems are most useful to airplanes that wish to attack a source of signals. For example, they can be of considerable assistance to low-flying aircraft intent upon attacking an enemy radar station. Although the location may be precisely known, when flying at low altitude it will seldom be possible to see the station until the aircraft is almost over it. Homing equipment should assist materially in keeping the aircraft headed toward the target.

Another application is the locating of airborne jammers or of radar-carrying aircraft for the purpose of attack. In this application, homing methods have the advantages over AI radar that they require less elaborate equipment and that they do not provide any radio warning to the enemy, even if he is equipped with warning receivers.

In the selection of homing equipment for a specific application it is exceedingly important to bear in mind the need for using an antenna system whose polarization corresponds to that of the transmitter. Thus, if the source of signals is an antenna having vertical radiating elements, a vertically polarized antenna should be used for the homing system if erroneous results are to be avoided. It should also be noted that most directional antenna systems operate properly only over a limited band of frequencies, since the problem of providing a broadband directional system is a very difficult one.

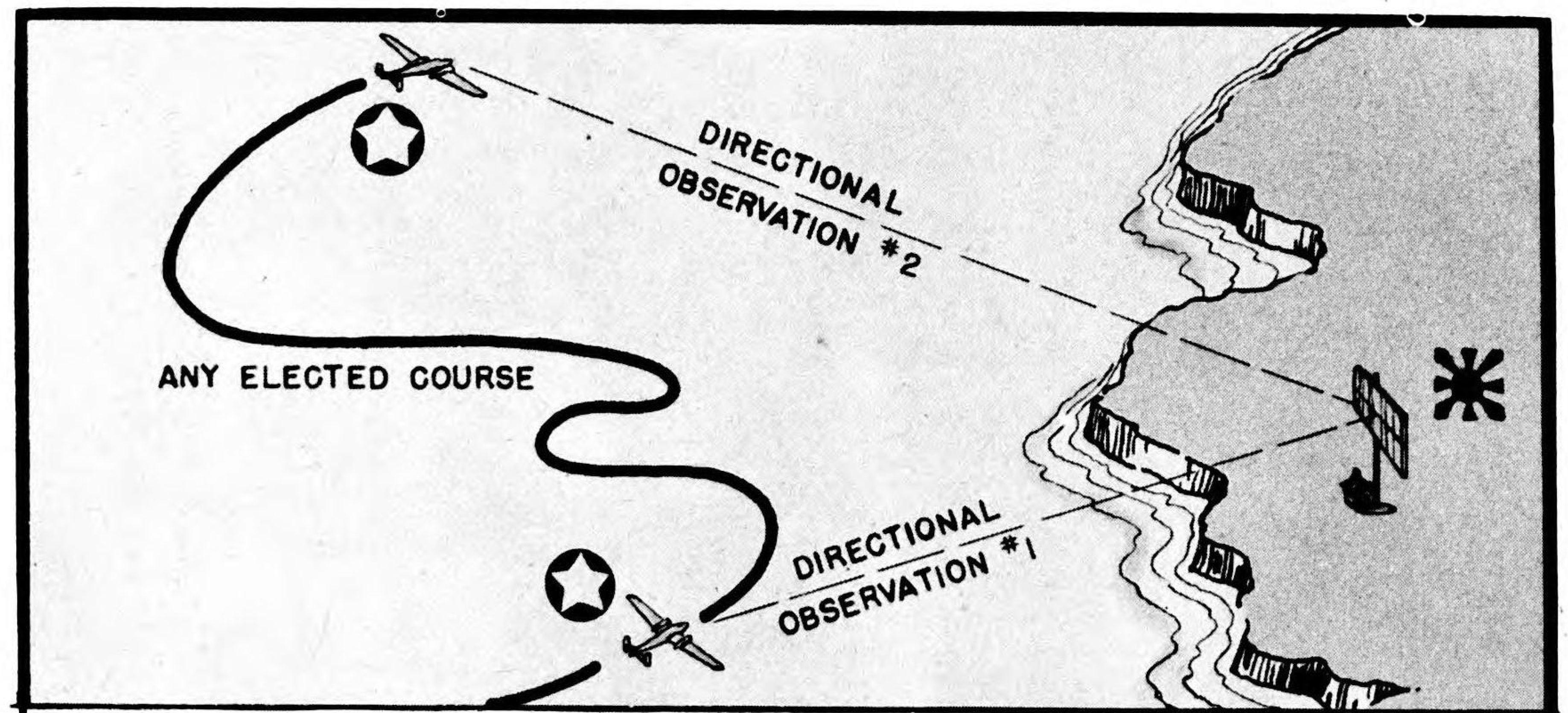
Homing equipment has not been found to be of any great practical value for radio and radar reconnaissance undertaken for the purpose of locating enemy installations. In operations of this type, it is necessary to turn the homing-equipped craft toward the target in order to determine its bearing and to repeat this operation from two or more locations. With aircraft this procedure causes the reconnaissance plane rapidly to approach dangerously close to the enemy installations. Furthermore, it is time-consuming because of the need for orienting the craft, first one way and then the other, to make certain it is on the correct heading. This operation often results in considerable doubt concerning the result, particularly if the radar signal is waxing and waning as it scans back and forth. The use of homing systems for spotting the locations of enemy installations, while possible, is not recommended. The use of a direction-finding system is preferable for this purpose.



When homing receivers are used for pin-pointing a transmitter location, it is necessary for the craft involved (it may be an aircraft, a vessel or other mobile vehicle) to follow at least two courses oriented toward the transmitter in order to obtain a fix. Since, in RCM activities, these operations are undertaken in enemy territory, the homing-equipped craft may have to approach undesirably close to enemy installations. Homing equipment is more useful for directing a craft toward a transmitter-target than for direction-finding purposes.

DIRECTION-FINDING SYSTEMS

A radio direction-finding system differs from a homing system in that the direction from which a signal is arriving may be determined directly from the indications of the direction-finder.



Direction-finding equipment is very useful for locating unknown transmitter sites. After two or more bearings are obtained the location of the transmitter may be ascertained by triangulation. In operations of this type, as contrasted to direction-finding with homing equipment, the search craft (it may be an aircraft, a vessel or other mobile vehicle) may follow any reasonable, elected course.

INTRODUCTION TO RECEIVERS

Equipment of this type is useful, not only in aircraft, but also in ground and seaborne craft or in fixed ground-based installations.

With a radio direction finder the direction toward a source of signals (radio, radar or jamming) may be ascertained without requiring the vehicle carrying the equipment to deviate from a prescribed course. Direction-finding equipment, while more complicated than homing equipment, does not necessarily require more skill for its operation; the reverse may, in fact, be true in some instances.

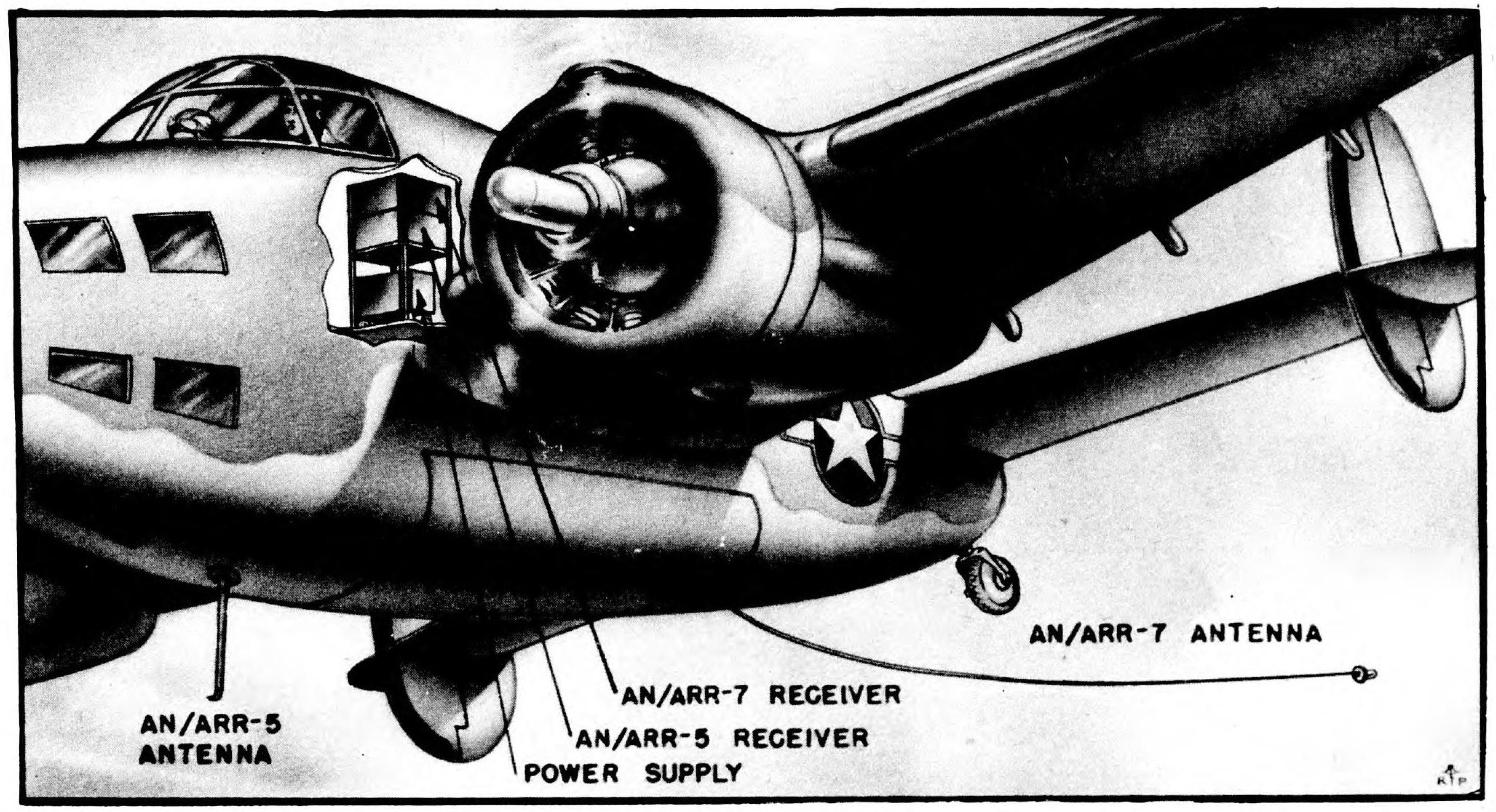
As with homing equipment, the polarization of the antenna of a direction-finder should be the same as that of the transmitter antenna. In the more elaborate systems provisions are made to obtain proper response from vertically, horizontally, and circularly polarized waves.

Direction-finding devices for use in the frequency range used for communication purposes are described elsewhere (Signal Communication Equipment Directory) and consequently are not covered here. On the following pages, however, information is given relative to equipment suitable for use in the radar-frequency bands.

SUMMARY OF RECEIVER EQUIPMENT

AN NUMBER	CODE NAME	FREQUENCY RANGE (MC)	TYPE OF OPERATION	REMARKS	PAGE NO.
ARR-5		27.8-143	GENERAL PURPOSE		64
ARR-7		0.55-28	GENERAL PURPOSE		56
SCR-587		38-3300	GENERAL PURPOSE	SUPERSEDED BY APR-4	68
	TUNING UNITS FOR SCR-587				70
APR-4		38-3300	GENERAL PURPOSE		72
	TUNING UNITS FOR APR-4				74
APR-5 A		1000-6000	GENERAL PURPOSE		76
APA-6X			PULSE ANALYZER	USED WITH GENERAL PURPOSE RECEIVERS	78
APA-11			PULSE ANALYZER	USED WITH GENERAL PURPOSE RECEIVERS	75
APA-10			PANORAMIC ADAPTER	USED WITH ARR-5, ARR-7 OR APR-4	80
APA-23			RECORDING ATTACHMENT	USED WITH APR-4 AND ARR-5	82
ARQ-5	NICKELODEON	18-80	PANORAMIC PRESENTATION		84
APR-2	AUTOSEARCH	90-1000	TAPE RECORDING AND AUTOMATIC SCANNING		86
APR-3	AMERICAN BOOZER	520-585 AND 477-497	WARNING AGAINST RADAR		88
APA-24	SETTER	100-750	DIRECTION FINDING ATTACHMENT	USED WITH APR-4 AND ARR-5	90
APA-17		300-1000	DIRECTION FINDING ATTACHMENT	USED WITH APR-4	92

RADIO RECEIVING SET AN/ARR-5

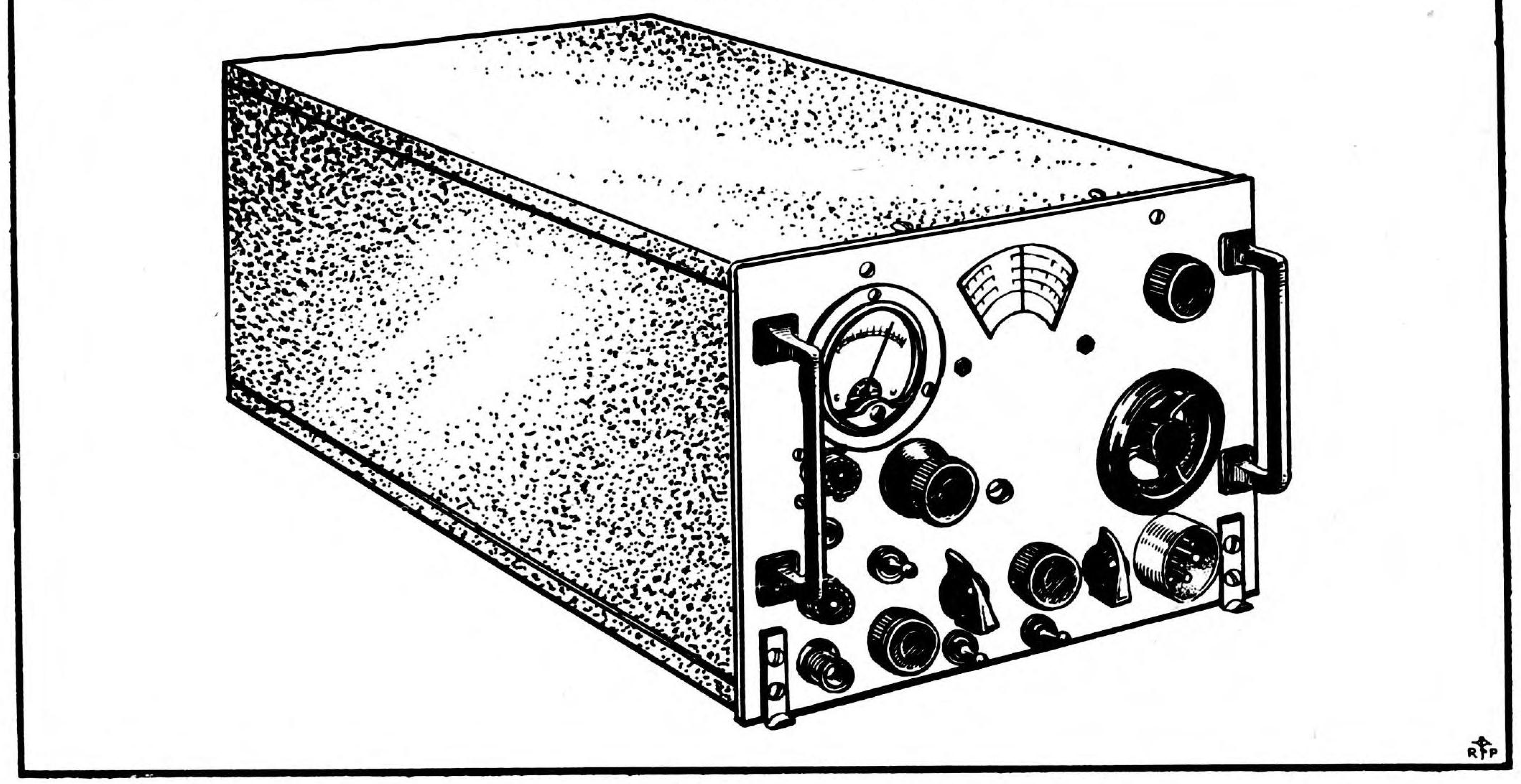


PURPOSE AN/ARR-5 is a general-purpose receiver for the frequency range from 27.8 to 143 Mc. It is especially adapted to countermeasure usage, however, since it has output connections for a pulse analyzer and a panoramic adapter. It is useful in general investigational work, in the setting of jammer frequency, and in most other countermeasure activities requiring the use of a receiver in this frequency range.

DESCRIPTION AN/ARR-5 consists of a single receiving unit (SARC B1-D) and an external rectifier power-supply unit (SARC A1-D). The power supply unit may also be used simultaneously to operate one or two other equipments (such as AN/ARR-7). The equipment provides the usual features of a standard communications receiver in its frequency range. Provision is also made for analysis of pulses by use of AN/APA-6 or AN/APA-11 in conjunction with this receiver, and also for fairly narrow-band (500 kc) panoramic reception by the use of AN/APA-10.

PERFORMANCE AN/ARR-5 is an extremely sensitive receiver for continuous-wave, amplitude-modulated, and frequency-modulated signal reception in the 27.8 to 143 Mc frequency range. Its performance compares favorably with that of any other standard receiver in its frequency range.

RECEIVER UNIT OF ARR-5



OPERATION The operation of AN/ARR-5 is essentially the same as that of any standard communications receiver in the same frequency range. The optional use of motor-driven tuning helps to reduce operator fatigue.

INSTALLATION AN/ARR-5 should be installed so that it is approximately level during normal flight, and so that the receiver unit is within reach of the operator. A whip antenna installation (see Antenna Section for details) is the most convenient type of antenna for this equipment.

PERSONNEL A properly trained operator is required with this equipment. Maintenance can be done by regular radio maintenance personnel properly supervised.

SPECIFICATIONS

FREQUENCY RANGE: 27.8 to 143 Mc in three bands: 27.8 to 47 Mc, 46 to 82 Mc, and 82 to 143 Mc.

INPUT POWER: 100 watts, 80 or 115 volts, 400 to 2600 cps. a.c. and 30 watts, 28 volts d.c.

SENSITIVITY: .05 watt output for 25 microvolts impressed upon the input terminals of the receiver.

TYPES OF SIGNALS RECEIVABLE: CW, AM, FM, and pulses.

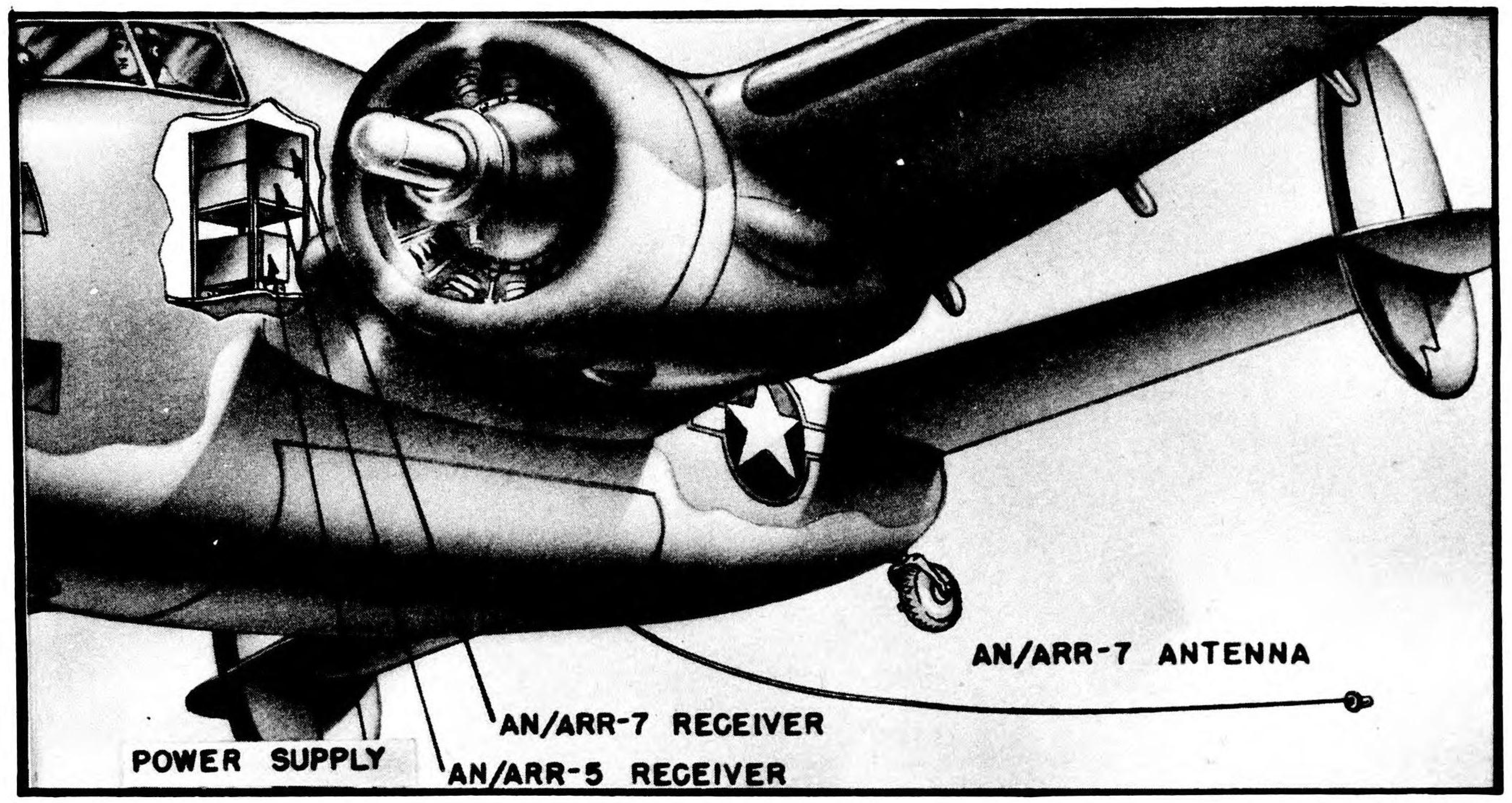
RECEIVER BANDWIDTH: 8 or 20 kc (adjustable) for AM: 150 kc for FM.

OUTPUT BANDWIDTH: 100 kc.

SIZE AND WEIGHT: Receiver unit SARC B1-D, 35 lbs. Power supply unit (for use with more than one receiver) SARC A1-D, 25 lbs.

STATUS Moderate production under way. Equipment Unclassified.
T. O. #: AN-08-30 ARR5-2.

RADIO RECEIVING SET AN/ARR-7



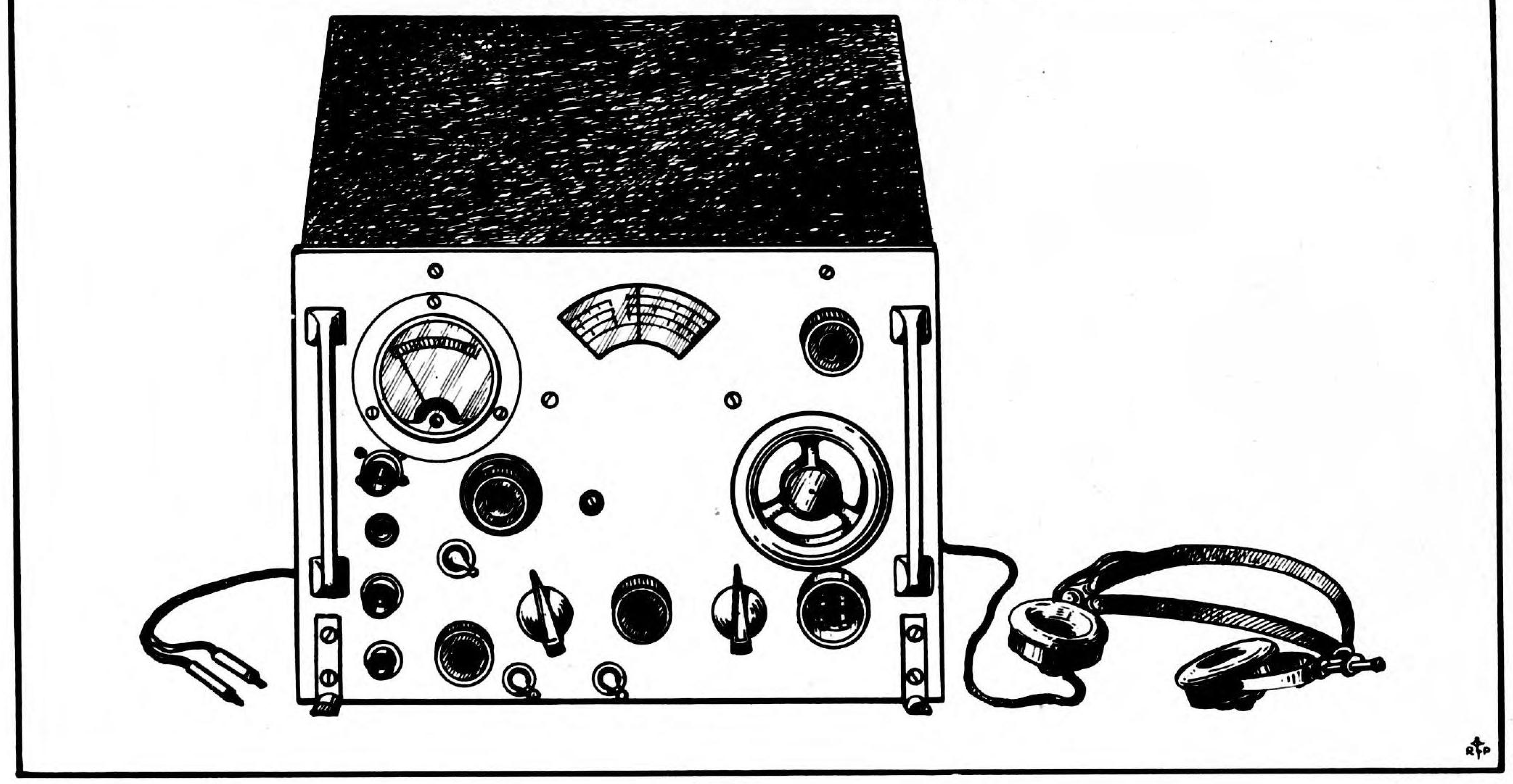
PURPOSE AN/ARR-7 is a general-purpose receiver for the frequency range from 550 kc to 28 Mc. It is especially adapted to countermeasures usage, however, since it has output connections for a pulse analyzer and a panoramic adapter. It is useful in general investigational work, in the setting of jammer frequency, and in most other countermeasures activities requiring the use of a receiver in this frequency range.

DESCRIPTION AN/ARR-7 consists of a single receiving unit (SARC B1-D) and an external power-supply rectifier unit (SARC A1-D). The power-supply unit may also be used simultaneously to operate one or two other equipments (such as AN/ARR-5). The equipment provides the usual features of a standard communication receiver in its frequency range. Provision is also made for analysis of pulses by use of AN/APA-6 or AN/APA-11 in conjunction with this receiver, and also for fairly narrow-band (100 kc) panoramic reception by the use of AN/APA-10.

PERFORMANCE AN/ARR-7 is an extremely sensitive receiver for continuous-wave or amplitude-modulated signals in the 550 kc to 28 Mc frequency band. Its performance compares favorably with that of any other standard receiver in its frequency range.

OPERATION The operation of AN/ARR-7 is essentially the same as that of any standard communications receiver in the same frequency range. The optional use of motor-driven tuning over an adjustable portion of the receiver band helps to reduce operator fatigue.

RECEIVER UNIT OF ARR-7



INSTALLATION AN/ARR-7 should be installed so that it is approximately level during normal flight, and so that the receiver unit is within reach of the operator. It is necessary to provide an antenna for the equipment. In most airborne installations a trailing wire antenna will be used (see Antenna Section for details).

PERSONNEL A properly trained operator is required with this equipment. Maintenance can be done by regular radio maintenance personnel properly supervised.

SPECIFICATIONS

FREQUENCY RANGE: 550 kc to 28 Mc, in 6 bands: 550 kc to 1.6 Mc, 1.5 to 3.1 Mc, 2.9 to 5.9 Mc, 5.75 to 11.5 Mc, 10.3 to 21.5 Mc, 20.4 to 28 Mc.

INPUT POWER: 140 watts, 80 to 115 volts, 400 to 2600 cps, a.c. and 30 watts, 28 volts d.c.

SENSITIVITY: Greater than 50 milliwatts output for 10 microvolts impressed upon the input terminals of receiver.

TYPES OF SIGNALS RECEIVABLE: CW, AM, and wide pulses.

OUTPUT CIRCUIT BANDWIDTH: 25 kc.

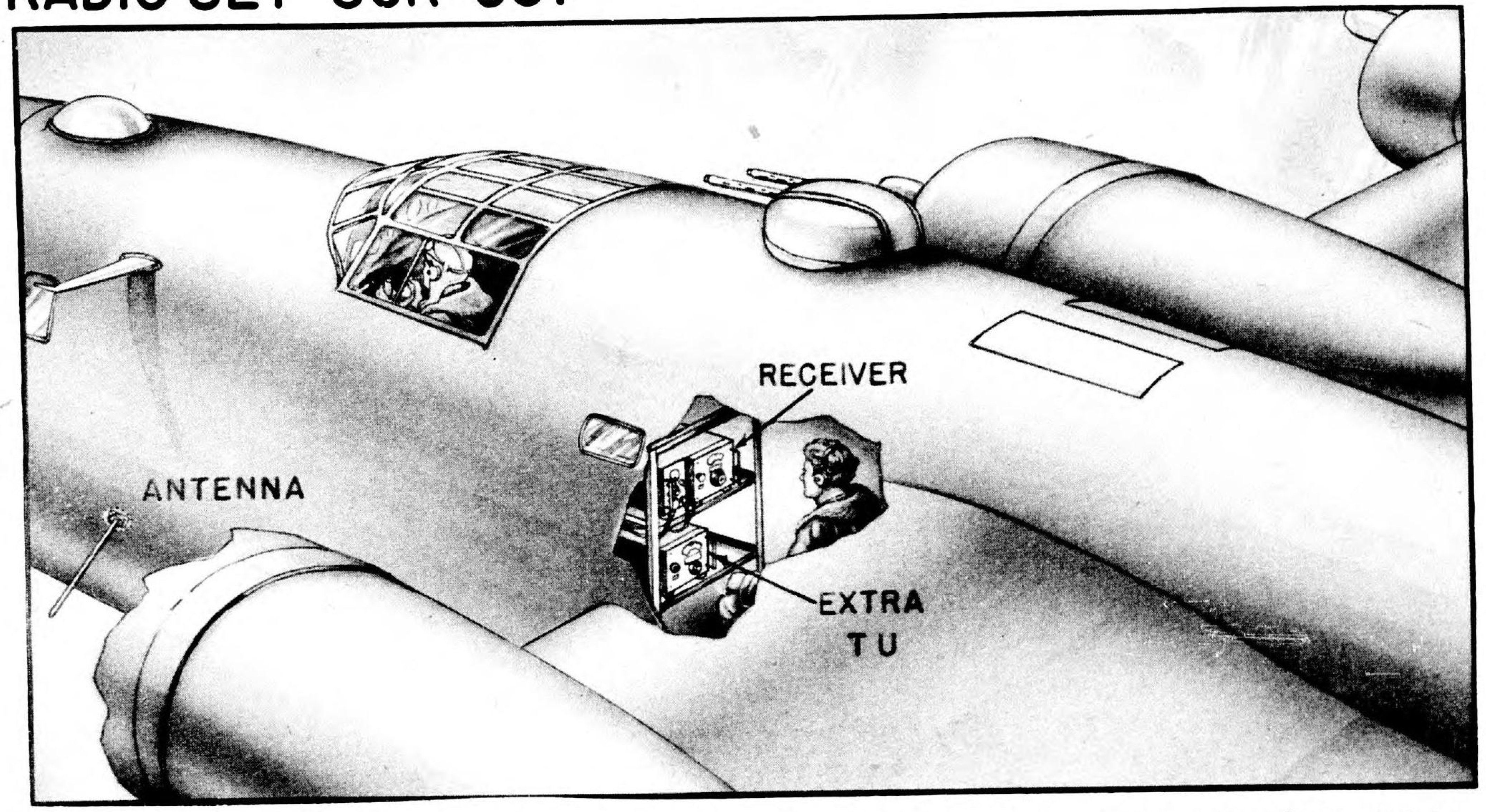
SELECTIVITY: Maximum, (with crystal filter) 1 kc; minimum, 10 kc.

SIZE AND WEIGHT: Receiver Unit - SARC B1-D, approximately 40 lbs. Power supply Unit (for use with up to three receivers) SARC A1-D, 25 lbs.

TECHNICAL FEATURES: AN/ARR-7 is a modification of the SX-28 Hallicrafter Communications Receiver. It consists of two stages of r-f amplification followed by a local oscillator and mixer and a 455 kc i-f amplifier. This is in turn followed by a detector and an audio system. The equipment also includes an automatic noise limiter, a beat-frequency oscillator, an 'S' meter, a phasing circuit for single-signal reception, and motor-driven adjustable sector tuning. In order to make possible the reception of wide pulses, the crystal filter may be cut out of the i-f amplifier circuit by throwing a switch on the panel.

STATUS Moderate production under way. Equipment Unclassified.

RADIO SET SCR-587

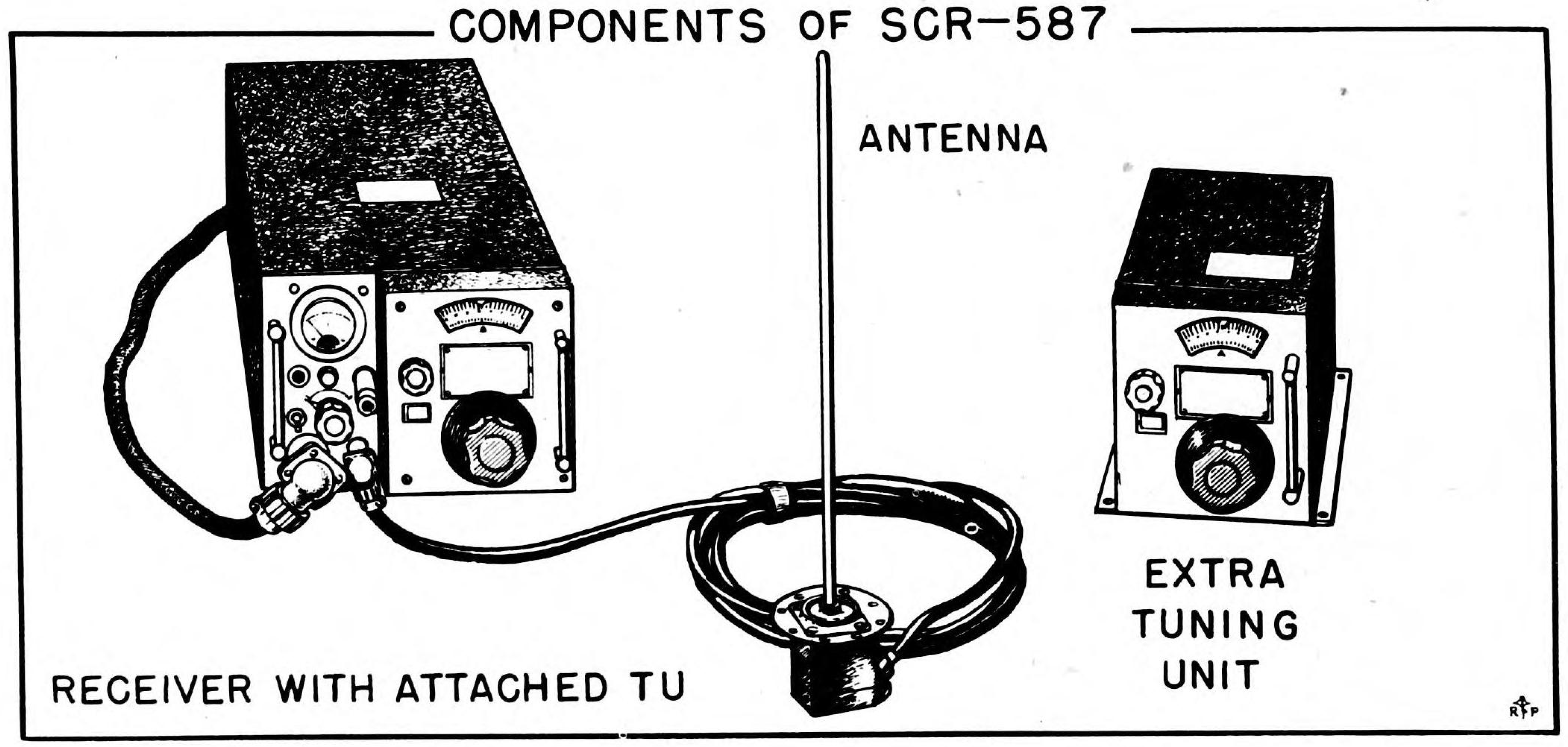


PURPOSE SCR-587 is an airborne search receiver for intercepting enemy radar and communication signals in the frequency range from 38 to 3300 Mc. This range includes the frequencies of all known and probable enemy radar systems, as well as many enemy communication channels. The equipment provides necessary information to determine effective counter measures.

DESCRIPTION SCR-587 comprises a radio receiver unit and four interchangeable r-f tuning units. Each tuning unit covers a portion of the complete frequency range. Several types of tuning units, employing different control features, are available. They are separately described hereafter. The receiver and one tuning unit are contained in one box (approximately SARC B1-D). A case is supplied to hold the other three tuning units, each contained in a small box. The set is designed for operation from a d-c source and is fitted with jacks for headphones and for an oscilloscope or analyzer. Its installed weight with antenna, transmission line and heaviest tuning unit is 43 pounds.

PERFORMANCE The set can receive signals from a much greater distance than a radar can detect the aircraft in which it is installed. It can discriminate between several closely adjacent signals. The accuracy of the frequency calibration is within ± 1% throughout its range. With motor control of tuning in the range from 38 to 1000 Mc the dial automatically sweeps back and forth across the tuner range once every minute. The 1000-3300 Mc tuning range is manually tuned with two-dial control.

COMPONENTS OF SCR-587



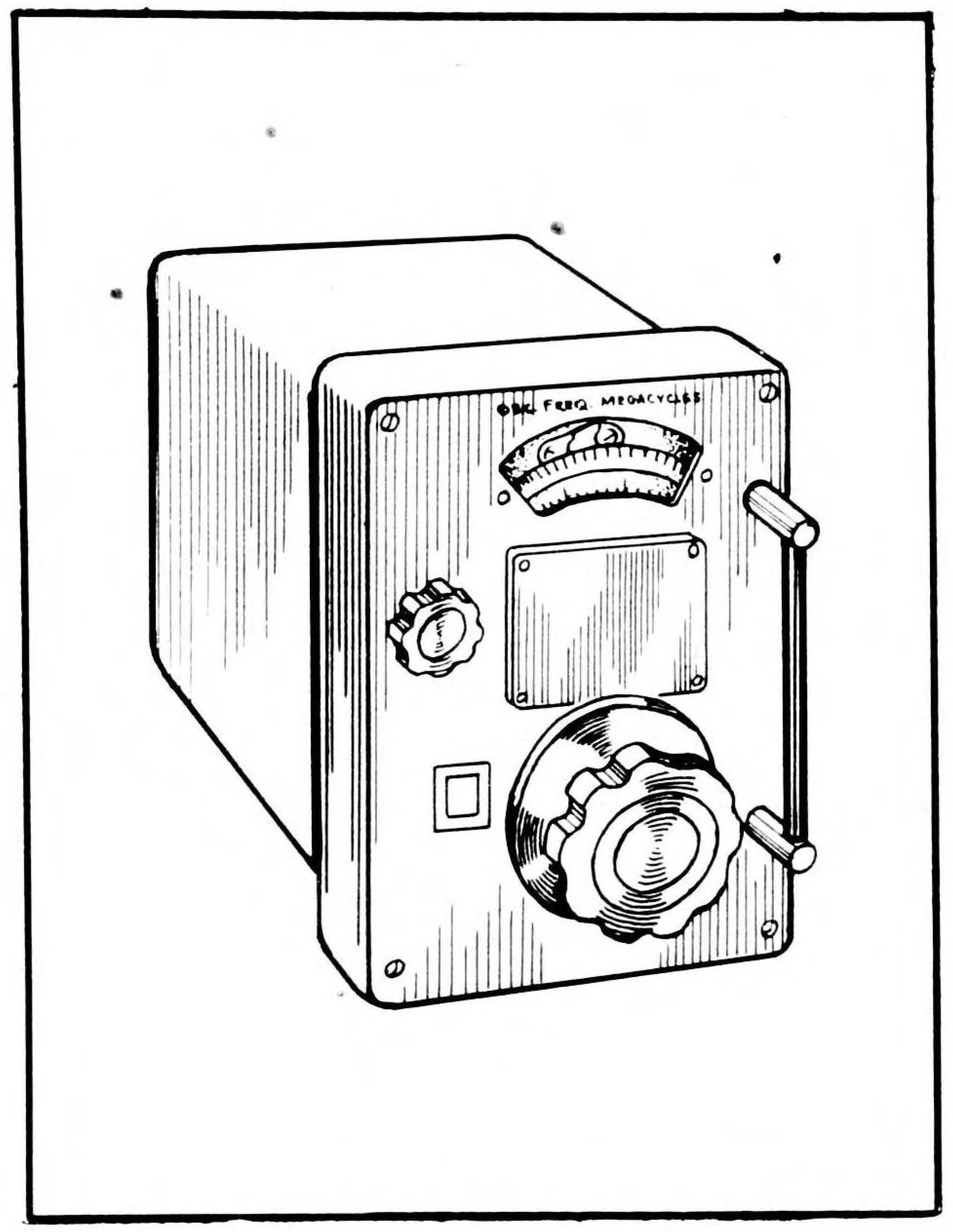
OPERATION A signal is tuned in by aid of headphones to determine its frequency and general characteristics. Specific characteristics are determined by aid of an oscilloscope or pulse analyzer, such as AN/APA-6 or AN/APA-11. The procedure requires the constant attention of the radio operator who, presumably, has no other duties at the time.

INSTALLATION The receiver should be securely mounted within reach of the radio operator and should be approximately level when the plane is in level flight. For non-directional reception, the antenna should be installed where its view of the transmitter to be received will not be obscured by large metal surfaces when the plane is in normal flight. It may be mounted at a 45-degree angle in order to receive either horizontally or vertically polarized signals.

PERSONNEL A specially trained operator is required for this equipment. Maintenance can be done by properly supervised radar mechanics.

SPECIFICATIONS
FREQUENCY RANGE: 38 to 3300 Mc, covered by 4 tuning units.
INPUT POWER: 90 watts, 28 volts, d.c.
OUTPUT: Audio and video (2 Mc wide)
SENSITIVITY: Depends on tuning unit.
DIAL ACCURACY: Within ± 1%.
ANTENNA: Depends on tuning unit, described elsewhere.
TUNING UNITS: Manual: TU-58A (80 to 370 Mc), TU-57A (290 to 950 Mc), TU-59A (1000 to 3300 Mc)
Motor Drive: TU-56A (38 to 95 Mc), TU-58B (75 to 300 Mc), TU-57B (300 to 1000 Mc)
TEST EQUIPMENT: TS-47/APR, TS-92/AP . GR-804-C.
SIZE AND WEIGHT: Approximately SARC B1-D, 22 pounds plus TU.
TECHNICAL FEATURES: SCR-587 comprises a tuning unit with antenna tuner, oscillator and mixer, a 5-stage i-f amplifier, a second detector and AVC, an output amplifier, and a heterotone oscillator for modulating unmodulated signals. Operating voltages supplied from self-contained dynamotor.

STATUS Light production completed. Equipment Restricted;
T. O. #: CO-AN-08-15GB-1.



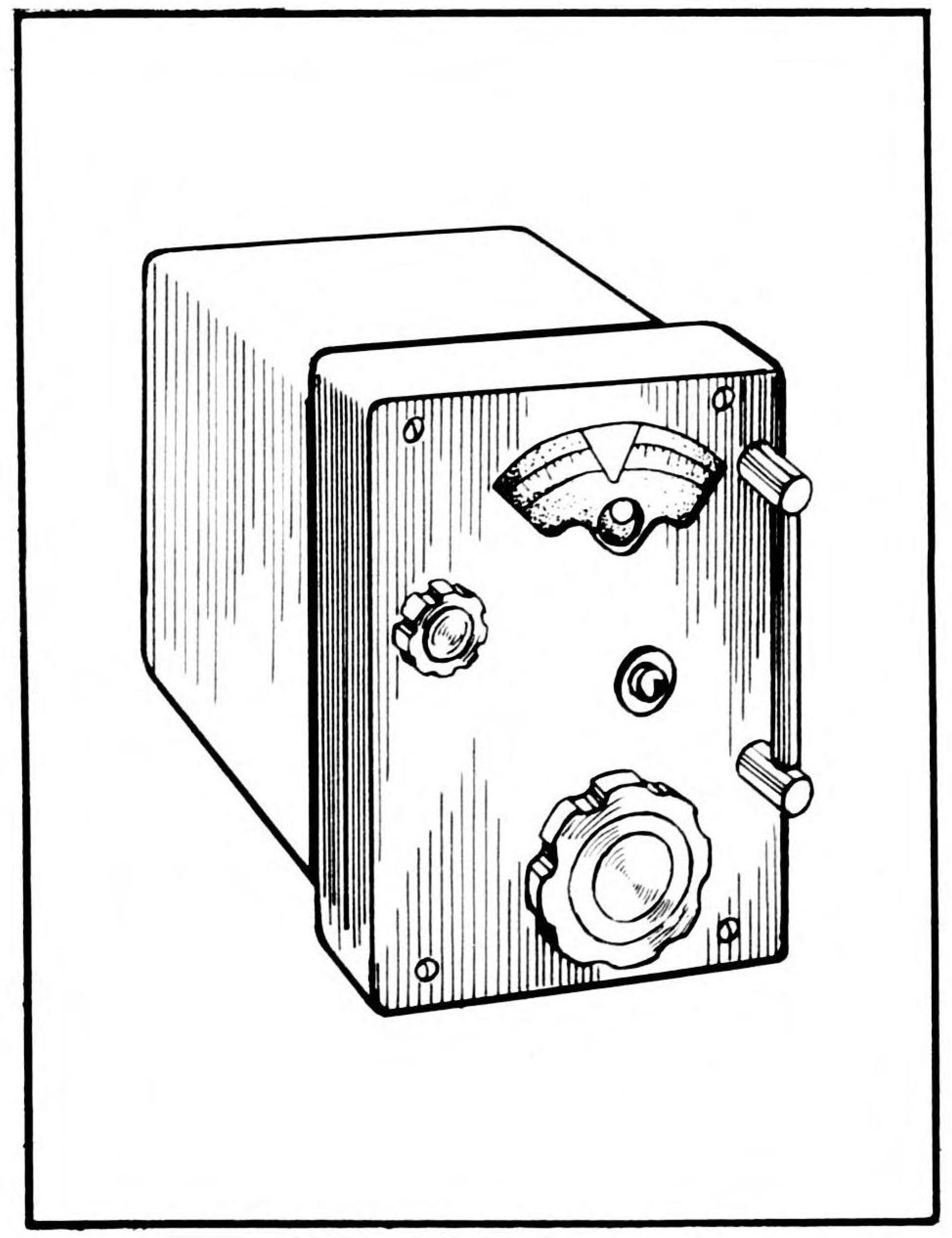
TUNING UNITS TU-57A & TU-58A

PURPOSE: TU-57A and TU-58A are interchangeable r-f tuning units used with SCR-587 search receiver in covering the frequency range from 80 to 950 Mc. Both provide manual control of two-dial tuning. TU-58A tunes from 80 to 370 Mc and TU-57A from 280 to 950 Mc.

DESCRIPTION: Each unit is contained in a box which slides on tracks into the tuning-unit well of the SCR-587. Except for their frequency dials, they are identical in external appearance. Each consists of a 'butterfly' type of tuner and local oscillator. In the TU-58A the mixer is a vacuum tube and in the TU-57A it is a crystal. Each unit is fitted with jacks and plugs for connection to the other circuits of the receiver. Both are quite sensitive and selective. Care must be taken by the operator to avoid spurious indication due to image and harmonic responses. These units are now being replaced by TU-57B and TU-58B.

SPECIFICATIONS:
FREQUENCY RANGE: 80 to 370 and 280 to 950 Mc, two dial manual control.
INPUT POWER: from receiver chassis.
ANTENNA: AN/97A
SIZE AND WEIGHT: Each unit 7-11/16" x 6-7/16" x 12-1/2", 11.5 pounds.

STATUS: Light production completed. Equipment restricted.



TU-59A

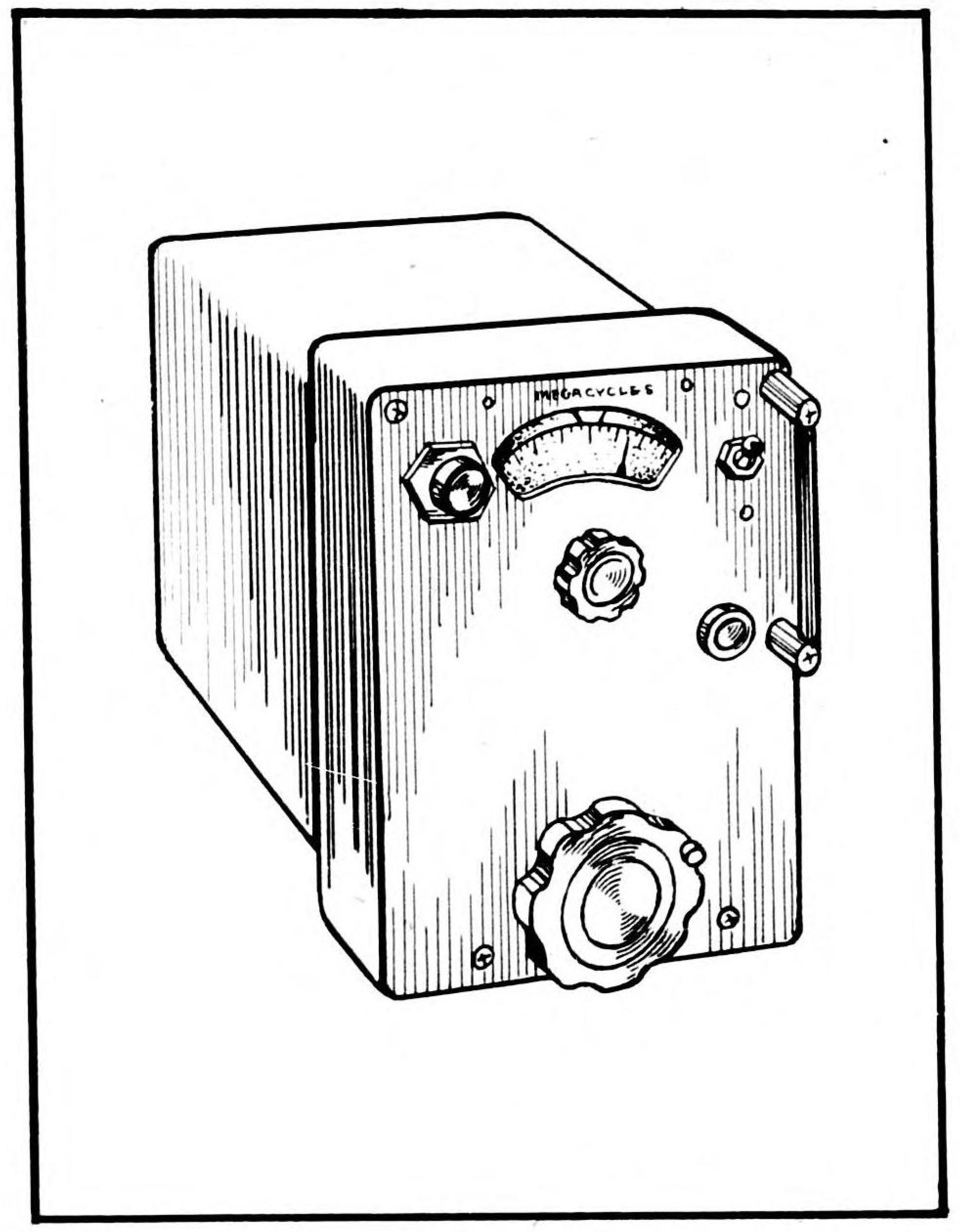
PURPOSE: TU-59A is a manually-tuned two-dial r-f tuning unit covering the frequency range from 1000 to 3300 Mc. TU-59A is intended for use with SCR-587 (or AN/APR-4) search receiver. It is interchangeable with the other tuning units for the respective receivers.

DESCRIPTION: Each unit is contained in a box which slides on tracks into the tuning-unit well of the receiver. It uses a 'butterfly' type of tuner with a vacuum tube oscillator and crystal mixer. It is fitted with jacks and plugs for connection to the other circuits of the receiver. Care must be taken by the operator to avoid spurious indication due to image and harmonic responses.

SPECIFICATIONS:
FREQUENCY RANGE: 1000 to 3300 Mc, two-dial manual control.
INPUT POWER: 300 volts from receiver chassis plus 28 watts, 28 volts d.c.

SENSITIVITY: 10 to 200 microvolts for a minimum audible signal with 50% modulation.
ANTENNA: AS-29/APR.
SIZE AND WEIGHT: 7-11/16" x 6-7/16" x 12-1/2", 13 pounds.

STATUS: Light production completed. Equipment restricted.



TUNING UNIT TU-56A

PURPOSE: TU-56A is an interchangeable r-f tuning unit used with SCR-587 (or AN/APR-4) search receiver in covering the frequency range from 38 to 95 Mc. It provides motor-drive control of single dial tuning. The dial is swept back and forth across the frequency range at an adjustable speed and can be stopped for manual tuning.

DESCRIPTION: The unit is contained in a box which slides on tracks into the tuning unit well of the receiver. It uses conventional tuner circuits with vacuum tubes for both oscillator and mixer. It is fitted with jacks and plugs for connection to the other circuits of the receiver. It is quite sensitive and selective.

SPECIFICATIONS:
FREQUENCY RANGE: 38 to 95 Mc, motor drive single dial tuning.
INPUT POWER: From receiver chassis, plus 10 watts, 28 volts d.c.
SENSITIVITY: About 5 microvolts for minimum audible signal 50% modulated.
IMAGE REJECTION: 35 to 60 db.
ANTENNA: AN-38/APT.
SIZE AND WEIGHT: 7-11/16" x 6-7/16" x 12-1/2", 10 pounds.

STATUS: Light production completed. Equipment restricted.

TUNING UNIT TU-58B

PURPOSE: TU-58B is an interchangeable r-f tuning unit used with SCR-587 (or AN/APR-4) search receiver in covering the frequency range from 75 to 300 Mc. It provides motor-drive control of single dial tuning. The dial is swept back and forth across the frequency range at an adjustable speed and can be stopped for manual tuning.

DESCRIPTION: The unit is contained in a box which slides on tracks into the tuning unit well of the receiver. It uses a 'butterfly' tuner circuit with vacuum tubes as oscillator and mixer. It is fitted with jacks and plugs for connection to the other circuits of the receiver. It is quite sensitive and selective.

SPECIFICATIONS:
FREQUENCY RANGE: 75 to 300 Mc, motor drive of single dial tuning.
INPUT POWER: From receiver chassis, plus 10 watts, 28 volts d.c.
SENSITIVITY: 2 to 10 microvolts for minimum audible signal in headphones with 50% modulated signal.
IMAGE REJECTION: 15 to 45 db.
ANTENNA: AN-38/APT.
SIZE AND WEIGHT: 7-11/16" x 6-7/16" x 12-1/2", 13 pounds.

STATUS: Light production under way. Equipment restricted.

TUNING UNIT TU-57B

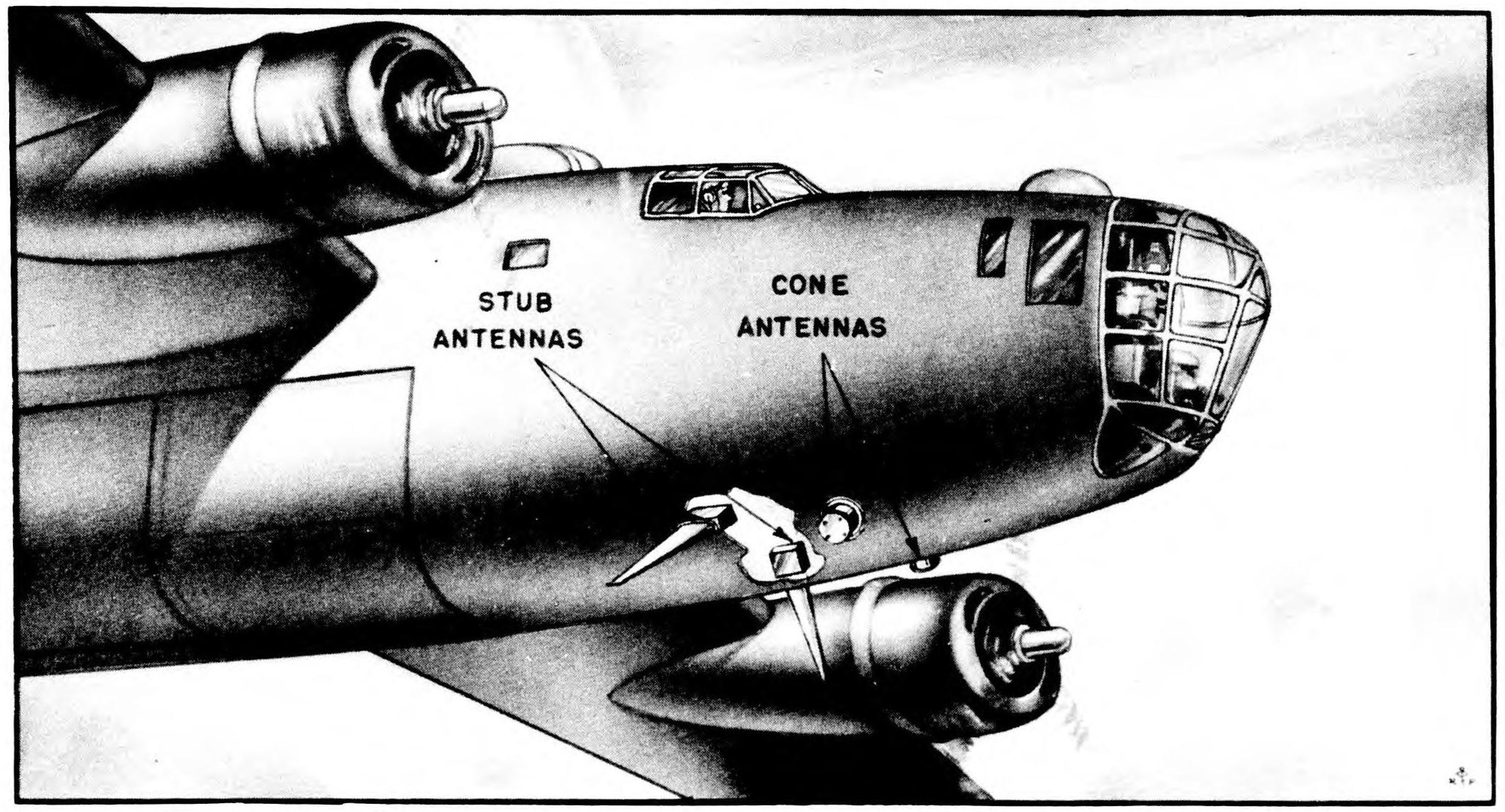
PURPOSE: TU-57B is an interchangeable r-f tuning unit used with SCR-587 (or AN/APR-4) search receiver in covering the frequency range from 300 to 1000 Mc. It provides motor-drive control of single dial tuning. The dial is swept back and forth across the frequency range at an adjustable speed and can be stopped for manual tuning.

DESCRIPTION: The unit is contained in a box that slides on tracks into the tuning unit well of the receiver. It uses a 'butterfly' type of tuner for the vacuum tube oscillator and crystal mixer. It is fitted with jacks and plugs for connection to the other circuits of the receiver. It is quite sensitive and selective.

SPECIFICATIONS:
FREQUENCY RANGE: 300 to 1000 Mc, motor drive of single dial tuning.
INPUT POWER: From receiver chassis, plus 10 watts, 28 volts d.c.
SENSITIVITY: 3 to 16 microvolts for minimum audible signal with 50% modulation.
IMAGE REJECTION: 10 to 45 db.
ANTENNA: AS-29/APR.
SIZE AND WEIGHT: 7-11/16" x 6-7/16" x 12-1/2". 13 pounds.

STATUS: Light production under way. Equipment restricted.

RECEIVING EQUIPMENT AN/APR-4



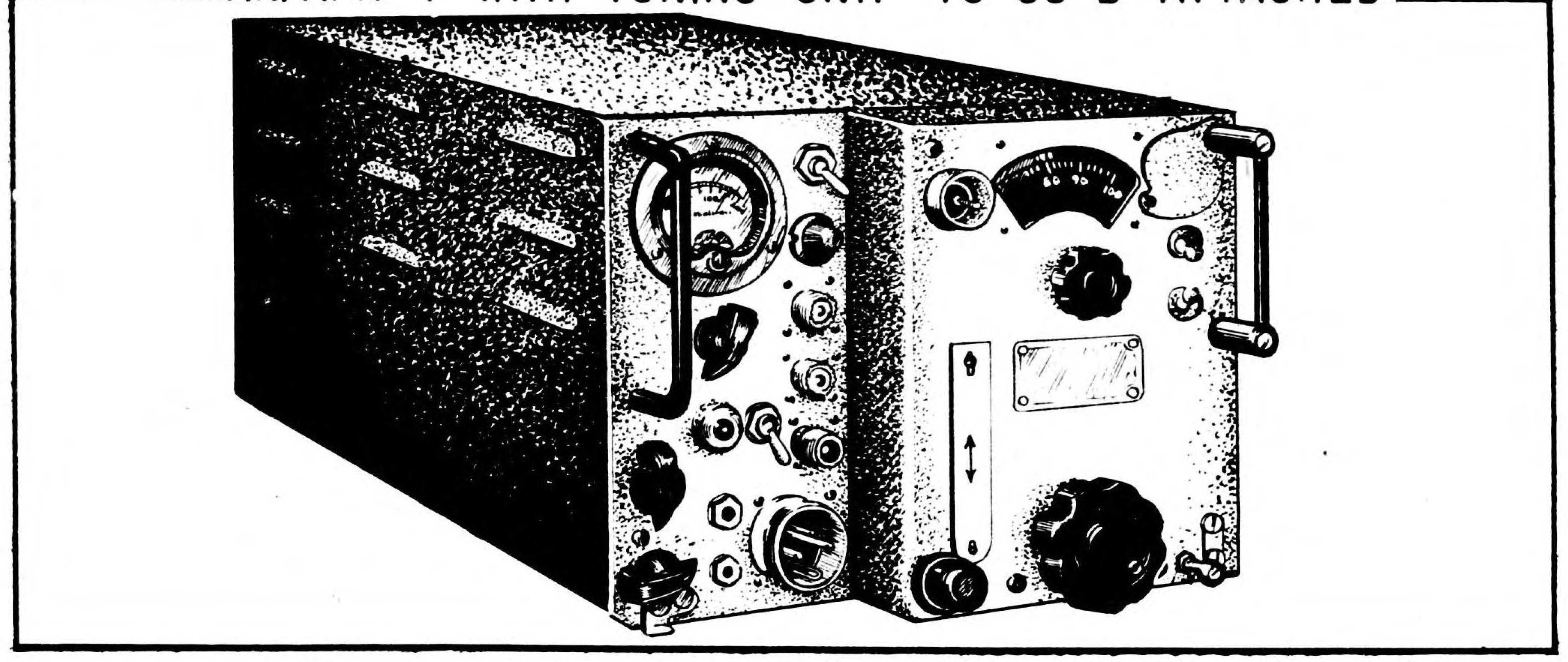
PURPOSE AN/APR-4 is an airborne search receiver for intercepting enemy radar and communication signals in the frequency range from 38 to 3300 Mc. This range includes the frequencies of all known and probable enemy radar systems, as well as many enemy communication channels. The equipment provides necessary information for determining effective counter measures.

DESCRIPTION AN/APR-4 is an improved version of SCR-587, which it is designed to replace. It comprises an assembly of three rapidly replaceable sub-assemblies: r-f tuning unit, i-f amplifier unit and power supply unit. Four interchangeable r-f tuning units are supplied, each covering a portion of the complete frequency range. Choice of two types of motor-driven tuning units may be had for the 38 to 1000 Mc range, either with or without an adjustable sector sweep at any desired part of the tuning range. These may also be manually tuned with one-dial control. The unit covering the 1000 to 3300 Mc range is manually tuned with two-dial control. The i-f amplifier has a gain control, optional automatic volume control, and can be switched to provide a wide or narrow bandwidth.

The assembly with one tuning unit is contained in a single box (SARC B1-D). A case is supplied to hold the other three tuning units. The set is designed for operation from an a-c source and is fitted with jacks for headphones and oscilloscope or analyzer. Its installed weight with antenna, transmission line and heaviest tuning unit is 44 pounds.

PERFORMANCE Sensitivity depends upon the tuning unit (frequency) and is so great at all frequencies that signals can be received from a much greater distance than a radar can detect the plane in which the set is installed. The accuracy of the frequency calibration averages ± 1% throughout the range and the set is especially adapted

AN/APR-4 WITH TUNING UNIT TU-58-B ATTACHED



to discriminate between closely adjacent signals. Since the accepted bandwidth can be changed, the wide bandwidth (4 Mc) is used for general searching and the narrow (0.5 Mc) for signal discrimination. With motor control of tuning, the dial sweeps back and forth across the range once every minute. With the sector-sweep type of tuner the speed and frequency coverage can be changed as desired.

OPERATION A signal is tuned in with the aid of headphones to determine its frequency and general characteristics. Specific characteristics are determined by aid of an oscilloscope or pulse analyzer, such as AN/APA-6 or AN/APA-11. The procedure requires the constant attention of the radio operator who, presumably, has no other duties at the time.

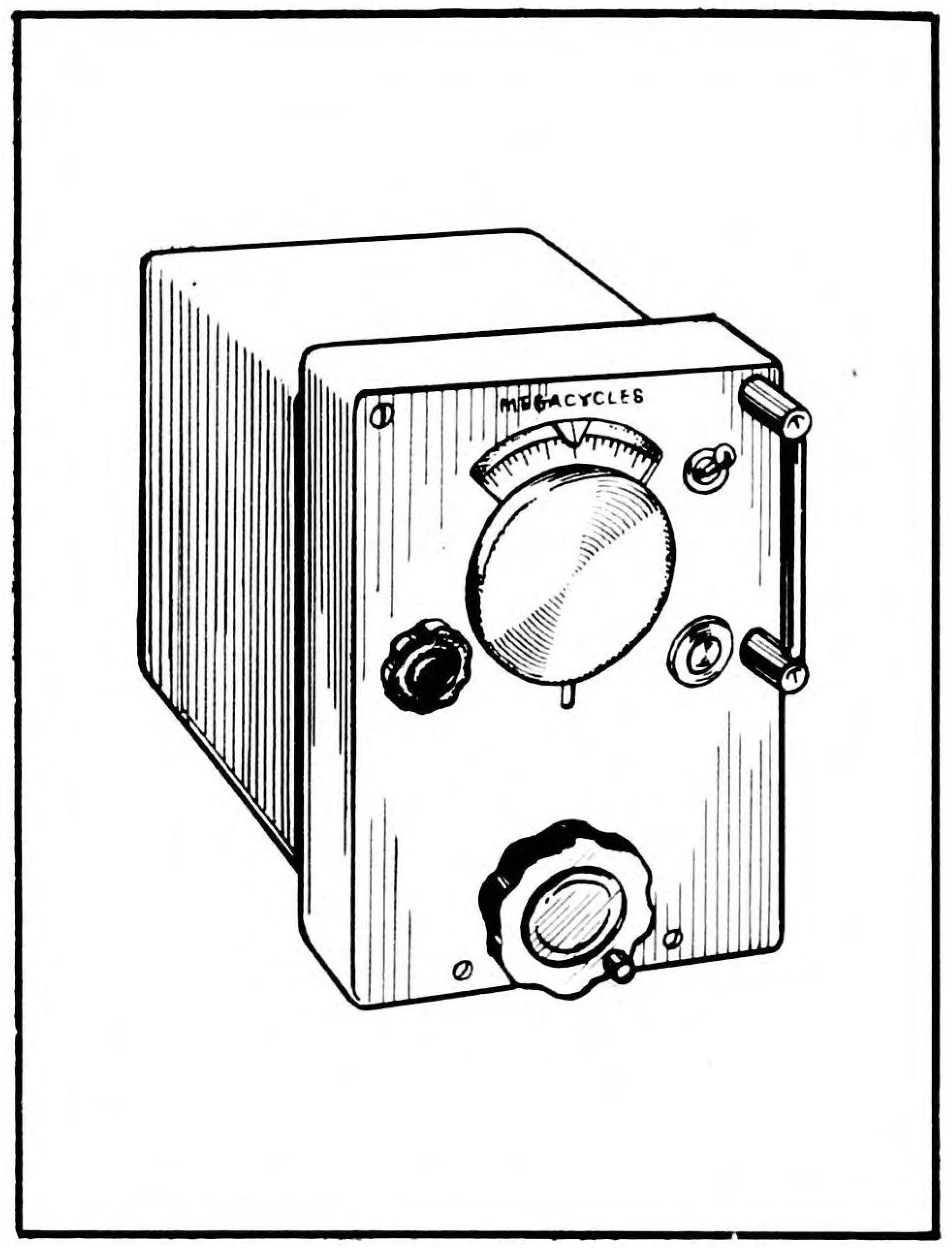
INSTALLATION The receiver should be securely mounted within reach of the radio operator and should be approximately level when the plane is in level flight. For non-directional reception, the antennas should be installed where their view of the radar to be jammed will not be obscured by large metal surfaces when the plane is in normal flight. They may be mounted at a 45-degree angle in order to receive either horizontally or vertically polarized signals.

PERSONNEL A specially trained operator is required for this equipment. Maintenance can be done by properly supervised radar mechanics.

SPECIFICATIONS
FREQUENCY RANGE: 38 to 3300 Mc, covered by 4 tuning units.
INPUT POWER: 90 watts, 80 or 115 volts, 60 to 2600 cps, a.c. plus 10 watts, 28 volts d.c.
SENSITIVITY: Depends on tuning unit.
DIAL ACCURACY: Within ± 1%.
ANTENNA: Depends on tuning unit.
TUNING UNITS: Without sector sweep: TU-56A, TU-57B, TU-58B, TU-59B. With sector sweep: AN/TN-16/APR-4, AN/TN-17/APR-4, AN/TN-18/APR-4, AN/TN-19/APR-4. (two-dial control).
TEST EQUIPMENT: TS-92/AP, TS-47/APR, and NAVY LAE, LAF, LAG.
SIZE AND WEIGHT: SARC B1-D, 18 pounds plus TU.

STATUS Moderate production under way. Equipment Restricted.

TUNING UNIT TN-16/APR-4



PURPOSE: TN-16/APR-4 is an interchangeable r-f tuning unit used with AN/APR-4 in covering the frequency range from 38 to 95 Mc. It provides motor-drive control of single-dial tuning and has an adjustable sector sweep which permits automatic search of any desired part of the tuning range. The rate of sweep can be varied over a 2:1 range. The sector sweep does not interfere with manual tuning over the entire range.

DESCRIPTION: The unit is contained in a box to be slid on tracks into the tuner well of the receiver. It uses tuner circuits with vacuum tubes as oscillator and mixer. It is fitted with jacks and plugs for connection to the other circuits of the receiver. It is quite sensitive and selective.

SPECIFICATIONS:
FREQUENCY RANGE: 40 to 105 Mc, motor drive, single dial, with sector sweep.
INPUT POWER: From receiver chassis.
SENSITIVITY: About 5 microvolts for minimum audible signal 50% modulated.
IMAGE REJECTION: 35 to 60 db.
ANTENNA: AN-38/APT.
SIZE AND WEIGHT: 7-11/16" x 6-7/16" x 12-1/2", 10-1/2 pounds.

STATUS: Moderate production under way. Equipment restricted.

TN-19/APR-4, which is similar in appearance to TU-59A (see page 70) and previously covered the same frequency range, has recently been changed. TN-19/APR-4 now covers 950 to 2200 Mc and single-dial tuning is employed. (This does not affect TU-59A). TN-54/APR-4 is a new development and will extend the total range since it covers 2200 to 4400 Mc.

TUNING UNIT TN-17/APR-4

PURPOSE: TN-17/APR-4 is an interchangeable r-f tuning unit used with AN/APR-4 in covering the frequency range from 75 to 300 Mc. It provides motor-drive control of single-dial tuning and has an adjustable sector sweep which permits automatic search of any desired part of the tuning range. The rate of sweep can be varied over 2:1 range. The sector sweep does not interfere with manual tuning over the entire range.

DESCRIPTION: The unit is contained in a box to be slid on tracks into the tuner well of the receiver. It uses a novel 'butterfly' type of tuner with vacuum tubes as oscillator and mixer. It is fitted with jacks and plugs for connection to the other circuits of the receiver. It is quite sensitive and selective.

SPECIFICATIONS:
FREQUENCY RANGE: 75 to 300 Mc, motor drive of single dial tuning with sector sweep.
INPUT POWER: From receiver chassis.
IMAGE REJECTION: 10 to 45 db.
SENSITIVITY: 3 to 16 microvolts for a maximum audible signal with 50% modulation.
ANTENNA: AS-29/APR.
SIZE AND WEIGHT: 7-11/16" x 6-7/16" x 12-1/2", 13-1/2 pounds.

STATUS: Moderate production under way. Equipment restricted.

TUNING UNIT TN-18/APR-4

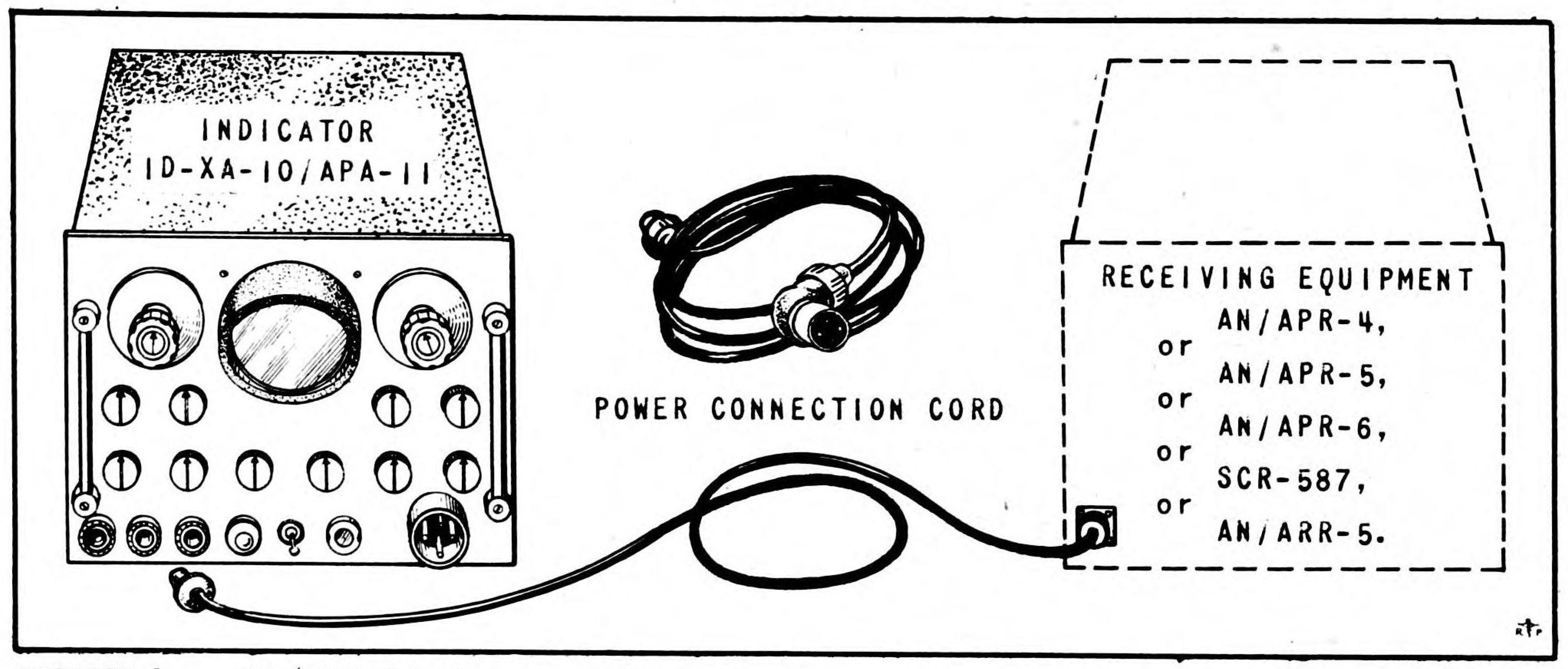
PURPOSE: TN-18/APR-4 is an interchangeable r-f tuning unit used with AN/APR-4 in covering the frequencies from 300 to 1000 Mc. It provides motor-drive control of single-dial tuning and has an adjustable sector sweep which permits automatic search of any desired part of the tuning range. The rate of sweep can be varied over 2:1 range. The sector sweep does not interfere with manual tuning over the entire range.

DESCRIPTION: The unit is contained in a box to be slid on tracks into the tuner well of the receiver. It uses a novel 'butterfly' type of tuner with a vacuum tube oscillator and crystal mixer. It is fitted with jacks and plugs for connection to the other circuits of the receiver. It is quite sensitive and selective.

SPECIFICATIONS:
FREQUENCY RANGE: 300 to 1000 Mc, motor drive of single dial tuning, with sector sweep.
INPUT POWER: From receiver chassis.
SENSITIVITY: 2 to 10 microvolts for a minimum audible signal with 50% modulation.
IMAGE REJECTION: 15 to 45 db.
ANTENNA: AN-38/APT.
SIZE AND WEIGHT: 7-11/16" x 6-7/16" x 12-1/2", 13-1/2 pounds.

STATUS: Moderate production under way. Equipment restricted.

RADAR INDICATOR ASSEMBLY AN/APA-11



PURPOSE & DESCRIPTION AN/APA-11 is an airborne pulse analyzer for use with search receivers in determining the characteristics of enemy radar and communication systems. It shows the shape, amplitude, duration, and repetition rate of pulsed signals and the modulation envelope of modulated signals. Such information is essential in deciding upon the most effective jamming tactics. AN/APA-11 is an improved version of AN/APA-6X. It incorporates a built-in oscilloscope and an audio-frequency oscillator. It consists of a single unit (SARC B1-D).

PERFORMANCE AN/APA-11 analyzes pulses in essentially the same way as AN/APA-6X except that pulse fronts are shown. A calibrated built-in audio oscillator enables accurate determination of the pulse-repetition frequency of one or more radar signals under observation at or near a given frequency. The equipment may also be operated as an ordinary oscilloscope, the sweep frequency being calibrated with the aid of the built-in oscillator. Optional provision is made for permanent recording by means of AN/APA-7.

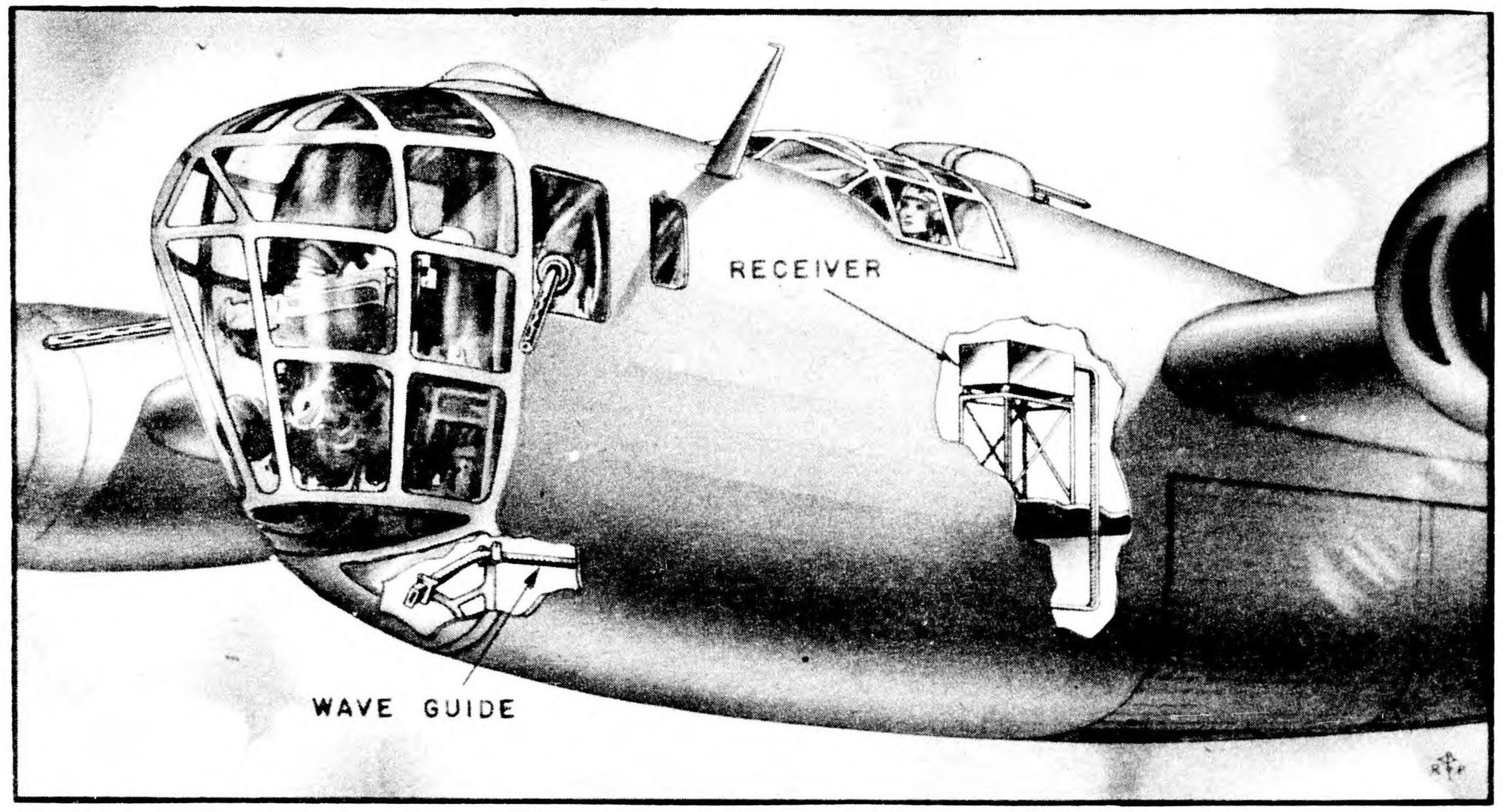
INSTALLATION, OPERATION, & PERSONNEL The equipment should be installed within reach and sight of the radio operator, in such a position that incident light is low. The method of use is similar to that of the AN/APA-6, except that pulse duration is measured with the aid of the oscilloscope centering control, which is calibrated in microseconds. Since AN/APA-11 is used with a receiver, the receiver operator can also operate this equipment. It can be serviced by the maintenance personnel who service the associated receiver.

ASSOCIATED RECEIVING EQUIPMENT: Any receiver with low-impedance output, such as AN/APR-4, -5, -6, AN/ARR-5, or SCR-587.
ASSOCIATED INDICATING EQUIPMENT: Photographic adapter AN/APA-7.
SIZE AND WEIGHT: SARC B1-D, 30 pounds (installed).
TECHNICAL FEATURES: The pulse input is simultaneously applied to two video amplifiers: one with a short time delay to initiate the sweep near the beginning of the pulse, and the other with a long time delay for vertical deflection of the cathode-ray. With a considerable difference in delay time and a high amplification in the short delay amplifier to produce a steep wave front, almost the entire pulse appears on the screen. Pulse duration is measured by a microsecond calibration on the horizontal centering control.

SPECIFICATIONS INPUT POWER: 150 watts, 80 or 115 volts, 400 to 2600 cps.
AMPLIFIER PASSBAND WIDTH: 100 cps. to 3 Mc.
PULSE-REPETITION-FREQUENCY RANGE: 30 to 6000 cps.
FULL-SCALE SWEEP LENGTHS: 5, 25, and 100 microseconds.

STATUS Moderate production under way. Equipment Confidential.

RADAR SET AN/APR-5A



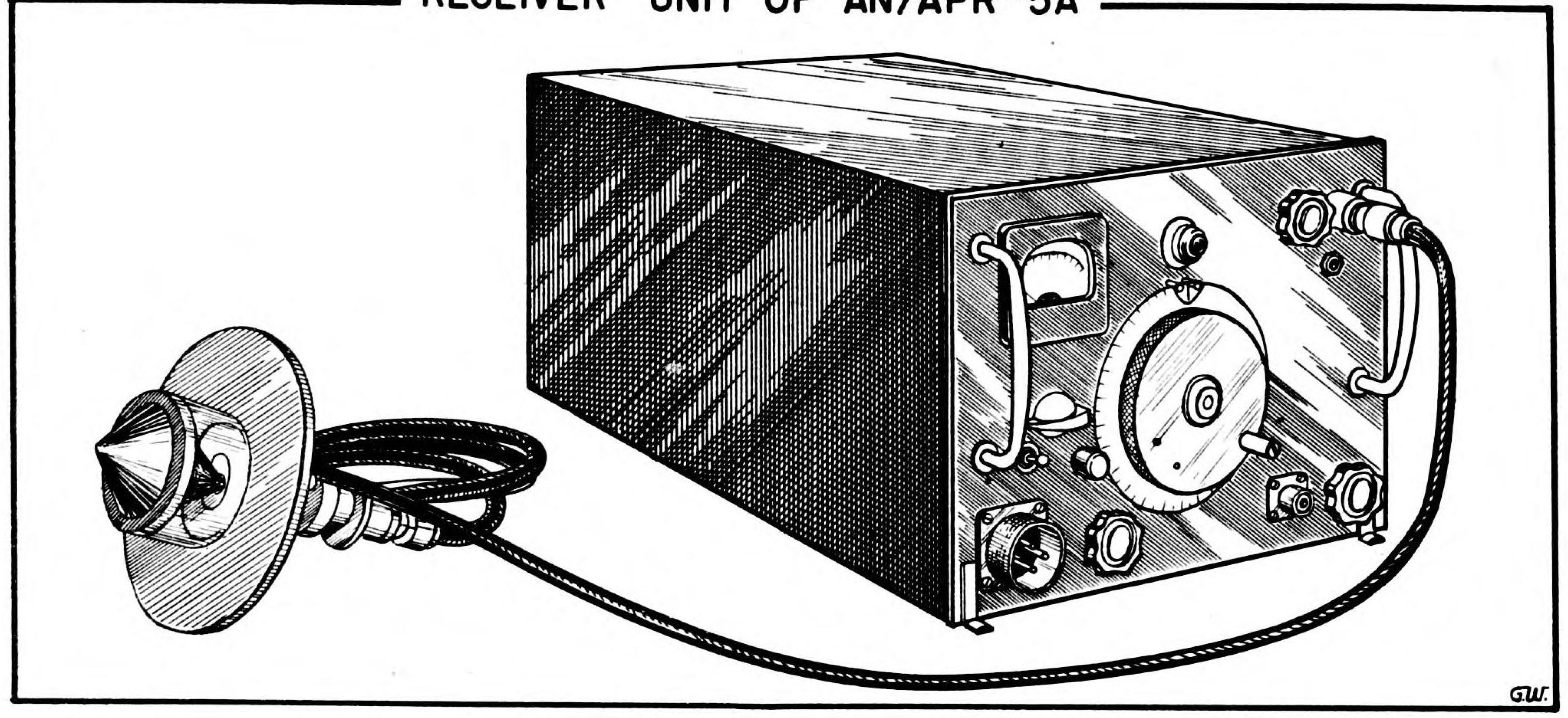
PURPOSE AN/APR-5A is an airborne search receiver for intercepting enemy radar and communications signals in the frequency range from 1000-6000 mc. There are at present few enemy radar sets operating in this frequency band, but recent intercepts show increasing activity and this receiver will be of great value in the future.

DESCRIPTION AN/APR-5A consists of a single receiving unit (SARC-B1-D) but covers the total range by means of replaceable R-F mixers. The first mixer permits coverage of the frequency band 1000-3100 mc and second mixer permits covering the band 3000-6000 mc. The equipment provides most of the features of a standard receiver including single dial tuning control, and a special intermediate frequency amplifier which is used to enhance the probability of intercepting a sweeping transmission in this frequency range. Provision is made for analysis of pulses by use of the AN/APA-6 or AN/APA-11 auxiliary equipment.

PERFORMANCE AN/APR-5A is a sensitive receiver for its frequency range. The sensitivity is sufficiently great at all frequencies so that signals can be received from a much greater distance than a radar can detect the plane in which the set is installed.

OPERATION The signal is tuned in with the aid of headphones to determine its frequency and general characteristics. Care must be taken during this operation to secure sufficient data on the signal to distinguish between image and harmonic responses of the receiver. Specific characteristics of the signal are determined with the aid of an oscilloscope, or a pulse analyzer such as AN/APA-6 or AN/APA-11.

RECEIVER UNIT OF AN/APR-5A



INSTALLATION The receiver should be securely mounted within reach of the operator, and must be mounted so that the antenna cable or wave guide is as short as possible (preferably less than 10 feet). For non-directional reception the antenna or wave guide should be installed where its view of the radar will not be obscured by large metal surfaces when the plane is in normal flight. The antenna or wave guide may be tilted at a 45-degree angle in order to receive either horizontally or vertically polarized signals.

PERSONNEL A specially trained operator is required for this equipment. Maintenance can be done by properly supervised radar mechanics.

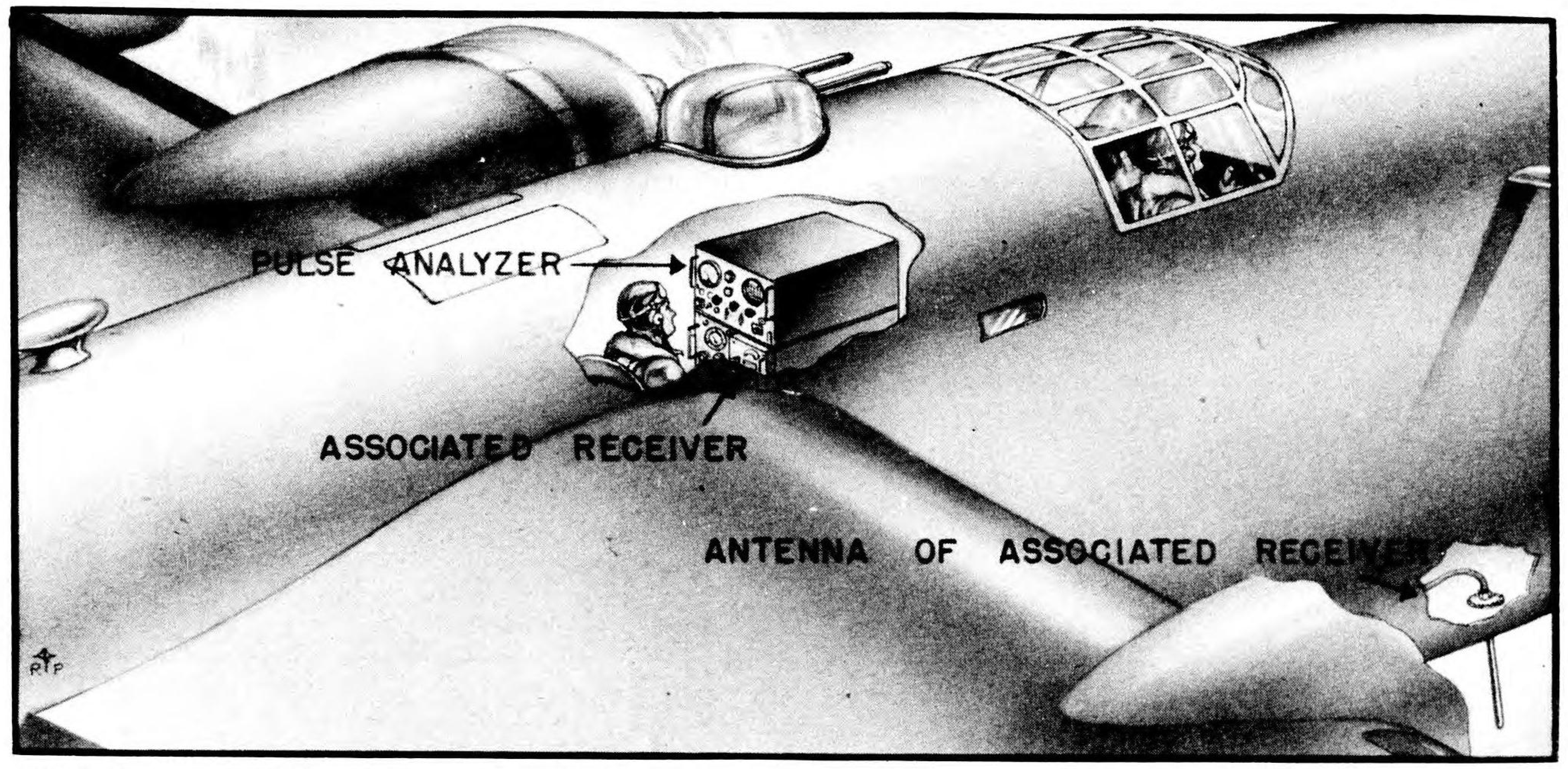
SPECIFICATIONS FREQUENCY RANGE: 1000 to 6000 Mc.
INPUT POWER: 150 watts, 80 or 115 volts, 400 to 2600 cps. a. c. plus 10 watts, 28 volts d.c.
OUTPUT: Audio and video.
SENSITIVITY: 50 microvolts from 70 ohm source.

DIAL ACCURACY: within ± 1%.
ANTENNA: AS-44/APR-5. and AS-45/APR-6
TEST EQUIPMENT: TS-47/APR and Navy LAE and LAG signal generators.
SIZE AND WEIGHT: SARC B1-D, 40 pounds.

TECHNICAL FEATURES: The receiver employs a superheterodyne circuit. The local oscillator of the receiver is a GL-446 'lighthouse' tube in a special double coaxial cavity. Two mixers are employed, one for the 1000-3100 mc frequency band and the other for the 3000-6000 mc band. The mixers are of different construction with each employing a crystal. The first covering the 1000-3000 mc band is in a coaxial cavity while the second is in a short section of wave guide. Replacement is made by removing four (4) bolts on the oscillator mounting replacing mixers and connecting to the proper antenna system. The signal is mixed with the fundamental of the local oscillator frequency and fed into a 30 mc I-F amplifier, 10 mc wide, which is followed by a second detector, audio and video amplifier and signal strength metering circuits.

STATUS Moderate production under way. Equipment Confidential.

RADAR INDICATOR ASSEMBLY AN/APA-6X



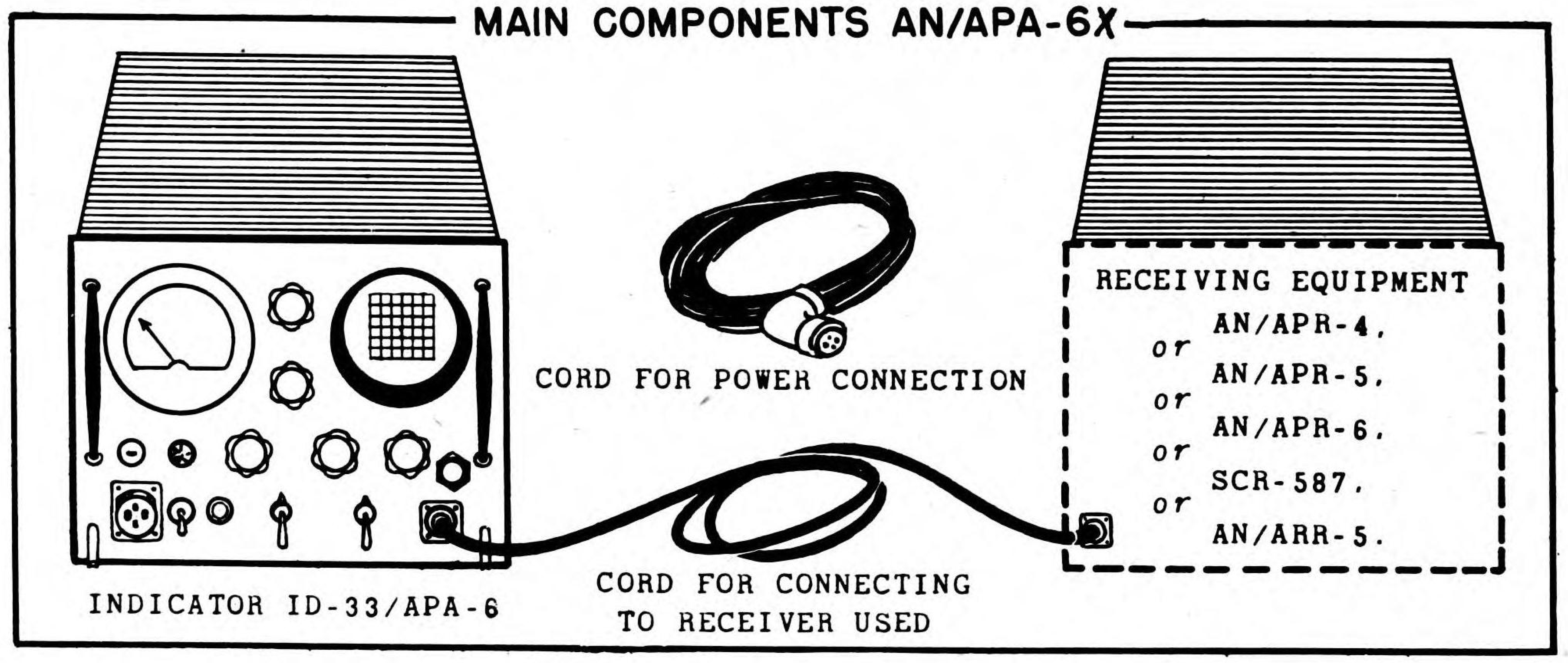
PURPOSE AN/APA-6X is an air-borne pulse analyzer used as an auxiliary unit with search receivers to study the characteristics of enemy radar transmitters. With its aid information may be obtained that is essential for designing and for planning effective use of countermeasure equipment.

DESCRIPTION AN/APA-6X presents on a scope a picture of the radar (or radio) pulses picked up by the receiver, so that each of these pulses may be examined for shape, duration, and amplitude. In addition, the repetition frequency of a pulsed signal may be read directly from a meter on the AN/APA-6X panel - the meter pointer indicating on the scale the number of pulses per second of the signal being received.

PERFORMANCE AN/APA-6X is suitable as an attachment to any receiver that can receive pulses. Any pulses can be analyzed that have a duration of from 1 to 100 microseconds, and that have repetition rates from 75 to 6000 pulses a second. This includes all known enemy pulses.

OPERATION To determine the length of a pulse showing on the scope, a sweep length of approximately 5, 25, or 100 microseconds may be selected by means of a switch on the front panel. This sweep length is visible as the time base line on the scope.

If more precise measurements of the pulse length are desired special circuits in the equipment permit a reference frequency to appear on the scope for calibrating the time base.
The AN/APA-6X meter will indicate the repetition frequency when one pulsed signal is being received. Should it happen that more than one pulsed signal is being picked up at or near the same radio frequency, the meter reading will be erroneous - indicating the sum of the pulse repetition rates. In this event, the repetition rate of the desired signal can be determined by use of an accurately calibrated audio signal generator (e.g., 0-10/APA-6X). to furnish the horizontal sweep on the scope. When the frequency



of the generator has been adjusted until it is the same as the repetition frequency of one of the pulses (pulsed signals) being examined, this pulse will become stationary on the scope. Any other pulse at a different repetition frequency will not be "stopped" with this adjustment, but will drift through the stopped pulse. Thus, the exact repetition frequency of the stopped pulse will be determined, since it is the same as the known frequency of the audio signal generator. (Or, the pulse repetition frequency of the stopped pulse may bear a simple relationship to the known frequency: for example, twice or half).

PERSONNEL Since observations will probably be made only intermittently, the regular operator of the receiver with which AN/APA-6X is used can be trained to make them without interfering with his other duties. The equipment can be serviced by maintenance personnel capable of servicing the receiver.

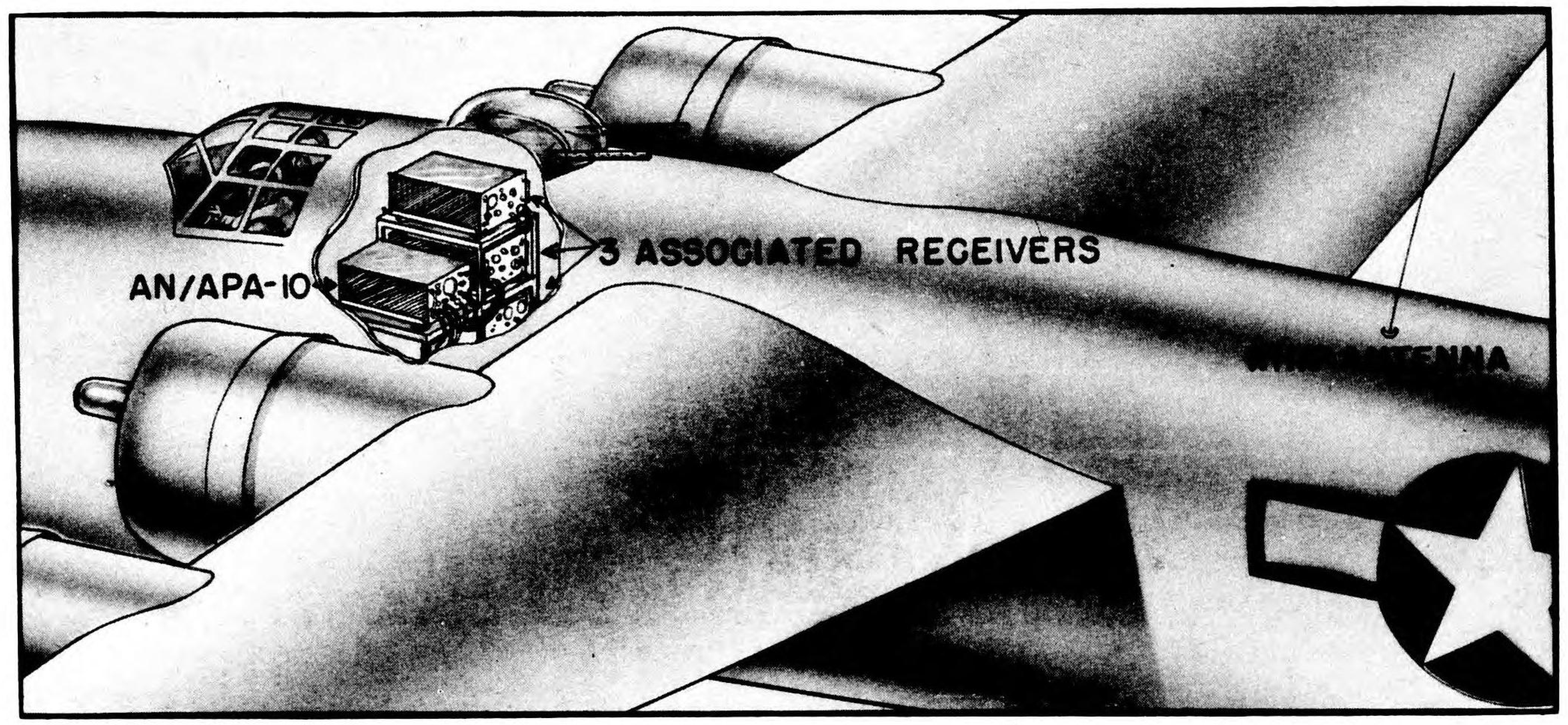
INSTALLATION AN/APA-6X must be installed within about 3 ft. of the associated receiver. A side-by-side installation is typical, since this is convenient for the operator. To prevent pulse distortion, a special cable is supplied and must be used for connecting to the receiver. Spare parts are included in a separate box.

SPECIFICATIONS INPUT POWER: 90 watts, 80 or 115 volts, 400 to 2600 cps.
INPUT IMPEDANCE: 1000 ohms.
FULL-SCALE SWEEP LENGTH: 5, 25, and 100 microseconds.
PULSE REPETITION FREQUENCY RANGE: 75 to 6000 cps.
AMPLIFIER PASSBAND: 100 cps. to 3 Mc.
TIME REQUIRED FOR INITIATION OF SWEEP: 1/6 microsecond.
ASSOCIATED RECEIVING EQUIPMENT: Any receiver capable of pulse reception and that provides low-impedance negative or positive pulse outputs of about 0.5 volt amplitude; such as, AN/APR-4, AN/APR-5, AN/APR-6, AN/ARR-5, or SCR-587.
ASSOCIATED AUDIO OSCILLATOR: 0-10/APA-6X (Hewlett-Packard 200C).
SIZE AND WEIGHT: SARC B1-D, 40 pounds.

TECHNICAL FEATURES: AN/APA-6 incorporates a wide-band amplifier and a sweep-generating circuit which allows the pulse to be examined on the scope. Each pulse starts the generation of the sweep voltage. There is also an electronic counting circuit which operates the panel meter that indicates the pulse repetition frequency. The damped sine wave used in the determination of pulse length is derived from a resonant circuit excited by the sweep oscillator.

STATUS Light production under way. Equipment Restricted; T. O. #: AN-08-10-218 and AN-08-10-219.

PANORAMIC ADAPTER AN/APA-10



PURPOSE AN/APA-10 is a panoramic adapter and oscilloscope for use with AN/APR-4, AN/ARR-5, or AN/ARR-7 receivers. AN/APA-10 indicates visually the frequencies of all signals present in a selectable relatively narrow portion of the 550 kc to 143 Mc frequency range. Such information is important in determining the correct frequency setting of jammer transmitters to cover the maximum possible number of enemy channels at one time, and in general investigational work to determine the distribution of enemy communications channels and the characteristics of signals for radio-controlled devices. AN/APA-10 also provides narrow-band reception in the 40 to 3000 Mc range; this permits determination of the individual frequencies of enemy radar or communications signals that are very close in frequency and could not ordinarily be separated by means of AN/APR-4 alone. The equipment may also be used as an airborne oscilloscope.

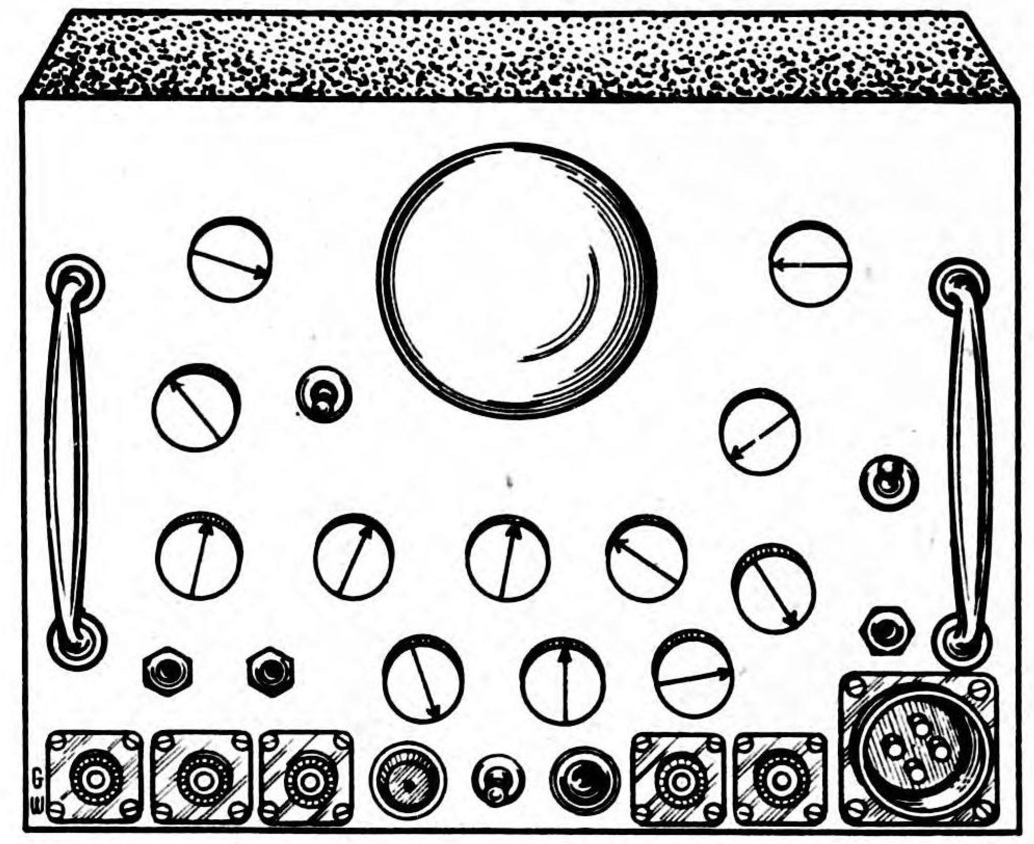
DESCRIPTION AN/APA-10 consists of a single unit (SARC B1-D), with provision for connection to the receivers listed above. Other receivers may be used if the appropriate plug-in sub-assemblies are available.

PERFORMANCE When used with AN/ARR-7, AN/APA-10 indicates on an oscilloscope the frequencies of all signals in a 100 kc band, centered at the frequency to which the receiver is tuned. The oscilloscope time base is calibrated in frequency, and pips appear at points on the time base corresponding to the frequencies of the received signals. Unmodulated c-w, amplitude-modulated, and frequency-modulated signals may be distinguished by the shapes of the pips.

For use with AN/ARR-5, it likewise shows the frequencies of all signals in a 1 Mc band centered at the frequency to which the receiver is tuned.

Provision is also made for head-phone reception of a selected narrow band of frequencies being received by AN/APR-4.

PANORAMIC ADAPTER AN/APA-10



AN/APA-10 may also be used as conventional oscilloscope with built-in 20 cps to 20 kc sweep circuit. Extra leads are provided for this purpose.

OPERATION & INSTALLATION AN/APA-10 must be mounted relatively close to the receiver with which it is to be used. The cables supplied with the equipment must be used for connection to the receiver, since they form an integral part of the circuits of the equipment. Once connection is made to the receiver, all that it is necessary to do to use any of the receivers with AN/APA-10 is to turn the selector switch to the proper position. Manual tuning is required for narrow-band reception with AN/APR-4.

SPECIFICATIONS **FREQUENCY RANGE:** With associated receivers, 550 kc to 3000 Mc:
100 kc panoramic, 550 kc to 43 Mc,
1 Mc panoramic. 28 Mc to 143 Mc,
Narrow-band 40 Mc to 3000 Mc.

INPUT POWER: 125 watts, 80 or 115 volts, 400 to 2600 cps, a.c.

OSCILLOSCOPE SWEEP: 50 to 20,000 cps.

SIZE AND WEIGHT: SARC B1-D, 40 lbs.

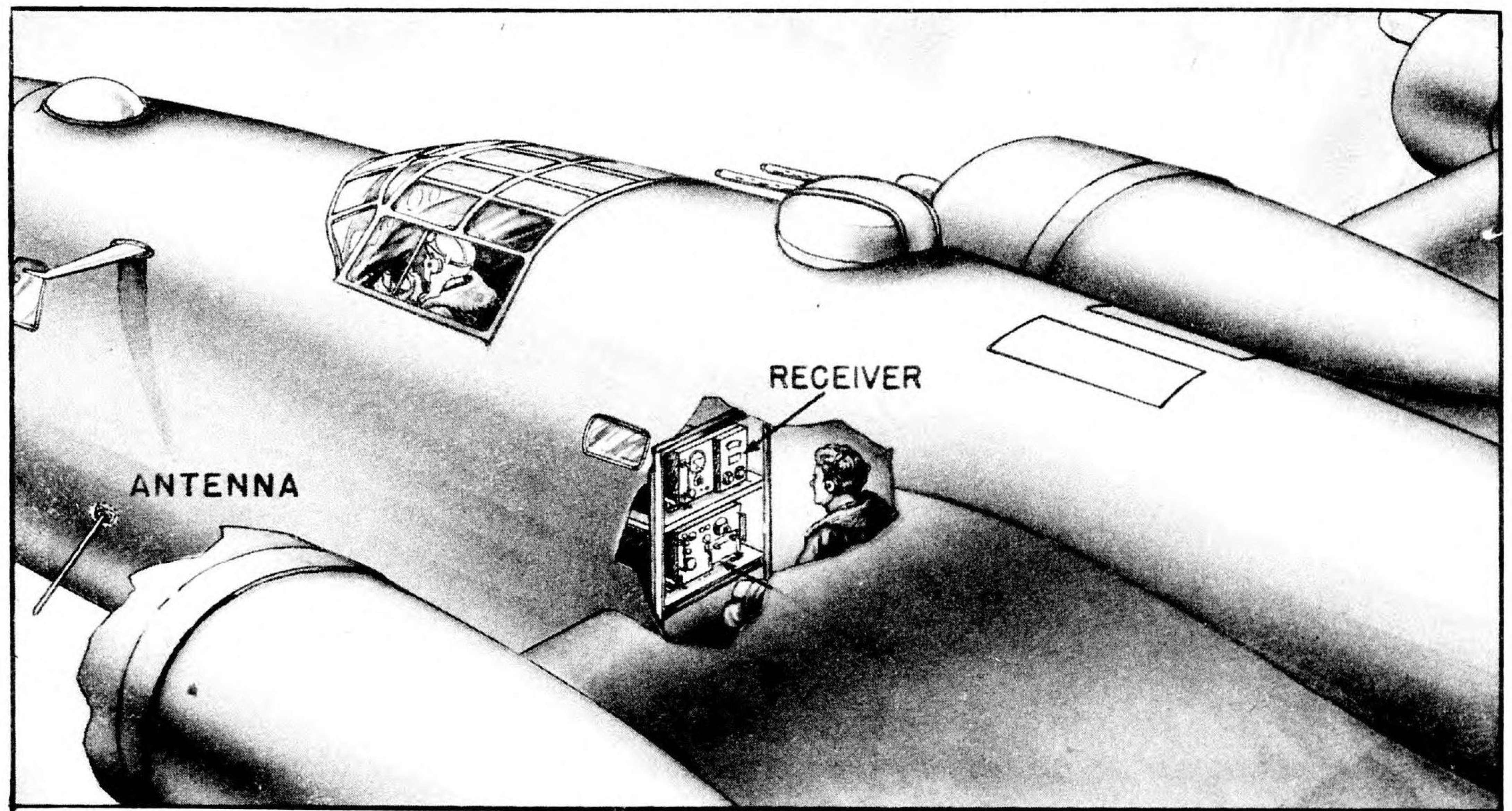
TECHNICAL FEATURES: Panoramic presentation is achieved by passing part of the output of the mixer stage of the receiver through a doubly peaked amplifier stage to compensate for the high selectivity of the mixer and r-f stage of the receiver. A second mixer and reactance-tube oscillator convert the signals to the intermediate frequency of the adapter. The signals are then amplified, detected, and applied to the vertical deflection plates of the cathode ray tube. The cathode-ray-tube sweep and the reactance-tube oscillator are driven in synchronism. The width of the band scanned may be varied from zero to the maximum value.

The narrow-band function of the equipment for use with AN/APR-4 consists of a manually tuned local oscillator which sweeps the i-f channel of the receiver, plus a mixer and a selective second i-f amplifier, followed by a detector and audio amplifier.

The equipment also contains a conventional type of oscilloscope circuit together with a servo sweep which may be triggered by any signal.

STATUS: Moderate production under way. Equipment Restricted.

RECORDING ASSEMBLY AN/APA-23



Shown above is a possible installation of Recording Assembly AN/APA-23 with the AN/APR-4 search receiver. The recording unit can automatically provide a tape record of received signals--the frequency and the time of reception of each signal being indicated on the tape.

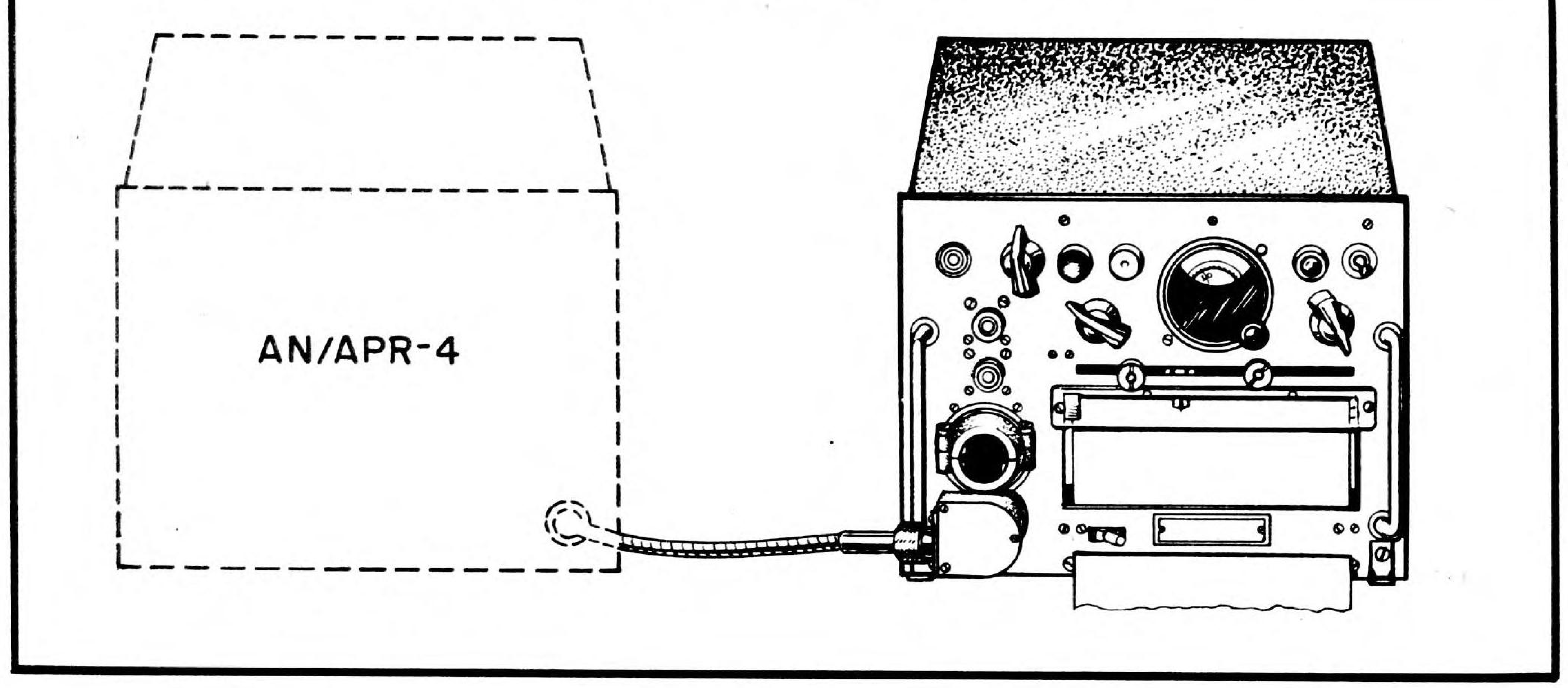
PURPOSE AN/APA-23 is a motor-operated recording unit for AN/APR-4 search receiver. When properly calibrated it automatically provides a permanent tape record of the frequencies and reception-time of all received signals. The operator is thus relieved from continuous listening and is partly free to perform other duties, including the investigation of new signals appearing on the tape.

DESCRIPTION AN/APA-23 consists essentially of a motor-operated stylus, amplifying circuits, and roll of paper tape, together with a time marking mechanism. By means of a short connecting length of flexible shaft the motor also sweeps the receiver's tuning dial through a desired range of frequencies. A panel switch permits the recording of either pulse or sine-wave signals. The equipment is contained in a single box (SARC B1-D) with a 2 x 6 in. tape-viewing window. Its installed weight is 50 pounds.

PERFORMANCE As the tape moves continuously past the window and is ejected from the box, its length is marked at one-minute intervals by the timing mechanism and its width is marked by the signal-actuated stylus which continuously sweeps back and forth in synchronism with the receiver tuning dial. The stylus marks the tape only when a signal appears. Under average conditions a recorder signal input of 80 millivolts is sufficient to mark the tape.

OPERATION The panel controls are an on-off switch, stops for the stylus' width of sweep (frequency bandwidth), a "manual-autosweep" switch, and a volume control. The frequency of a received sig-

RECORDING UNIT AN/APA-23



nal is measured by means of a pre-calibrated frequency scale laid across the window. The frequency scale is pre-calibrated for the sector being searched. This is accomplished by manually tuning to a series of frequencies in the desired sector, pushing the calibration button of the recorder to mark each selected frequency, cutting off the strip, and writing the values on the scale. The tape must be watched for the appearance of a new signal during autosweep operation and must occasionally be cut off as it is ejected. When a new signal appears, the operator switches the recorder from "autosweep" to "manual" and tunes in the signal for observation.

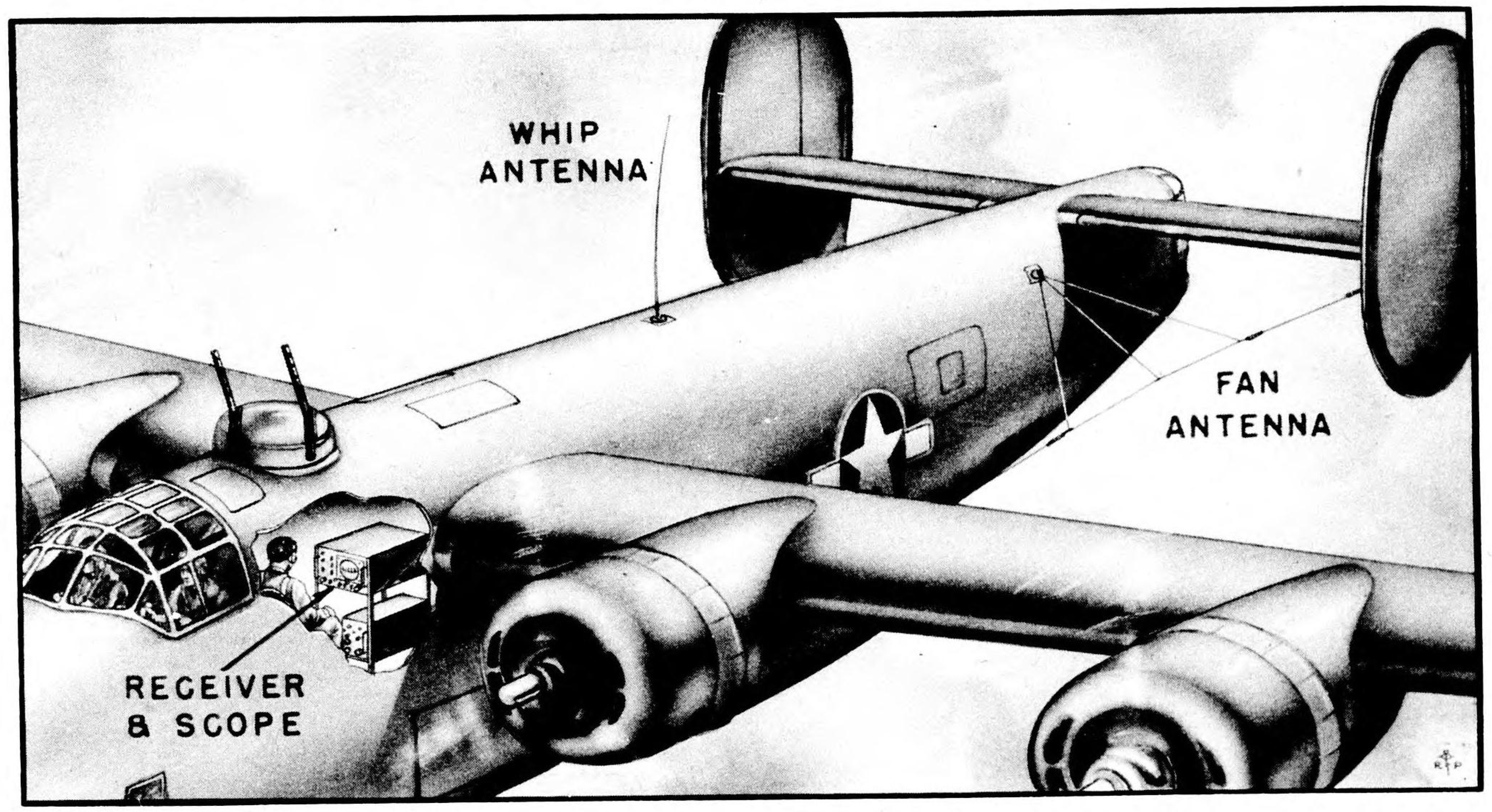
INSTALLATION AN/APA-23 is secured alongside and connected to the receiver with which it is to work. A small gear-box is attached to the receiver as a connection to the flexible shaft from the recorder motor, thus providing the proper speed of rotation for the tuning dial.

PERSONNEL The operator of the associated receiver is partially relieved from attending to it and is thus free to perform other duties. The equipment can be operated without attention only when the frequency and time of reception of signals are all that must be known. It can be serviced by the maintenance personnel which services the receiver.

SPECIFICATIONS FREQUENCY RANGE: Depends on tuning unit of receiver.
INPUT POWER: 85 watts, 80 or 115 volts, 60 to 2600 cps, a.c.
SENSITIVITY: Required input to recorder is about 0.10 volts for pulses and from 0.28 to 0.07 volts for sine waves, at frequencies from 50 to 10,000 cps.
TAPE: WU Teledeltos: ejected 7½" in. per hour.
SIZE AND WEIGHT: SARC B1-D, 50.5 pounds.
TECHNICAL FEATURES: Amplified (3 stage) video output of receiver is applied to motor-swept stylus, sine wave signals directly and pulse signals thru intermediate trigger circuit. Motor also drives tuning dial thru reduction gear.

STATUS Moderate production planned. Equipment Restricted.

RECEIVING EQUIPMENT AN/ARQ-5 (NICKELODEON)



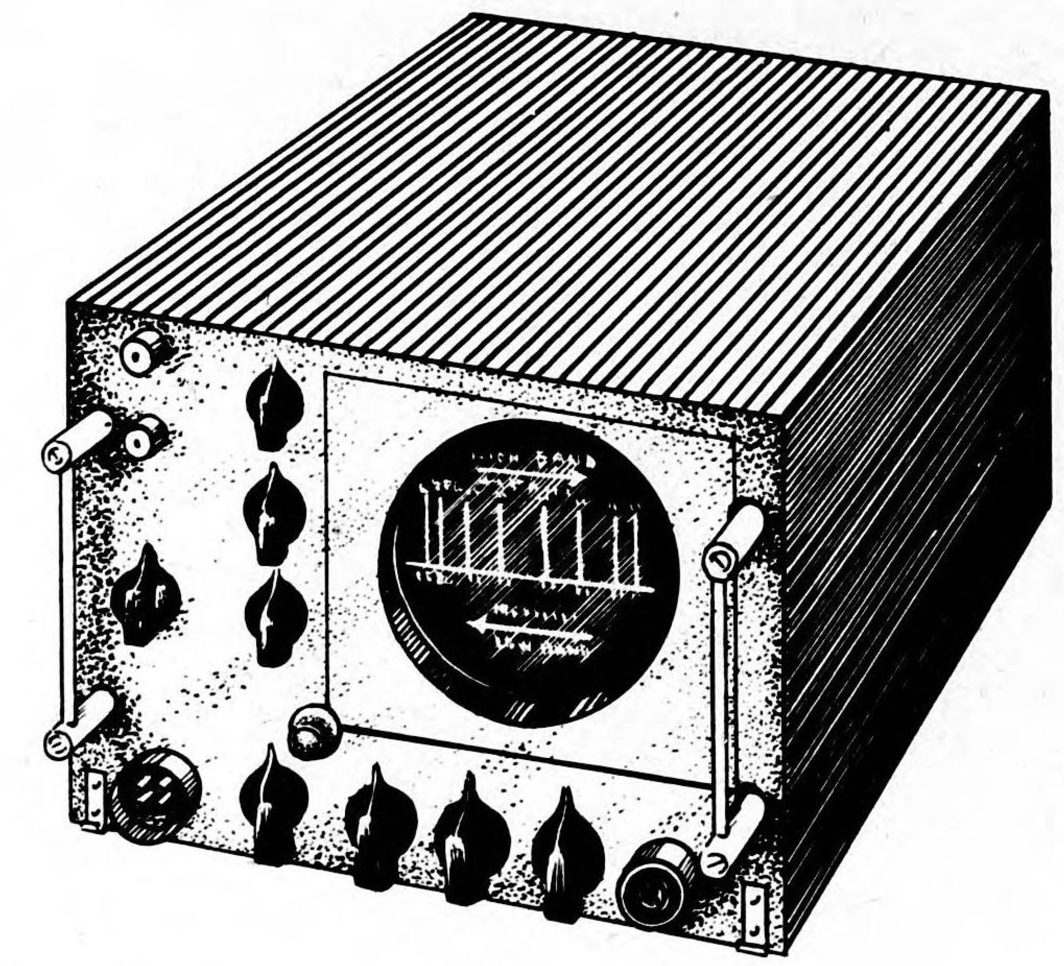
PURPOSE AN/ARQ-5 displays at all times the approximate frequency of received signals in the frequency band from 18 to 80 Mc. The equipment may be used whenever the only (or chief) information required is the frequency of the received signals. It should be extremely useful in guided missile and communications monitoring service and also for jammer frequency setting.

DESCRIPTION AN/ARQ-5 consists of a single unit (size SARC B1-D) which contains both the receiving unit and the indicator scope.

PERFORMANCE AN/ARQ-5 provides a sensitive receiver which examines the entire band from 18 to 80 Mc simultaneously. It gives a panoramic presentation in which signals appear as vertical deflections along a 5 inch cathode ray tube trace calibrated from 18 to 50 and from 48 to 80 Mc. These two bands of frequencies are superimposed on the scope, but may be identified by pushing a button on the panel which causes signals in one band to move in one direction on the scope and signals in the other band to move in the opposite direction. Some indication as to the type of signal is also given by its appearance on the scope.

OPERATION The equipment requires no tuning adjustment during use. It is necessary, however, to watch for the appearance of signals in the

RECEIVING EQUIPMENT AN/ARQ-5



frequency band covered, to discriminate in which of the two bands the signal is (by pushing the button on the front panel), and to interpret the results obtained.

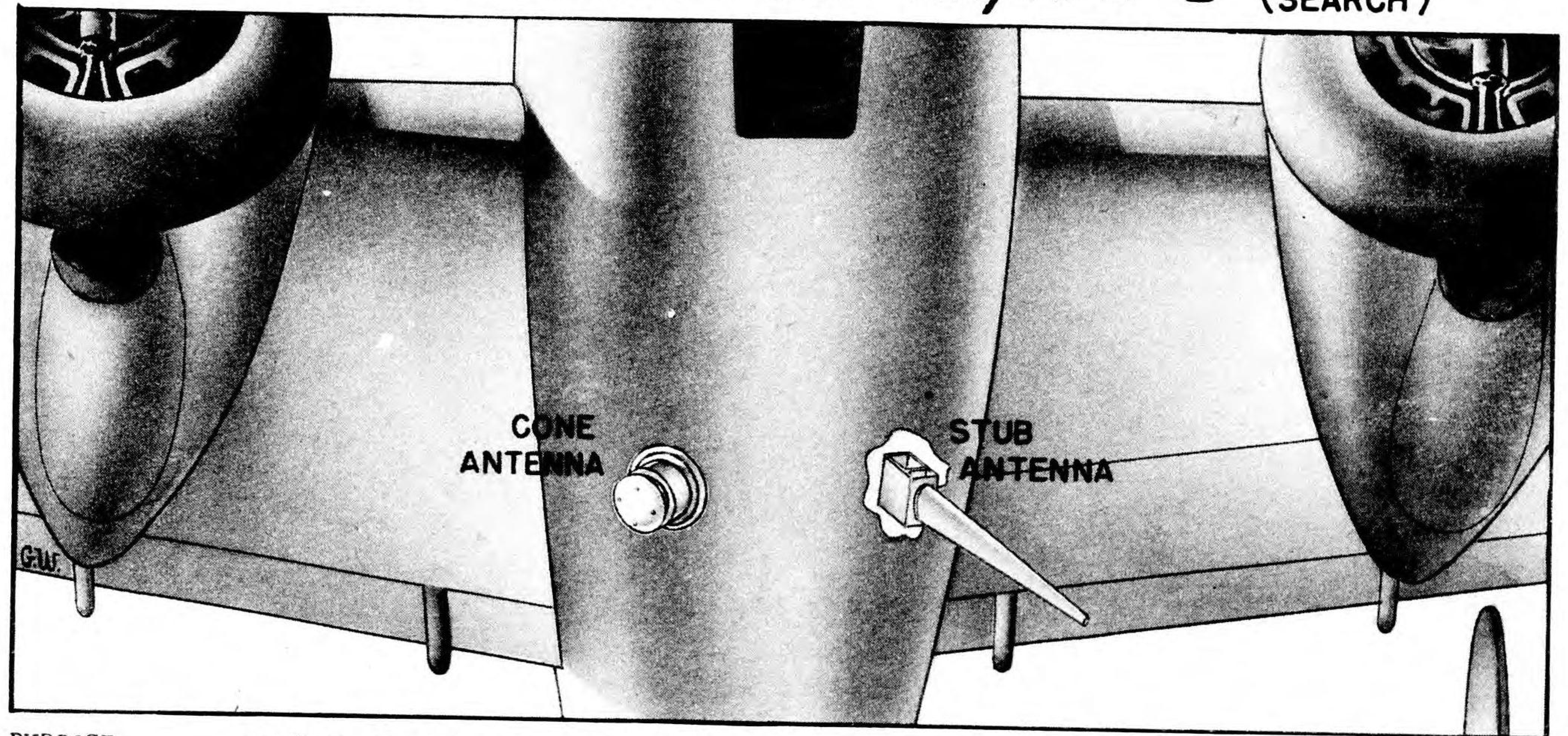
INSTALLATION AN/ARQ-5 should be installed so that it is approximately level in normal flight. It should be installed in a place where incident light is low. A whip antenna installation is required.

PERSONNEL An operator is required at all times to watch the oscilloscope on the equipment. Regular radio maintenance personnel properly supervised should be capable of servicing the equipment.

SPECIFICATIONS
FREQUENCY RANGE: 18 to 50 Mc and 48 to 80 Mc, both bands simultaneously presented entirely.
INPUT POWER: 125 watts, 80 or 115 volts, 400 to 2600 cps, a.c. and 50 watts, 28 volts d.c.
SENSITIVITY: 25 microvolts for ¼ inch deflection with noise just appearing on base line.
TYPES OF SIGNALS RECEIVABLE: CW, AM and FM.
RESOLVING POWER: 50 kc for CW signals.
CALIBRATION ACCURACY: Within ± 1 Mc.
TEST EQUIPMENT: TS-47/APR, GR-804C.
SIZE AND WEIGHT: 1 SARC B1-D, 50 pounds.
TECHNICAL FEATURES: AN/ARQ-5 is a superheterodyne panoramic receiver with 18 to 50 Mc band and 48 to 80 Mc band (image of the 18 to 50 Mc) simultaneously presented on a 5 inch cathode ray tube. Discrimination of band is obtained by changing i-f frequency with push button and observing left or right shift on screen. The i-f frequency is 15 Mc with a second (narrow) i-f centered at 1.1 Mc.

STATUS Moderate production under way. Equipment Confidential.

RADAR RECEIVING EQUIPMENT AN/APR-2 (AUTO-SEARCH)



PURPOSE

AN/APR-2 is an airborne search receiver designed for determining instantly the approximate frequency of any signal being transmitted in the range from 90 to 1000 Mc. Most and probably all enemy radar systems are now in this range. There are also some enemy radio communications channels in this range.

DESCRIPTION

AN/APR-2 consists of a single receiving unit (SARC B1-D) which tunes over the total frequency range in two steps. Although separate antennas and separate circuits are used for these two frequency steps the receiver records and indicates signals continuously over the entire 90 to 1000 Mc range. Provision is made for a visual indication of signals (flashing neon bulb), a permanent tape record of signals, and a headphone indication of signals.

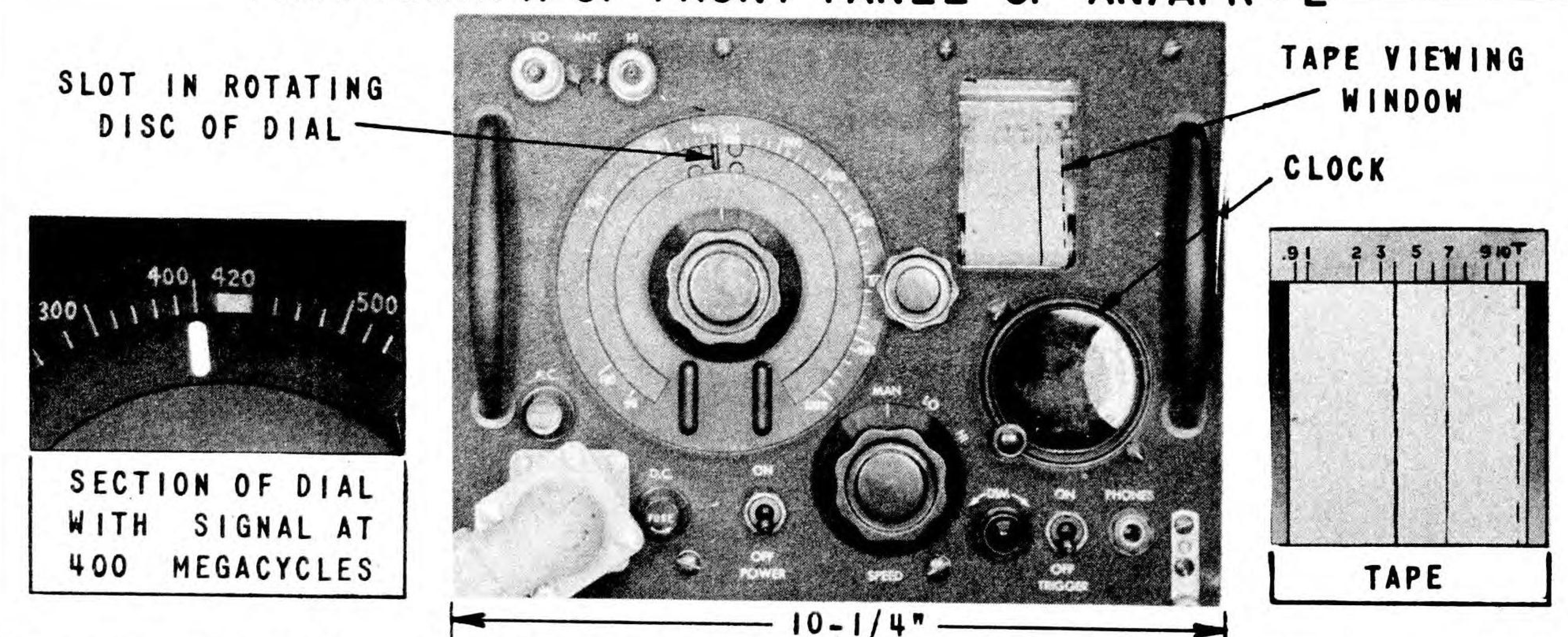
PERFORMANCE

AN/APR-2 can receive signals from a much greater distance than any radar in its frequency range can detect the plane carrying the equipment. Several signals may be presented at once, giving effectively complete coverage at all times of the entire frequency band. The receiver cannot discriminate between several signals being transmitted near the same frequency - only one slot of light at a given place on the dial, or one mark at a given place on the tape would be visible. A strong signal makes a wider slot of light (or mark on the tape) than a weak one, but to determine the number of transmissions near the same frequency a more selective receiver is needed; e.g. AN/APR-4. AN/APR-2 also provides time markings on the recording tape so that correlation can be made between the plane's position and the signals being received.

OPERATION

No attention is needed during flight when automatic search is used except that the time must be noted when the receiver is switched on so that a later analysis of the recording tape can correlate recorded frequencies with the aircraft navigation log. In case an operator is available it is possible to gain some notion of the general type of a received signal by use of the headphones provided.

PHOTOGRAPH OF FRONT PANEL OF AN/APR-2



The rotating disc in the center photo is stopped so that the slot is at the 400 Mc point on the frequency-calibrated dial. At left is shown the light that flashes in the slot when a 400 Mc signal is received during operations. The tape in the photo has recorded a signal at 700 Mc. At right is shown the tape after it has recorded two signals, of which the 400 Mc signal is the stronger. On the tape's right edge, time has been recorded -- the short lines being minute marks, and the double-length line being the hour mark. The switches on the panel are used to regulate the speed of the rotating disc and the recording tape, to turn on manual control, to plug in headphones and to adjust the clock.

INSTALLATION

If it is desired to watch the dial flash, the receiver should be located where incident light is low. To receive both vertically and horizontally polarized signals, the antenna should be mounted at a 45 degree angle from the vertical.

PERSONNEL

No extra personnel is required for automatic search use. A specially trained operator is needed intermittently to investigate the general type of signals which might be received. Properly supervised radar mechanics can maintain this equipment.

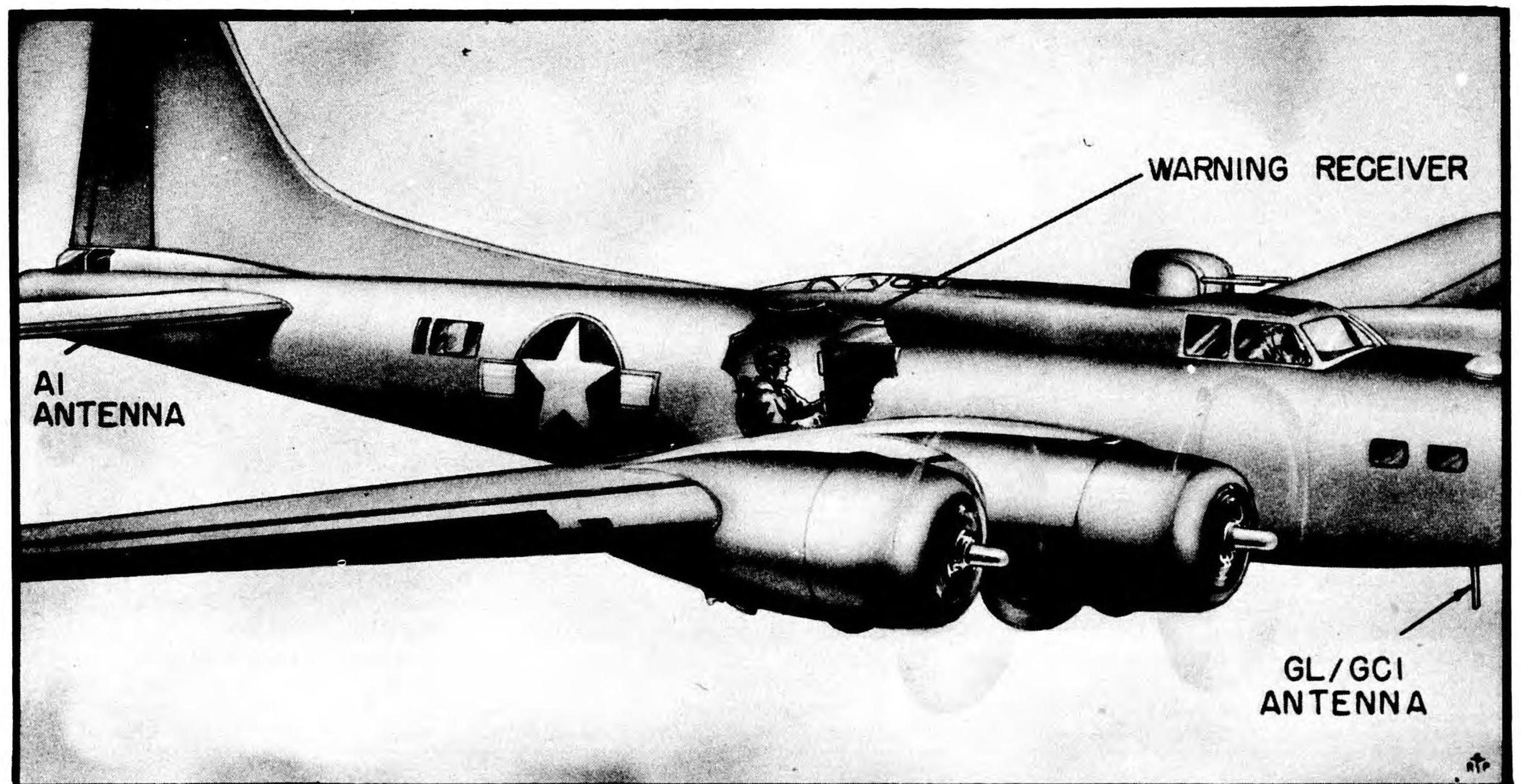
SPECIFICATIONS

FREQUENCY RANGE: 90 to 1000 Mc.
INPUT POWER: 100 watts, 80 or 115 volts, 400 to 2600 cps, a.c., and 50 watts, 28 volts d.c.
SENSITIVITY: Autosearch, 400 to 800 microvolts
Manual Tuning, 200 to 400 microvolts at antenna input from 50 ohm source.
PREAMPLIFIER PASSBAND: 8 to 50 kc.
ACCURACY OF DIAL CALIBRATION: Within ± 2% from 90 to 800 Mc, within ± 3% above 800 Mc.
ACCURACY OF TAPE RECORD: Frequency, within ± 4%.
Time, within ± 1 minute in 8 hours.
SCANNING RATE: Approximately 6 or 2 sweeps a second.
RECORDING TAPE: WU Grade L Teledeltos paper, 600 ft. per reel. Tape width is 35 millimeters. At the scanning speed of 6 sweeps per second the tape is fed at the rate of 2.4 inches per minute.
ASSOCIATED ANTENNAS: AS-25/APR-2 and AS-26/APR-2.
TEST EQUIPMENT: TS-47/APR, GR-804C.
SIZE AND WEIGHT: SARC B1-D, 44 pounds. The total installed weight with antennas and cables is about 60 pounds.
TECHNICAL FEATURES: The 90 to 1000 Mc range is covered in two continually swept ranges of 90 to 420 and 420 to 1000 Mc by two tuned ('butterfly') circuits. Crystal detectors demodulate the radio frequency signal voltage appearing across these tuned circuits, and their output is fed into two separate high-gain amplifier channels. The outputs of these amplifiers are commutated to amplifier-trigger circuits in proper relationship to give continuous rapid coverage and presentation. When using headphones a switch permits listening to the signal before or after it has passed through the trigger circuit. This allows either (1) accurately setting on frequency when tuning manually, or (2) checking and adjusting trigger operation to eliminate noise.

STATUS

Moderate production under way. Equipment Restricted;
T. O. #: AN-08-30APR2-2.

DETECTING EQUIPMENT AN/APR-3 (AMERICAN BOOZER)



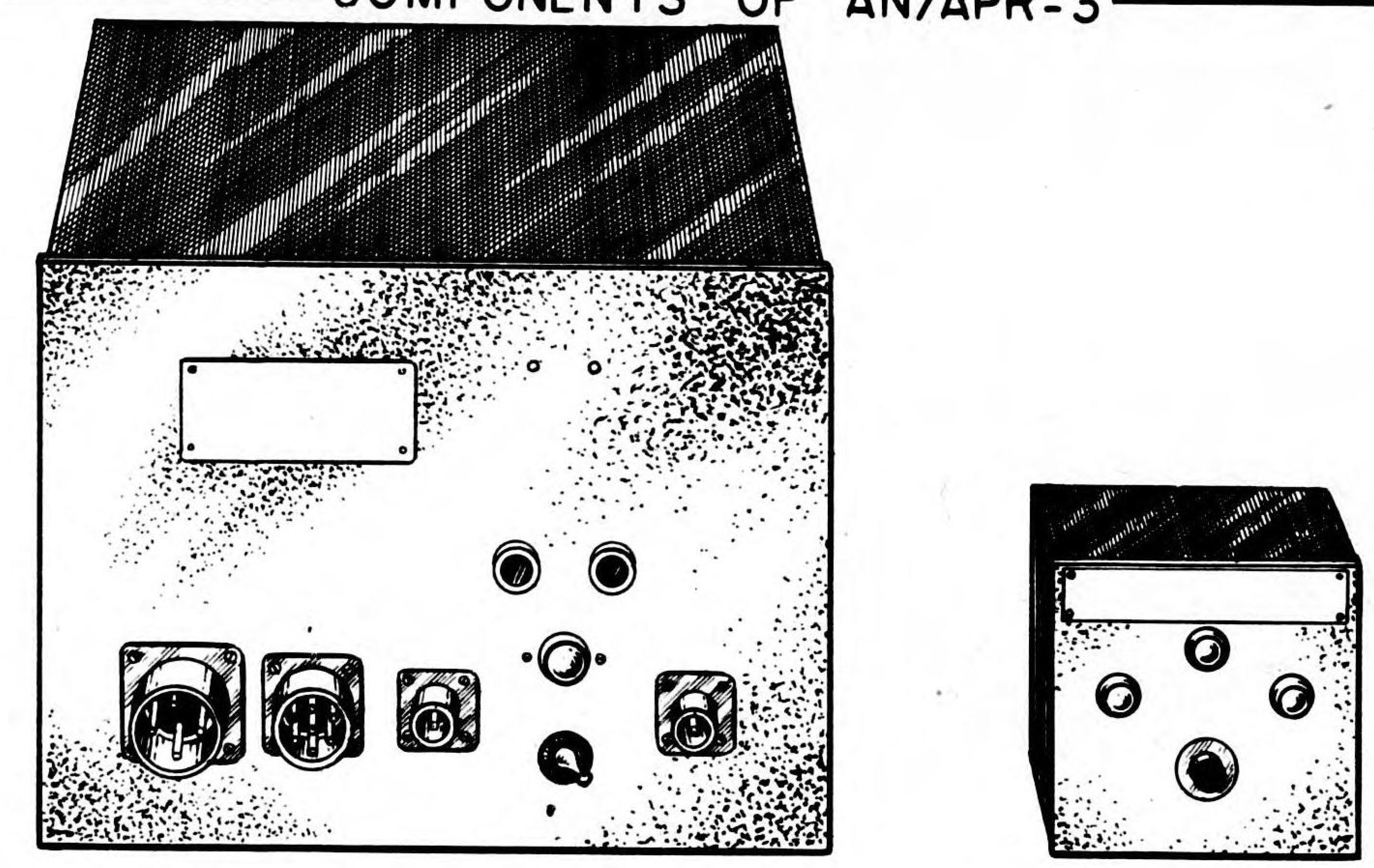
Shown above is a possible installation of Detecting Equipment AN/APR-3. The two antennas are used to warn (1) of radar-equipped enemy interceptor planes, and (2) of enemy gun-laying and GCI radar.

PURPOSE AN/APR-3 receiver gives warning against enemy radar. It is designed especially to warn against the standard German aircraft interception radar, the Wurzburg ground-controlled interception, and the Wurzburg gun laying radar. The use of this equipment helps in effective evasive action to avoid fighter interception or anti-aircraft fire.

DESCRIPTION AN/APR-3 consists of a receiving unit (SARC B1-D) and a small warning light box, which perform the complete function of warning against each of the three types of radar previously mentioned. Three colored lights are provided for warning, one light for each of these three types.

PERFORMANCE AN/APR-3 furnishes warning of the approach of a plane carrying AI radar before such plane is close enough to make effective use of its radar. No information about the attacking plane is furnished other than the fact that it is approaching; however, this is generally enough to permit effective evasive tactics. The equipment also provides warning against ground-controlled interception radar and gun-laying radar. The GCI warning has a time delay which is adjustable between ½ minute and 2½ minutes, so that the warning is given only after the GCI radar has been tracking the plane for a sufficient time to be thought dangerous. The GL warning is given after an adjustable time delay period of 5 to 30 seconds. This time delay is also provided to prevent warnings

COMPONENTS OF AN/APR-3



being given before the radar has tracked the plane long enough to be dangerous. Both the gun-laying and ground-controlled interception warnings are given in sufficient time to permit effective evasive tactics.

OPERATION No adjustment of the equipment in flight is required. Ground setting of the gain control, time delay controls, etc., is necessary about once a week. All that is required for operation of the equipment is turning on the power and observing the warnings furnished.

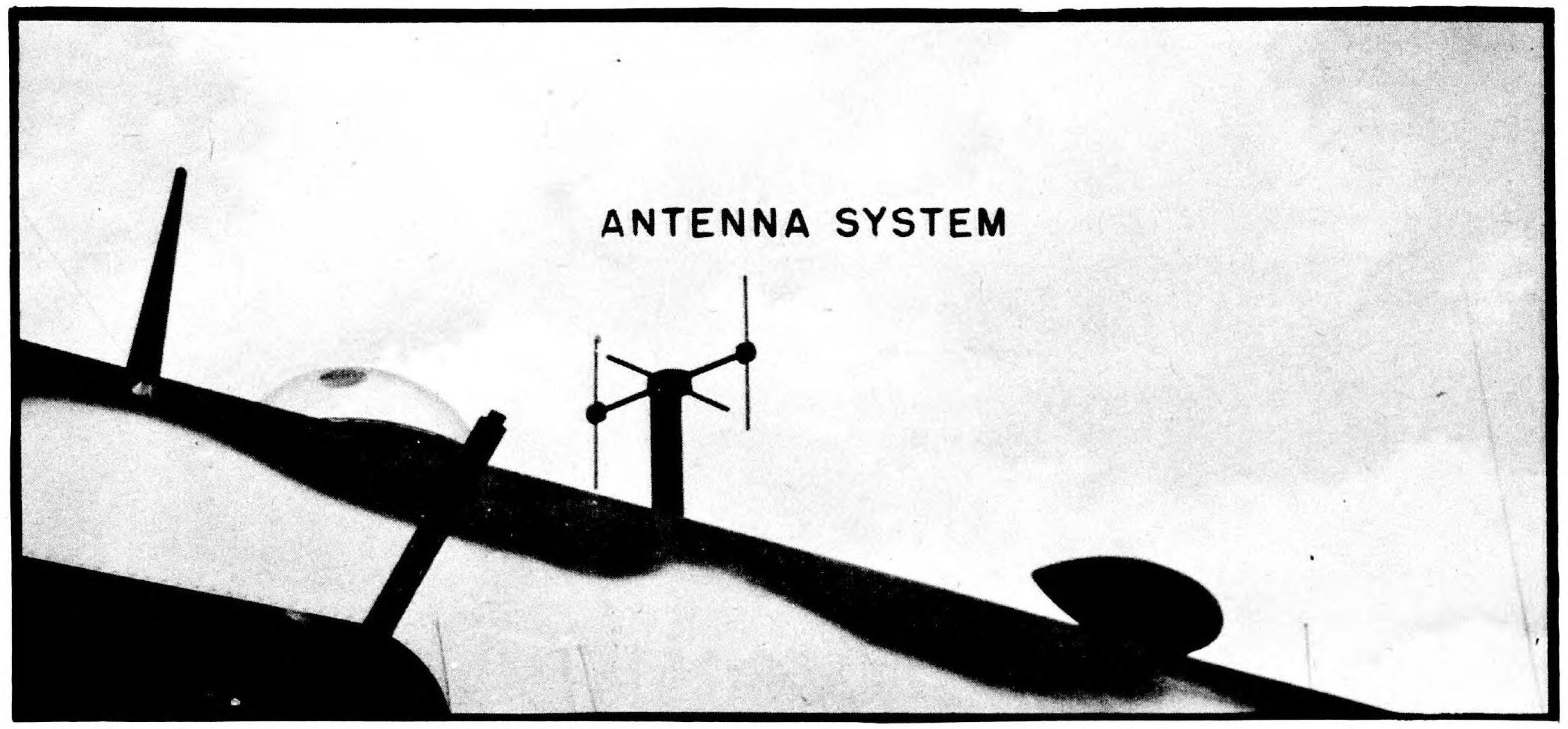
INSTALLATION Two antennas should be installed. One is placed on the underside of the aircraft for warning against gun-laying and ground-controlled interception radar; the other on the underside of the tail of the aircraft for warning against aircraft interception. The receiving unit may be mounted at any convenient point within the aircraft, and the warning light should be mounted near the pilot. Special precautions must be taken to insure a noise-free installation (from an electrical viewpoint) for this receiver.

PERSONNEL No extra personnel for operation of the equipment in flight is required. Properly supervised radar mechanics can maintain it.

SPECIFICATIONS FREQUENCY RANGE: AI Channel - 477 to 497 Mc. GL and GCI Channel - 520 to 585 Mc. (Pulse repetition frequency separation of GL and GCI signals is provided).
INPUT POWER: 100 watts, 28 volts d.c.
SENSITIVITY: Sufficient to furnish adequate warning against radars involved.
ANTENNAS: Two type AS-65/APQ-2.
TEST EQUIPMENT: Not yet determined.
SIZE AND WEIGHT: SARC B1-D, 50 pounds.
TECHNICAL FEATURES: AN/APR-3 consists of two receiving channels. The AI channel consists of a tuned r-f filter for the AI frequency band followed by a crystal detector and audio amplifier circuit and warning circuit. The GL and GCI channel consists of a tuned r-f filter for the GL and GCI frequency band followed by a crystal detector and audio amplifier, a pulse repetition frequency separating circuit, and warning circuits for GL warning and GCI warning.

STATUS Light production planned Equipment Confidential.

D-F ANTENNA ASSEMBLY AN/APA-24 (SETTER)



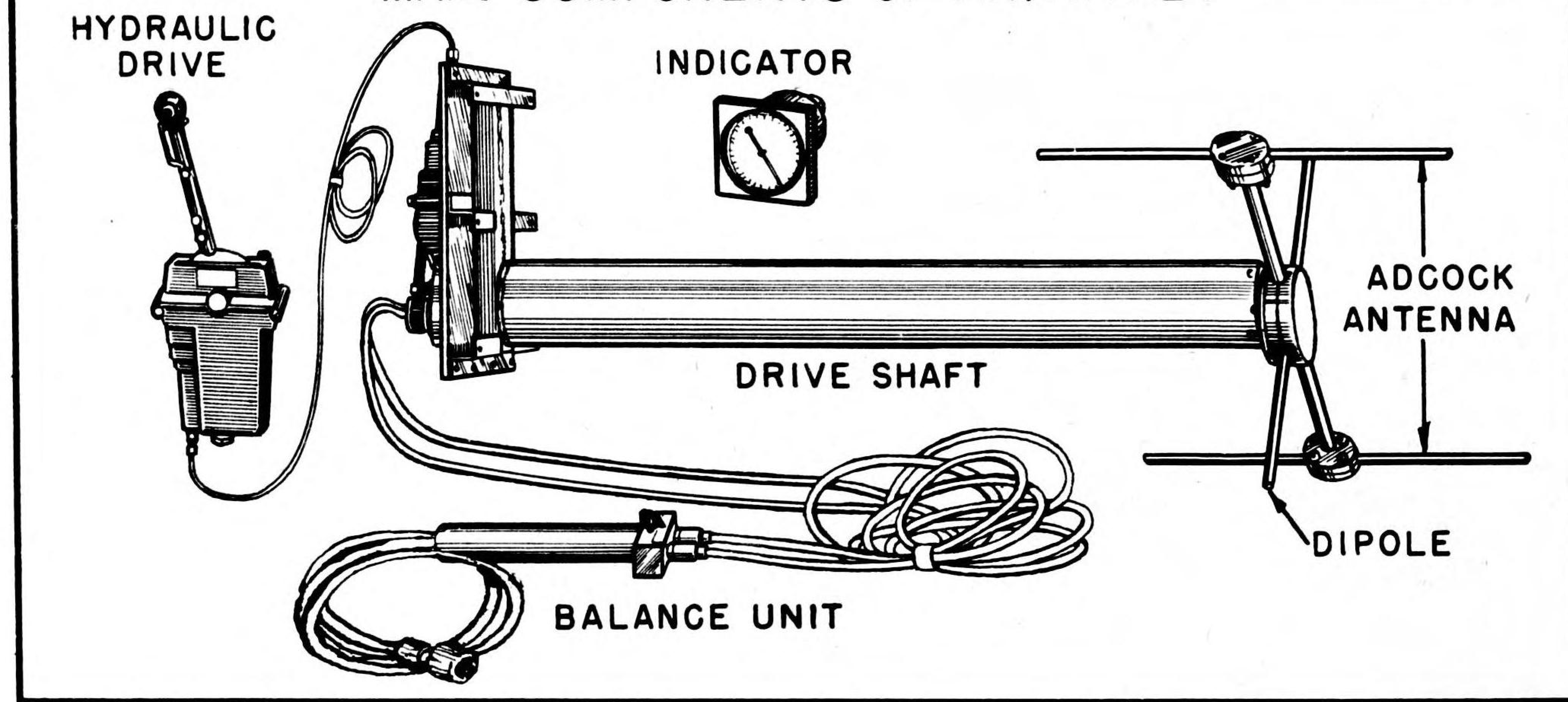
PURPOSE AN/APA-24 is an airborne direction-finding attachment for use with a sensitive radio receiver, such as AN/APR-4 or SCR-587. AN/APA-24 indicates the direction from an aircraft to a station transmitting in the frequency range from 100 to 165 Mc, 165 to 275 Mc, or 275 to 450 Mc, depending on the antenna head used. The equipment presents information useful in locating radar stations, either for planning countermeasures activities or for homing operations. A fourth antenna head has been developed which covers the frequency range 450 to 750 Mc.

DESCRIPTION The attachment consists of a rotatable antenna system and a direction indicator, with intermediate operating and control devices contained in two small boxes, and connecting lines. A separate interchangeable antenna head is provided for each of the three operating bands mentioned above. AN/APA-24 weighs 20 pounds and requires a clearance of 50 in. vertically and 40 in. horizontally when used with the largest antenna head. The antenna system comprises one antenna to receive horizontally polarized signals and two antennas for vertically polarized signals. The antennas are mounted on a common shaft with remote control of rotation and and with remote indication of direction.

PERFORMANCE The antenna system can be rotated through an azimuth of 360 degrees. Either vertical or horizontal polarization can be selected by a switch in order to provide the stronger signal. The indicator has an accuracy of ± 5 degrees under average conditions.

OPERATION After the receiver has been tuned to a desired signal and the polarization selected to give the strongest possible signal strength as heard in the headphones, the antenna control is moved to the point of null (least) signal intensity. The indicator reading then shows the incoming signal's angular direction to the aircraft axis. The procedure is repeated when the aircraft is in another location in order to eliminate any ambiguity as to the direction

MAIN COMPONENTS OF AN/APA 24



Picture of antenna assembly should be turned 90 degrees in a counter-clockwise direction, when the Adcock antenna may be seen to consist of two vertical dipoles and the single dipole will be horizontal.

of the transmitting station. Greater accuracy or finer discrimination between closely adjacent signals can be obtained by using an oscilloscope instead of headphones as the receiver indicating device.

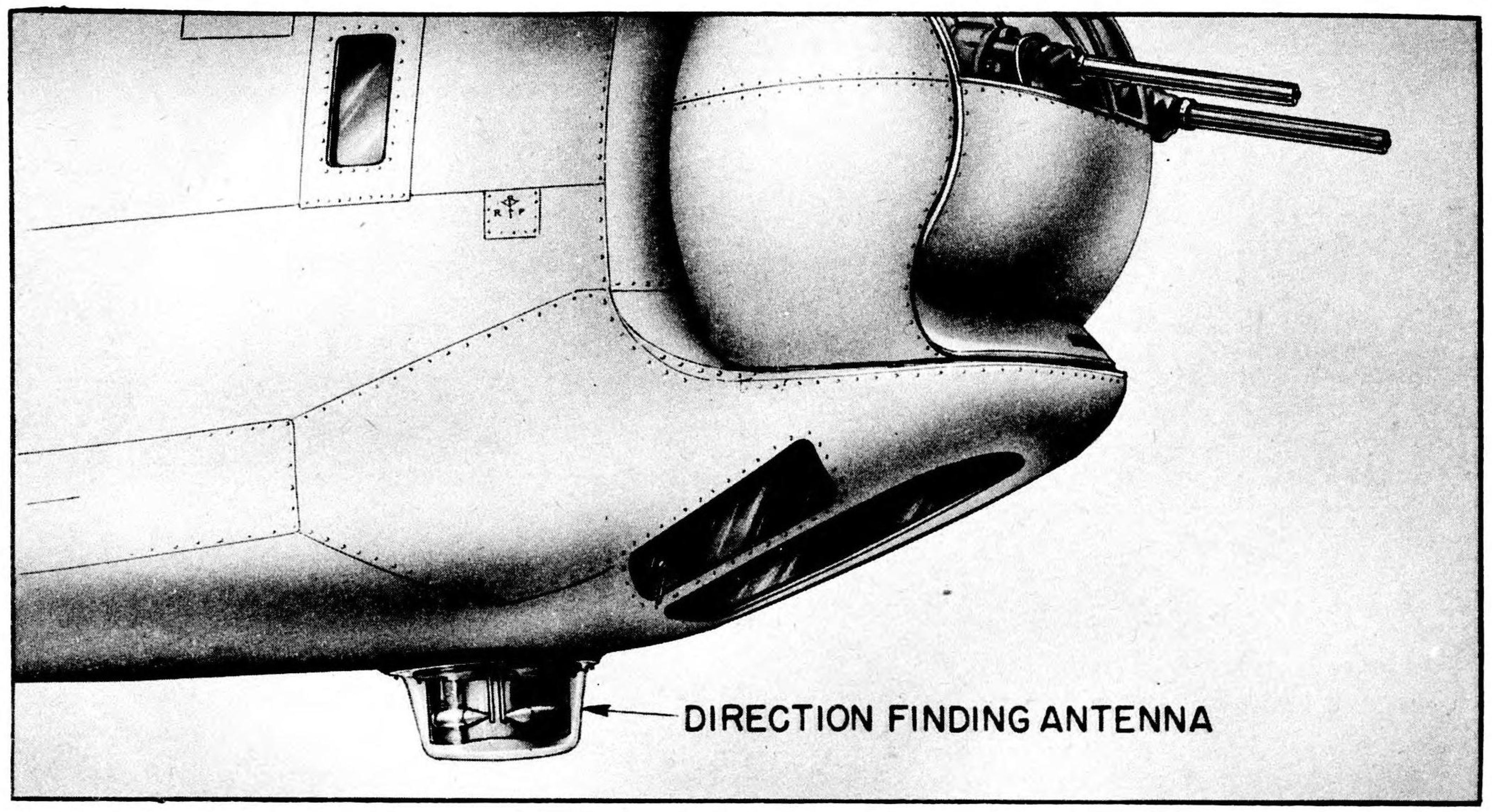
INSTALLATION The antenna assembly should be mounted so that its retractable strut projects vertically (preferably from the under side of the plane) at a point where its vision is not obscured by aircraft surfaces during normal flight. The "Vertical-Horizontal" antenna switch, the antenna turning lever, the receiver and the selsyn indicator should be mounted near the operator's position. Antenna heads can be interchanged readily.

PERSONNEL Personnel qualified to operate and maintain the receiver with which AN/APA-24 is used can operate and maintain this antenna system with a little extra training.

SPECIFICATIONS
FREQUENCY RANGE: 100 to 165 Mc, 165 to 275 Mc, 275 to 450 Mc, 450 to 750 Mc.
INPUT POWER: 1 watt, 110 volts, 400 cps, for selsyns.
POLARIZATION: Vertical or horizontal.
AZIMUTH: 360 degrees.
ACCURACY: Within ± 5 degrees.
SIZE AND WEIGHT: Projects 50" x 20", 20 pounds, with largest antenna head.
TECHNICAL FEATURES: The antenna assembly comprises a horizontal dipole and two vertical dipoles (Adcock) phased, so that the nulls lie on the axis of the horizontal dipole. The three are mounted on a common drive shaft which is rotated by a hydraulic Servo mechanism. Polarization is selected by means of a balance converter and switch. Selsyn type indicator connected to a selsyn in the antenna base is provided for improved accuracy in determining direction.

STATUS Moderate production under way. Equipment Restricted.

RADAR DIRECTION FINDING ASSEMBLY AN/APA-17



PURPOSE AN/APA-17 is an airborne device for indicating the direction of a radar station by means of signals received therefrom. It operates in the frequency range from 300 to 1000 Mc. It is designed primarily for use with AN/APR-4. The information obtained is used to determine the location of enemy radar equipments.

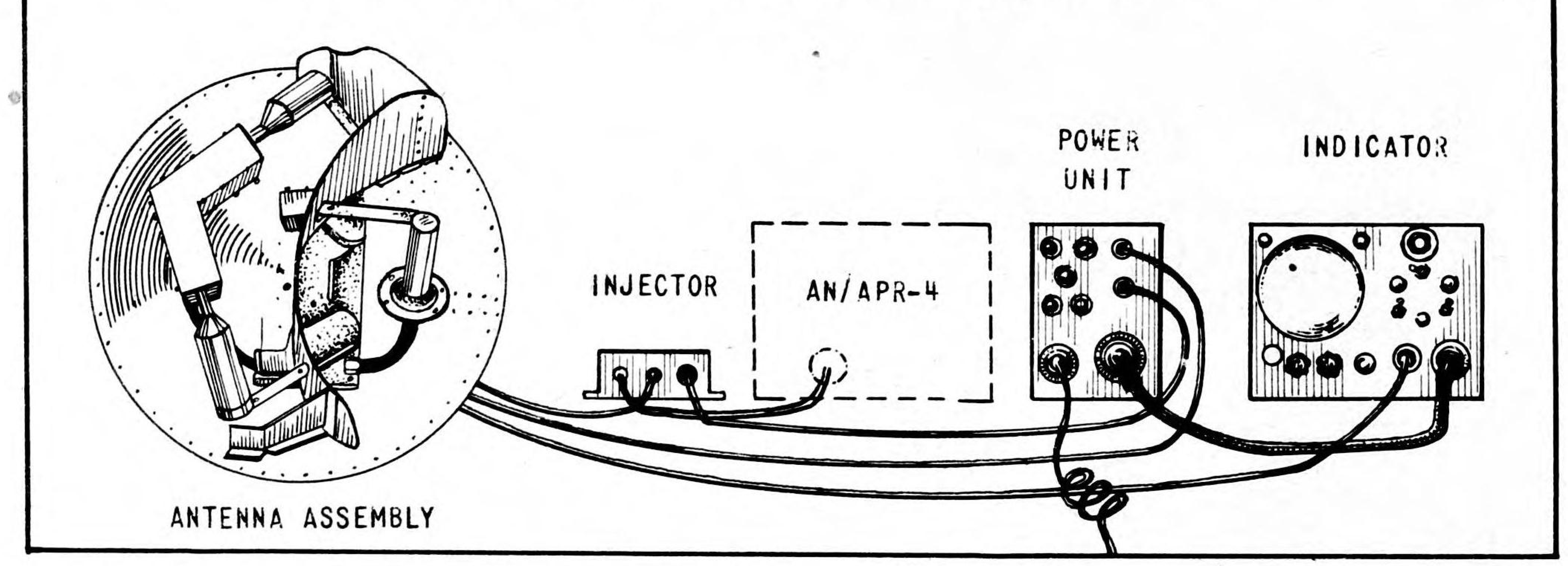
DESCRIPTION AN/APA-17 comprises a rotating antenna assembly, an indicator unit, (size SARC B1-D), a power unit, (size SARC A1-D), and an injector in a small box. The installed weight, exclusive of receiver and connecting cables, is 75 pounds.

The antenna assembly consists of two antenna systems with their reflectors, mounted on a motor-driven base plate. They are designed for directional reception of horizontally and vertically-polarized signals, respectively. The assembly projects 11½ inches outside the aircraft.

The indicator unit is a cathode-ray oscilloscope with a 5 inch screen. Besides the usual controls, means are provided for selecting reception of either horizontally or vertically polarized signals.

PERFORMANCE The antenna is rotated at speeds variable up to 140 revolutions per minute. The signal goes from the antenna to the receiver, where its frequency is indicated by the dial calibration. The receiver output is fed to the indicator unit where the antenna's radiation pattern is continuously pictured on the screen. The

MAIN COMPONENTS AN/APA-17



sharp apex of the pattern points to the bearing of the signal source, as shown on a surrounding scale marked in degrees. The screen indication can be read to an accuracy of ± 5 degrees for a 300 Mc signal or ± 3 degrees for a 1000 Mc signal. The direction of a desired station can readily be distinguished among overlapping patterns produced by several other closely-adjacent signal frequencies.

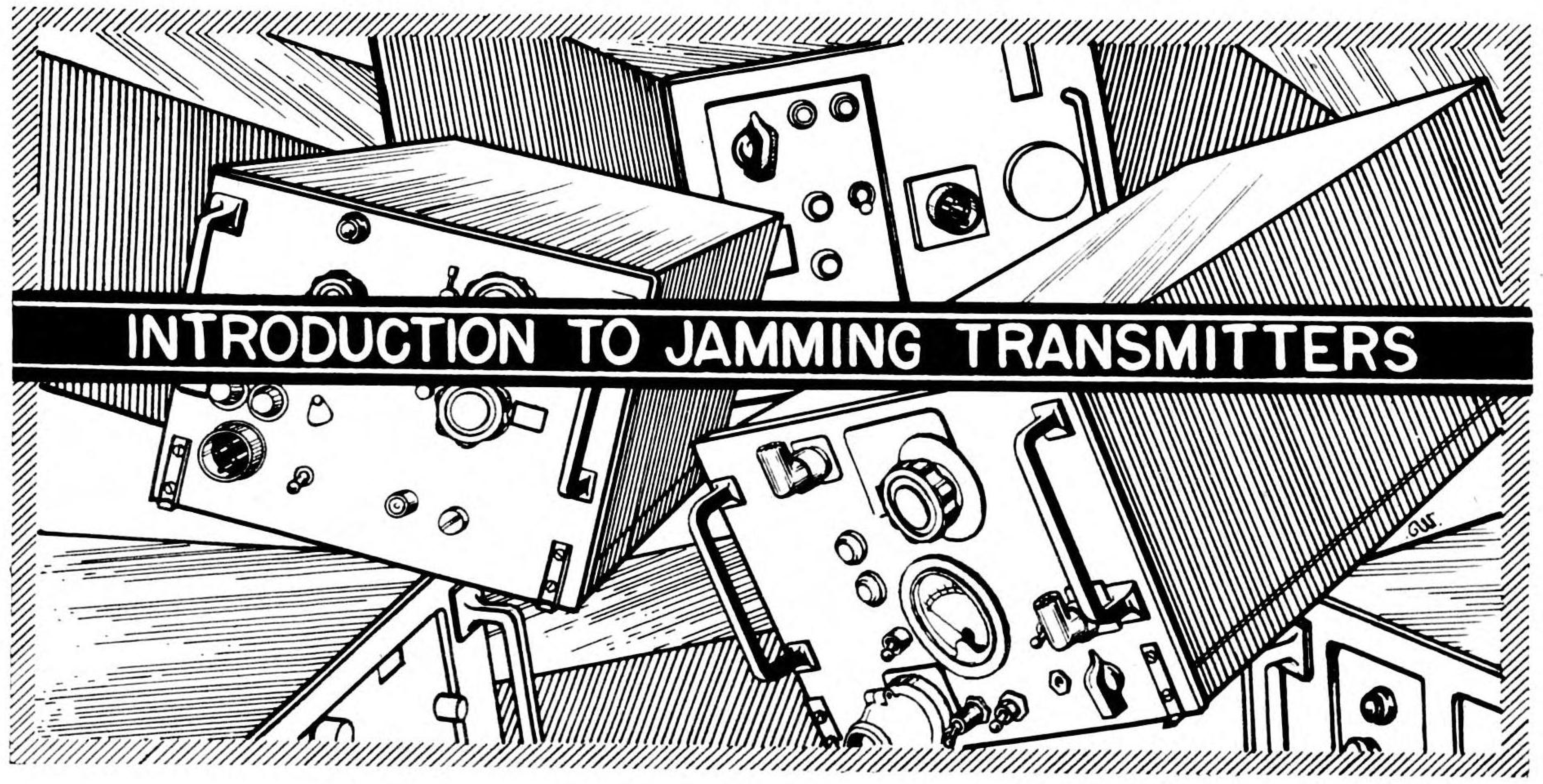
INSTALLATION Special directions for outside installation of the antenna system and inside installation of the motor-drive, connecting cables, indicator unit, and power unit are given in the Instruction Book for AN/APA-17. The indicator and power units should be mounted as close as possible to the receiver.

OPERATION Operation of the equipment involves tuning in the desired signal on the receiver, setting the indicator controls for optimum readability of the pattern, and recording the signal bearing. The time that an observation is recorded must be carefully correlated with the position of the plane at that time, which involves keeping close contact with the navigator of the plane.

PERSONNEL The attendance of one operator is required while observations are being made. Since the observations are intermittent, the regular operator of AN/APR-4 receiver can probably handle the equipment without interfering with his other duties. The regular maintenance men for AN/APR-4 can service AN/APA-17.

SPECIFICATIONS
FREQUENCY RANGE: 300 to 1000 Mc.
INPUT POWER: 125 watts, 115 volts, 400 to 2600 cps, a.c. and 50 watts, 28 volts, d.c.
ANTENNA DRIVE: 28 volt aircraft motor.
SWEEP DRIVE: Thru two selsyns, one geared to motor.
ACCURACY: Within ± 5 degrees.
POLARIZATION: Vertical with stub antenna, and horizontal with 2 dipoles.
SIZE AND WEIGHT: SARC B1-D and A1-D, plus 2-1/8" x 4-1/2" x 6", 75 pounds. Antenna assembly projects 11-1/2" and has 20" diameter.

STATUS Light production under way. Equipment **confidential.**



INTRODUCTION TO JAMMING TRANSMITTERS

Jamming transmitters are distinguished, among other things, by:

(a) Whether they are intended for use against communications or radar channels.

(b) Whether they are airborne, shipborne, ground-based, or expendable.

(c) Whether they provide barrage or spot jamming.

(d) Their effective output power.

For this reason there is a variety of jamming transmitters, each intended for specific applications. There may even be more than one type of transmitter for a given frequency band, each differing from the others in one or more of the above respects.

As already mentioned, the success of any radio countermeasure activity depends to a great extent upon the skill with which the operation is planned and executed. Intelligent planning, however, requires a thorough knowledge of the virtues and shortcomings of available methods and equipment. Therefore, some of the more pertinent factors that influence the use of jamming transmitters are discussed on the following pages.

Much of this material applies equally well to both communications and radar jamming so that, in the interests of conciseness and an integrated presentation, both fields are covered together. As a guide to those having particular interests, those paragraphs that pertain exclusively to either communications or radar are so indicated in the section headings.

COMMUNICATIONS vs. RADAR JAMMERS

Transmitters intended for jamming communications channels differ in a number of respects from those intended for jamming radar channels. For example, communications jammers operate on lower frequencies than do radar jammers, the dividing line occurring at about 50 to 100 Mc. Also more power per receiver channel is generally required for communications jamming than for radar jamming. On the other hand, the communications channel is very narrow (a few cycles for some hand telegraph to a few thousand cycles for voice) as compared to the radar channel (fraction of a megacycle to a few megacycles). Finally, the type of modulation that may be excellent for distracting the communications operator may differ greatly from that which is most effective in obscuring the desired signals on a radar indicator.

It is in general more difficult to jam a communications channel than a radar channel. One reason for the greater difficulty is the fact that the desired signal on the communications receiver is usually stronger than the echo signal received by the radar. A second reason is that communications channels, notably radio telegraph channels, are very narrow. It is therefore necessary either to tune the jammer accurately to the center of the channel or to radiate ample power over a band of frequencies in the region of the victim signal to insure that there is sufficient energy within the acceptance band of the receiver to jam the desired signal.

AIRBORNE vs. GROUND-BASED vs. EXPENDABLE JAMMERS

Jamming by transmitters located on the ground requires a maximum amount of power, whereas expendable jammers require the minimum amount if they are sown, as intended, close to the communications or radar receivers that are to be jammed. This is fortunate, since ground-based equipment has the greatest amount of input power available, whereas expendable jammers have the least. Airborne jammers, on the other hand, probably are the most versatile, since (excluding long-distance, sky-wave jamming) they can reach the most receivers, can generally be carried by the aircraft to be protected, and in jamming ground-to-ground channels can be flown over the scene of action. Thus they can often accomplish the desired result with much less power than even the most advantageously located ground-based unit would require. However, in the jamming of ground-to-ground channels, in spite of the advantages of great mobility, relatively low power, etc., airborne equipment is not necessarily the best.

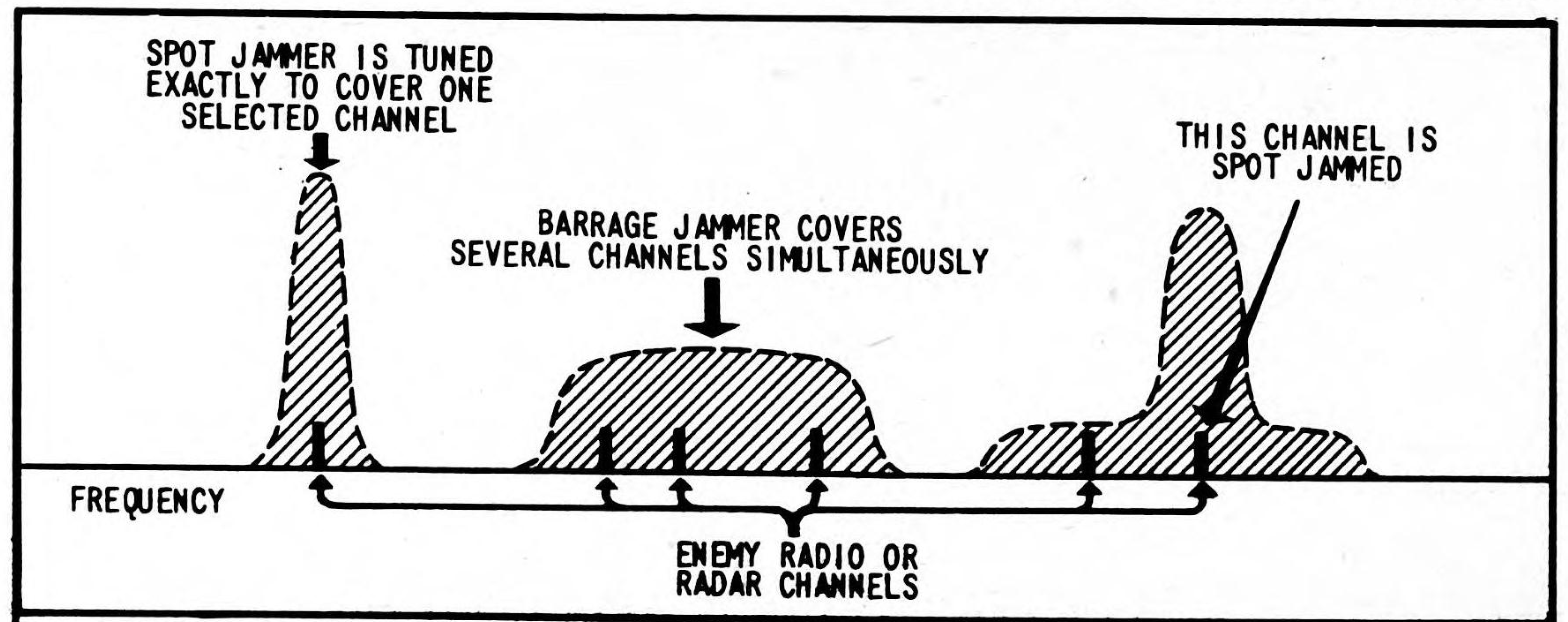
As a practical matter it may be best to confine airborne equipment to use against particular enemies of the aircraft, and to use ground-based or mobile equipment against particular enemies of the ground forces. Individual exceptions to this general policy will, of course, be advisable. An example is the use of ground-based jammers against AI radar and GCI communications channels as already mentioned (*Introduction to Radio Countermeasures*).

The use of parachute-borne, expendable jammers that can be dropped in the immediate vicinity of the receivers to be jammed offers interesting possibilities. Expendable jammers may be of several types, such as: parachute-borne (to jam during the period of descent), grounded (to jam from the ground), and floating (to screen small boats, etc.). In general, jammers of this type will not be effective against systems having highly directive antennas unless the jammers are directly in the beams of the antennas. Thus, in the case of radar, expendable jammers are of doubtful value because of the difficulty, if not impossibility, of keeping them in the radar beam. In the communications field, on the other hand, expendable jammers have possibilities, since highly directional antennas are seldom used for the services under consideration. Here, as in all other cases where the merits of various types of jammers to accomplish a given end are being weighed, consideration must be given to the weight, bulk, life, and effectiveness of the various devices that are available.

BARRAGE vs. SPOT JAMMING

The process of radiating jamming energy over a band of frequencies so as to be certain of blanketing the victim channel (either communications or radar) is known as barrage jamming. Contrasted to barrage jamming is spot jamming, in which the transmitter is tuned to exactly the same frequency as the victim signal.

The difference between spot and barrage jamming is analagous to that between rifle and shotgun firing. As in directed rifle firing, spot jamming requires skilled personnel. Barrage jamming, like shot-gun firing, on the other hand, requires less skilled "aiming", since the transmitter can be pre-set to blanket a comparatively wide portion of the frequency band. A barrage jammer, however, since it spreads the energy over a large part of the frequency spectrum (just as shot-gun fire covers a large area) requires considerably more power for the same degree of effectiveness than does an accurately tuned spot-jammer. Thus although with a given amount of power, spot jamming is more effective than barrage jamming, the former requires the attendance of skilled operating personnel.



The distribution of active enemy communication or radar channels in any given area of operations is likely to be more or less random at any given instance, as illustrated above. A spot jammer may be adjusted so as to concentrate all its output power on a given channel, as at left above, whereas a barrage jammer may be adjusted to cover a number of adjacent channels simultaneously. The term spot jamming is also used to mean the centering of a jammer exactly on the enemy frequency even though other channels are more-or-less covered too --as illustrated at right.

In the jamming of <u>communications</u> channels, the presence of an operator is usually desirable in order to identify signals that are to be jammed. Under some conditions the frequency bands of the enemy signals may be well known and not adjacent to any of our own, so that there is no need for continual identification.

In the jamming of <u>radar</u> channels, the type of operation to be undertaken will influence, to a large extent, whether spot or barrage jamming is used. Spot jamming, for example, would probably be used with ground-based jammers operating against one (or a few) enemy radars. Under such circumstances, however, the need for skilled personnel is no handicap as such personnel would probably be available anyway to maintain the jamming equipment. In airborne applications, however, the need for an operator and additional equipment may not be compatible with other requirements. Furthermore, even though operators could be provided, the use of spot jamming is not feasible in tight formations of aircraft flying over numerous radar sets. It is obvious that there would be no end of confusion if the various operators attempted to seek out and jam individual radars. Barrage jamming is clearly indicated in this type of application.

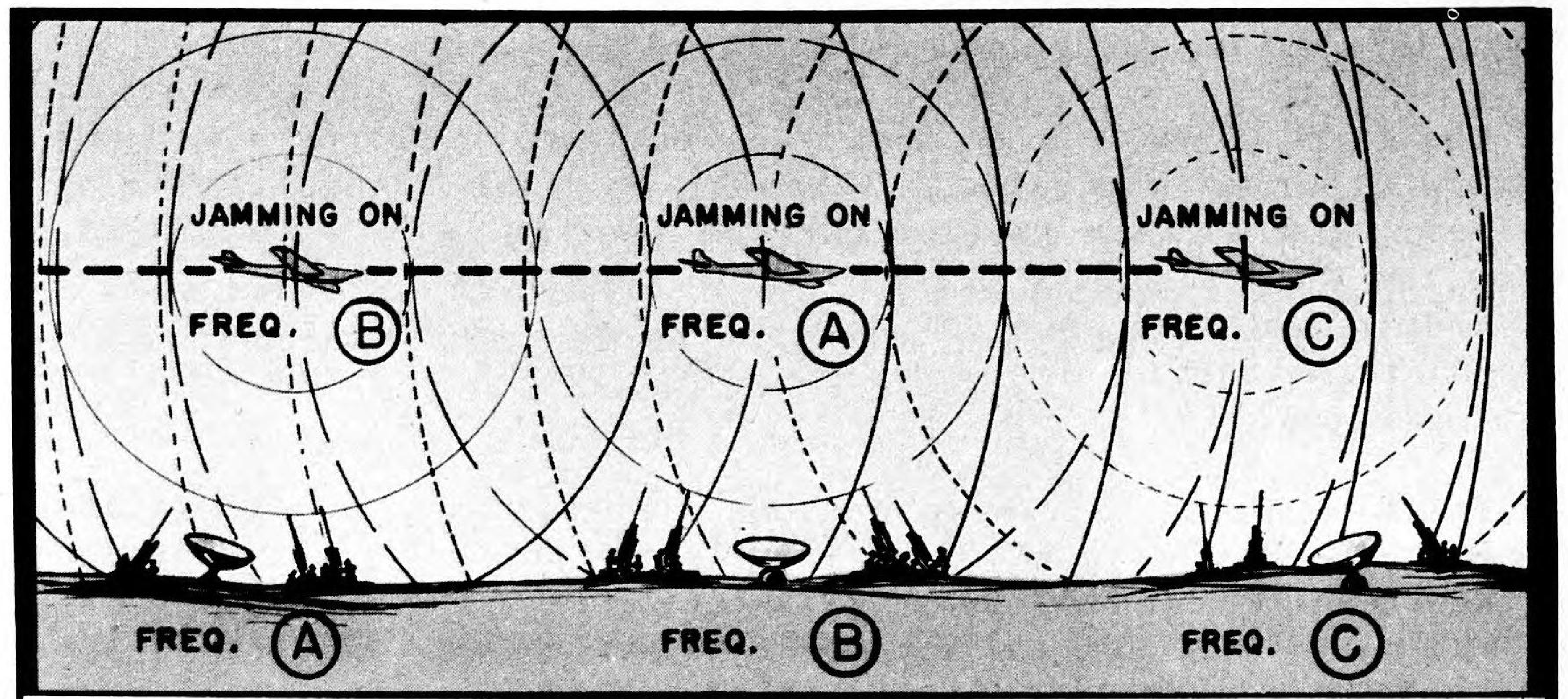
AUTOMATICALLY-TUNED JAMMING EQUIPMENTS

It is sometimes practical to use automatic devices that seek the victim signal, accurately align the jammer to its frequency, and then periodically monitor the enemy transmissions in order to terminate the jamming as soon as the enemy no longer uses the channel that is being jammed. Because of the feature of listening through one's own jamming, these devices are sometimes called "listening-through" systems.

Such automatic equipment is not as adaptable to communications signals as to radar and radio-controlled-device channels because of the large number of signals generally present in a communications band and the need for carefully identifying the intended victim. Experimental developments indicate, however, that for certain communication applications it is practical to develop equipment that will keep a jammer automatically aligned to the carrier of an enemy radio telegraph signal within close limits without at any time stopping the jamming long enough to permit the transmission of intelligence. The completion and procurement of equipment of this type, which is at present available only in laboratory form, is contingent upon the development of a tactical need for it.

For airborne jamming applications against radar and radio-controlled devices (either ground-based or airborne) automatic searching and jamming equipment would not, of course, be useful for daytime operations in which aircraft were flying in tight formations. Under these circumstances the jammers would probably lock upon each other. In night-time operations, however, or in isolated daytime flights, where the aircraft are an appreciable distance (say one mile) from each other, the use of automatic equipment is feasible, provided that it is capable of coping with the enemy's method of radar operation.

The type of automatic operation that is used will depend upon the enemy system. For example, if the theater of operations is one wherein the enemy radars are so widely spaced that only one need be jammed at a time, the automatic operation may be one wherein the jammer seeks the enemy frequency, transmits jamming signals thereon, and periodically listens-through to see if the victim signal is still there. When it is no longer present, the jammer ceases to operate and then searches for the next signal to be jammed, repeating the whole process over and over again. This type of operation has one possible hazard. If the enemy should have available fighters that are equipped to home on the jammer-carrying aircraft, there is the possibility that it may be intercepted.



Automatic searching and jamming transmitters sweep through the radio-frequency spectrum, lock on the first signal encountered and then transmit jamming signals on that frequency. The order of selection of the signals that are interfered-with depends upon their frequency and not on their geographical location. Therefore, the signals being jammed will not necessarily be those emitted by the nearest transmitter. After a prescribed period of jamming, the device may search for the next signal (in frequency) and interfere with it, or continue to jam the original signal until it is no longer present, or follow some other predetermined procedure.

Another type of operation would be one in an area in which there are many radars, a number of which may follow a given target at the same time. In this case, the automatic jammer operation may be one wherein the jammer seeks an enemy frequency, jams the first one encountered for a pre-determined length of time (say from 30 seconds to 2 minutes), then stops and seeks the next (as regards frequency) signal, jams it, and then moves on, etc. This type of operation can be effective against GCI and GL, even though all radars are not jammed all the time, since in either case accurate data is required for some period of time in order to make an interception or to provide accurate data for gun fire. The type of jammer operation just described is also effective in preventing homing on the jammer by interception since the length of time the jamming emission stays on any one frequency is relatively short.

It should be borne in mind that there is a simple counter-countermeasure for any listening-through device that stops jamming and moves on to the next signal as soon as the victim signal disappears. The victim station would only have to interrupt his transmissions long enough for the jammer to note its absence and to cease jamming. It would then be possible to make use of the equipment that had been jammed, at least until the jammer again returned to its frequency. From the point of view of the jammers, difficulty on this score can be obviated by jamming any signal for a predetermined period of time without listening-through.

TYPES OF JAMMING MODULATION

The type of modulation employed for jamming purposes depends upon whether a telegraph, telephone, or radar channel is being jammed, upon whether spot or barrage jamming is being employed, upon the vulnerability of the victim receiver to various types of modulation, and upon the kind of modulation that can be produced at the carrier frequency and power output at which the jammer operates.

In the jamming of communications channels, one consideration in the choice of type of modulation is the psychological reaction of an operator to novel forms of interference. The modulation may be chosen to distract the listener, rather than to obliterate the desired signal. This technique is of particular importance when the jammer lacks sufficient power to mask the victim signal completely, since some form of distracting signal, although weaker than the victim signal, may succeed in preventing the reception of any great amount of intelligence. A distracting type of signal does not appear to be effective in radar jamming. Here, the desired display must be obliterated or confused if the jamming is to be effective.

The type of modulation used for spot jammers should be such that the bandwidth of the jammer exceeds that of the victim channel by an amount only sufficient to allow for inaccuracies in aligning the jammer with the victim signal and for the frequency drift of the jammer and the victim channel. Barrage jammers should be provided with a form of modulation that distributes the energy evenly over the band of frequencies that is being barraged. Furthermore, in radar jamming, the type of modulation must be such as to avoid "holes" through which the desired signal may be seen. In general, a random type of modulation is more effective than a periodic type since, in many instances, anti-jamming measures may be taken to cope with the latter kind of interference.

Through poor design, some communications or radar receivers may be very vulnerable to some simple form of modulation. Since it is often possible to obtain larger power outputs and relatively simple design when simple types of modulation are employed, such shortcomings of enemy equipment should be exploited. At the same time, the ease with which these weaknesses may be corrected must also be borne in mind, since the useful life of any offensive radio countermeasures devices depends upon how difficult it is to devise an antidote and put it into service. As an example of this, it is to be noted that some receivers may be made less vulnerable to simple types of jamming signals simply by manipulating the volume controls in what might be considered an abnormal manner.

Although tests may indicate that a given receiver is particu-

larly vulnerable to a certain type of modulation, it does not necessarily follow in practice that this type is the best to use.

In determining the best type it is necessary to give consideration to the practical aspects of employing this type of modulation in an actual transmitter. For example, one type of modulation may be found to be twice as effective as another, yet it may be possible, with a given amount of input power, to obtain four times as much output with the less desirable modulation. Under these circumstances use of the latter may be indicated.

At the higher frequencies, particularly in barrage jamming in the radar band, there is a practical limit to the modulation bandwidth that can be obtained. Furthermore, in the case of high-power radar barrage jammers a number of problems are encountered in connection with the modulation of the amount of power that is involved. An understanding of these problems will be of material aid in planning the use of such equipment and in looking forward toward future developments.

One particular type of jamming modulation, noise, deserves special mention. Noise is a random type of modulation and one wherein the energy distribution is uniform, except as it may be influenced by limitations in associated circuit elements. Noise modulation therefore lends itself particularly well to barrage jamming and, for that matter, also to spot jamming. Since it has no periodically recurring frequency it cannot be filtered out, or eliminated by any other means, without also eliminating the desired signal. As is well known, the noise level is the basic factor that limits the sensitivity of any receiver.

Noise has another attribute that makes it a desirable type of jamming modulation. This is the fact that the presence of a noise jamming signal in a receiver may not be recognized as deliberate jamming. It is, therefore, a subtle type of jamming that may be practiced for some time, upon the uninitiated, before being recognized for what it is. There is, however, another factor to be considered in this respect, particularly in the jamming of communications channels. Many operators are experienced in listening through background noise and will therefore have less difficulty in adjusting themselves to this form of interference than to stepped-tones or some other novel form of jamming. Furthermore, an inexperienced operator is prone to stop listening when he hears peculiar interference or realizes he is being jammed. With noise jamming, not realizing he is being intentionally jammed, this operator continues to copy or to try to copy. These factors are variable, however, and to some extent are transient in nature and should be considered as such.

A disadvantage of noise modulation, from the equipment point of view, is the possible difficulty of generating the desired amount of noise modulation power, particularly at the higher frequencies and at the higher output levels.

CONTINUOUS WAVE (cw) JAMMING OF COMMUNICATIONS

The use of an unmodulated carrier (cw) for jamming may be effective in communications channels but will have little, if any, effect upon well-designed radar receivers. To be effective, against telegraph channels operated by skilled personnel, the jamming cw signal must be accurately tuned so that the difference in frequency between the desired and undesired signals is within 2 to 10 cps and keyed at the same rate or slightly faster than the victim signal.

In telephone channels the intermodulation products that result from the presence of an undesired cw carrier can also be effective in preventing the reception of intelligence. In this case the optimum difference in frequency between the desired and the undesired carrier for maximum jamming is in the vicinity of 500 cps. It is to be noted that in the two types of communications channels mentioned, cw interference is effective only in spot jamming and then only if present in sufficient strength and if accurately adjusted to the optimum relative frequency for jamming.

CONTINUOUS-WAVE (cw) JAMMING OF RADAR

Relatively simple arrangements may be incorporated in radar receivers to cope with cw jamming. Even when such precautions have not been taken, readable indications can often be obtained through considerable amounts of cw jamming by judicious operation of the various controls. In general, the use of cw for jamming either communications or radar channels is not a particularly economical method, since, if the same amount of radiated energy can be made available in the form of a suitably modulated signal, the jamming will be much more effective. It is therefore evident that the energy in the modulation sidebands is of considerable interest in any jamming application.

SIDEBAND ENERGY DISTRIBUTION

A knowledge of the distribution of energy in the sidebands of a modulated jamming transmitter is essential in planning the details of tactical application of the jammer, especially in barrage jamming. This is particularly true when a number of transmitters must be used to cover the band of frequencies involved. As de-

tailed below, the distribution of sideband energy considerably influences the manner of setting the carrier frequencies of the various transmitters involved in a barrage operation of this type. Information concerning the distribution of the sideband energy is also vital to calculations of the effectiveness of a jammer for protecting a given target against a specific radar.

Theoretically, the distribution of energy in modulation sidebands is confined to specific frequencies when recurrent waveforms are used for the modulation. Consequently, there are likely to be gaps in the spectrum. The widths of these gaps are a function of the parameters involved and under some circumstances these types of modulation may be entirely unsatisfactory for the purpose in hand.

In practice, the actual distribution of sideband energy may differ considerably from the theoretical values because of the characteristics of the electrical circuits involved. For example, there may be a considerable amount of incidental frequency modulation of the carrier. Under these circumstances, as compared to the theoretical distribution, there is relatively large amounts of energy spread over a considerable band in the vicinity of the carrier frequency. A transmitter having incidental frequency modulation is more effective in jamming receivers close to the nominal carrier frequency than if the frequency modulation were not present. The incidental frequency modulation allows the carrier energy to be effective in jamming, even though cw anti-jamming devices may be in use.

When amplitude modulation is used, a large amount of the available output energy of a jamming transmitter may be dissipated in the carrier. This suggests the use of some form of carrier-suppressed emission in order that the total output capacity of the transmitter may be available in the modulation sidebands.

A novel form of a carrier-suppressed (really carrier-less) emission is employed in the DINA type of transmitter. In its basic form this transmitter consists of a DIrect Noise Amplifier (whence the name DINA), designed to amplify in the radio-frequency range in which transmissions are desired, which is connected to a source of noise. Noise components, at the desired frequency, are thus amplified until they have sufficient power to be radiated. Consequently there is no carrier and all the available output capacity of the transmitter is made available in sideband energy.

In the design of DINA transmitters difficulties arise from the necessity of tuning the wide-band amplifiers in order to choose the frequency band to be jammed. Greater flexibility and over-all simplicity may be achieved by generating the noise energy in a fixed frequency band and heterodyning to the desired transmission frequency. This method has the added advantage that it makes possible the use of the output of the noise source in the frequency range where it is most efficient.

Another important consideration in the design of jammers is the choice of the signal with which the carrier is modulated. If the carrier is modulated with a sine wave, the jamming may actually increase the amplitude of the pip in the enemy radar screen. This effect occurs because the pip "rides on top" of the jamming signal and the increased input to the second detector resulting from the jamming signal allows the second detector to operate on a more favorable portion of its characteristic. If the carrier is amplitude-modulated by noise that is highly clipped (i.e. noise in which the peaks have been cut off), and the band width of the radar receiver is wide in comparison with the jammer band, the resulting disturbance in the radar scope is flat-topped. The pip "rides on top" of such a disturbance, and so the jamming is ineffectual even though the frequency coverage may be satisfactory. If the band width of the radar is small in comparison with the jammer band width, on the other hand, the resulting disturbance on the radar scope is sufficiently irregular to mask the pip effectively. This problem does not arise when the carrier is frequency-modulated by noise.

JAMMER FREQUENCY SETTING

If the jammers are otherwise in good operating condition, the success of any plan of jammer activity depends entirely upon the accuracy with which the transmitters are adjusted to the victim frequency. In the manually adjusted transmitters used for spot jamming, therefore, means must be provided for determining the victim frequency and for accurately adjusting the jammer to this frequency. An operator trained to identify the intended victim signals and to adjust the jamming transmitter is also required.

In spot jamming, the jammer carrier must be set as closely as possible to the frequency of the victim signal. In ground-based or shipborne equipment this does not present a serious problem since ample equipment and operating personnel can generally be made available. In airborne installations, on the other hand, the need for conserving weight and personnel makes it desirable to pre-set the jammer to the proper frequency on the ground before take-off. Unfortunately this cannot be done to spot jammers, because of the setting accuracy that is required. Deviations introduced by receiver or frequency-meter calibration inaccuracies, by reading and resetting errors, and by frequency drifts in both the frequency-meter and the transmitter because of changes in temperature, pressure, humidity, and power supply voltages, all combine to make it impractical to pre-set spot jammers. The accuracy required depends upon the type of jamming used and ranges from a few cycles per second in keyed cw jamming to 0.5 Mc or so in radar jamming. Over-all accuracies of 0.1 per cent or considerably better are evidently necessary.*

Even though it may not be feasible to pre-set an airborne spot jammer prior to take-off, the equipment should be adjusted before take-off as closely as possible to the frequency to be jammed. To make a major frequency change in the air is generally difficult and time-consuming. Furthermore, by setting up the equipment as nearly as possible to the desired frequency, the performance of the set can be accurately checked at approximately the frequency at which it will be used.

As contrasted to spot-jammers, barrage jammers can usually be pre-set to the proper frequency band and, in airborne equipment, the attention required during flight can thus be reduced to simply turning the equipment on and off at the proper time.

In the jamming of communications channels the procedure for setting the jammers on-frequency is merely to make certain that the barrage completely covers the band of frequencies to be jammed In radar jamming, however, additional considerations must be taken into account. For example, the bandwidth of a radar barrage jammer is seldom great enough to cover the entire band over which the enemy radar is likely to be spread. Furthermore, because of the limited output power of all but the most recent types of available airborne barrage jammers, one or more units are generally required in each aircraft that is to be screened. When only one or two transmitters are involved in a given operation, they should be accurately adjusted so as to span the spectrum in which the enemy radar carriers are most likely to be located.

In large formations, however, where many jammers are available, it is important that their frequencies be accurately adjusted so that the maximum possible number of channels are occupied by the jammer carriers. This may be done by carefully spacing the carriers uniformly across the band occupied by the enemy systems. Under these circumstances the carriers, particularly if they have incidental FM, contribute greatly to the jamming effectiveness. In an operation of this kind, the absolute accuracy of the frequency meter used for setting the carrier frequencies need not be very great since it is only the relative accuracy that is important, particularly if it is possible to check all transmitters against the same frequency meter.

*For equipment and methods of setting jammers on-frequency see Section on Test Equipment.

OPERATIONAL TACTICS

The use of communications and radar jamming and deception methods in actual operations is subject to the prevailing doctrines in the theater involved. A discussion of these doctrines would obviously be out of place in this book. A few generalities pertaining to methods of use may be mentioned, however.

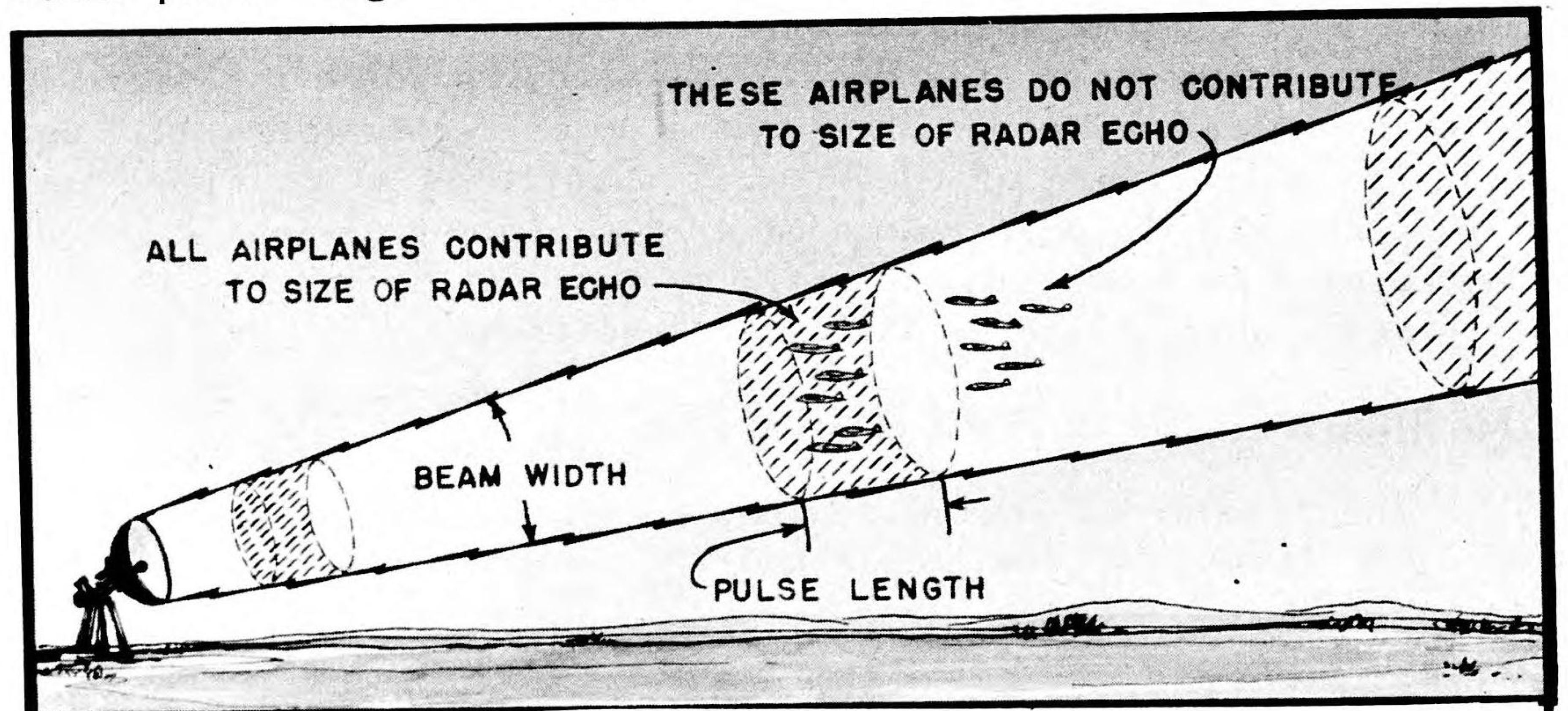
Communications and radar jamming transmitters should, as a rule be used only as much as is necessary to accomplish the desired results. This practice will hinder direction-finding and homing on the jammers by the enemy and, incidentally, will limit the time during which the enemy operators can study and become accustomed to the particular type of the jamming signal being used. As mentioned elsewhere, one of the most effective anti-jamming measures is sufficient operator training and experience. Conversely, the element of surprise plays a large part in determining the effectiveness of a jamming operation.

In radar jamming there is still another reason for limiting the use of the jammers as much as possible. When self-screening is used (that is, where the target to be screened from the enemy radar is carrying its own jammer), if the jammer is turned on before the craft is within the field of view of the radar, its presence will be revealed to the radar. This results from the fact that the strength of the emissions from the jammer considerably exceeds the strength of the radar echo (except when the target is close to the radar) and consequently the radar receiver will respond to the jamming transmissions long before it receives a sufficiently strong echo to detect the presence of a target. Although neither the size of the target nor its range can be ascertained by reception of jamming emissions, its bearing will be revealed and a warning given of the possibility of an attack from that quarter.

An exception to the general philosophy of limiting jamming transmissions as much as possible would be in an instance in which a false appearance of activity is to be created. Just as in communications deception practices, if the enemy comes to associate jamming operations with increased activity, it may be desirable, on occasion, deliberately to operate jammers for deception and confusion and purposes.

Although the size and shape of a formation will undoubtedly be dictated by tactical considerations, it should be borne in mind that these factors also influence the jamming effectiveness. The effectiveness of airborne radar jamming transmitters used for self-screening can be increased considerably if the formation of planes is made up so that the aircraft are all within the beam

width but are not all within the distance corresponding to the radar pulse length.* The jammers on all the planes will then con-



If operational tactics permit, the effectiveness of a flight of jammer-carrying planes can be considerably increased if all aircraft can be kept within the beam width of the radar while being spaced in depth at a distance greater than that corresponding to a pulse length. Under these circumstances, although all aircraft contribute to the jamming, only those within a pulse-length "distance" contribute to the amplitude of a specific radar echo.

tribute to the jamming effectiveness but only those planes which are within the distance corresponding to the pulse length will contribute to the amplitude of the echo. The echoes from the various aircraft will be spread on the radar screen and, therefore, the amplitude of the jamming signal needed to cover them up need not be so great as it would be if all echoes added together in height.

JAMMING POWER REQUIREMENTS

In general it is desirable to employ as much jamming power as possible. As a practical matter, however, the weight, bulk, portability, and power drain of the equipment often determines the size of the transmitter that can be used. Furthermore, it is not economical on any score to provide jamming transmitters that are appreciably larger than necessary to accomplish the desired end.

The exact calculation of the jamming power required in order to effectively neutralize a given communications or radar system involves a knowledge of such factors as the power output of the enemy transmitter, the transmitting and receiving antenna gains and directivity patterns (in both the vertical and the horizontal planes), the distance between the jammer and the receiver, the strength of the desired (from the enemy viewpoint) signal at the receiver, the jam-to-signal ratio for the type of modulation in-

*A radar pulse may be thought of as a 'slug' of radio energy moving radially away from the source (at the rate of 186,000 miles per second or 1000 ft.per microsecond) and occupying, at any given instant, a portion of space that is 1000 ft. in depth for each microsecond of pulse length. Since all targets within this area will be illuminated simultaneously, they will all create echoes which, on the radar indicator, will blend together into one pip.

volved and, in radar jamming, the effective size of the target. A discussion of the exact mathematical relationships whereby the jamming power, for a specific case, may be calculated is beyond the scope or intent of this book. The manner in which the various factors involved influence the jamming power requirements will be outlined. A knowledge of these relationships is of considerable value since, if the performance of a given jammer against a given enemy system is known, an accurate estimate can be made as to its performance under slightly different conditions.

COMMUNICATIONS JAMMER POWER REQUIREMENTS

In the jamming of communications channels, line-of-sight between the jammer and the victim receiver seldom exists (as it often may in radar jamming) so that, in addition to the above factors, it is generally necessary to take into consideration the effect of the earth upon the propagation of the jamming signal. Because of the large number of parameters involved, this can be done readily only by reference to propagation curves that have been prepared for the particular values of frequency, soil conductivity, dielectric constant, and transmitter and receiver antenna height involved.

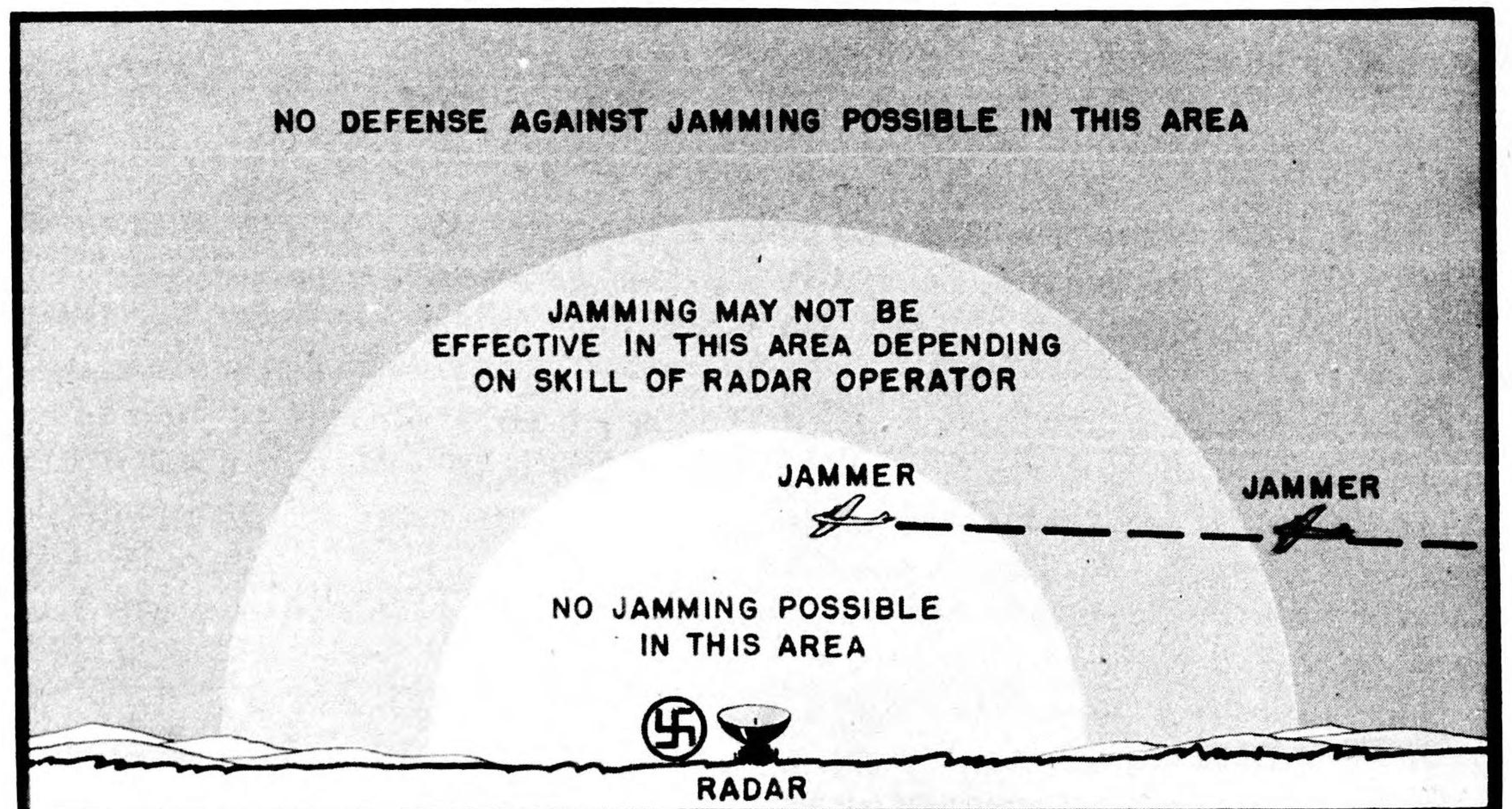
Other factors being equal, the power required to jam a communications channel is

1. Directly proportional to:
   - a. the power output of the victim's transmitter,
   - b. the power gain of the associated antenna,
   - c. the discrimination of the receiving antenna against the jamming signal,
   - d. the jam-to-signal ratio for the type of receiver and modulation involved.
2. Inversely proportional to the power gain of the jammer antenna in the direction of the victim receiver.

It is evident that, in order to calculate the effectiveness of a jammer accurately, considerable information, some of it concerning the victim equipment, must be available. It is possible under some circumstances, however, to make use of a comparison method that will often give sufficiently accurate results to be useful. This method consists in setting up a receiving site where the relative value of the victim and the jamming signal can be determined and then, from a knowledge of the location of the enemy receiver and the jammer, calculating the estimated effectiveness of the jamming. Although this method also involves the use of wave-propagation curves, it does not require so much detailed information concerning the enemy equipment.

RADAR JAMMER POWER REQUIREMENTS

In radar jamming, the closer the target is to the radar, the greater is the power required for jamming. This is so since the strength of the receiver echo increases as the distance between the target and radar decreases, and the more jamming power is therefore required to obliterate it. This condition exists even when self-screening is practiced (target carries a jammer) because although the jamming signal received at the radar thus increases as the target approaches, the size of the echo increases at a greater rate. For this reason, the minimum distance at which a jammer can screen a given target is a measure of the effectiveness



As a jammer-equipped craft approaches a radar, it can provide self-screening from the point where the radar would normally first detect the target, to a point where the strength of the echo signal is so great that it is no longer obliterated by the jamming signal. The greater the power of the jammer, the closer the jammer-carrying craft can approach the radar without being detected by it.

of the jammer. In general, however, it is to be noted that considerably less power per channel is required for radar jamming than for communications jamming. This is true largely because of the fact that in the former it is necessary only to obliterate an echo whereas in the latter it is necessary to cope with a direct signal.

If the distance at which a jammer is effective is determined by experience for a given set of circumstances, the performance to be expected under other conditions may be estimated from the following relationships. Other factors being equal, the minimum distance at which a given radar jammer will be effective is

1. Directly proportional to the square root of:

    a. the effective echo area of the target.

    b. the effective peak power of the radar.

    c. the power gain of the radar transmitting antenna.

    d. the jam-to-signal power ratio for the type of modulation employed.

2. Inversely proportional to the square root of:

    a. the jammer output power.

    b. the power gain of the jammer antenna in the direction of the radar.

From the foregoing it is evident that if the effective area of a target is increased four times, the minimum distance at which screening will still be obtained becomes twice as great as originally; or, if the enemy increases the equivalent radiated power from his radar by a factor of 10, the minimum distance is increased 3.16 times (square root of 10). Similarly, in order to halve the minimum effective distance, the jammer power must be quadrupled.

CONVERSION OF STANDARD COMMUNICATIONS TRANSMITTERS INTO JAMMERS

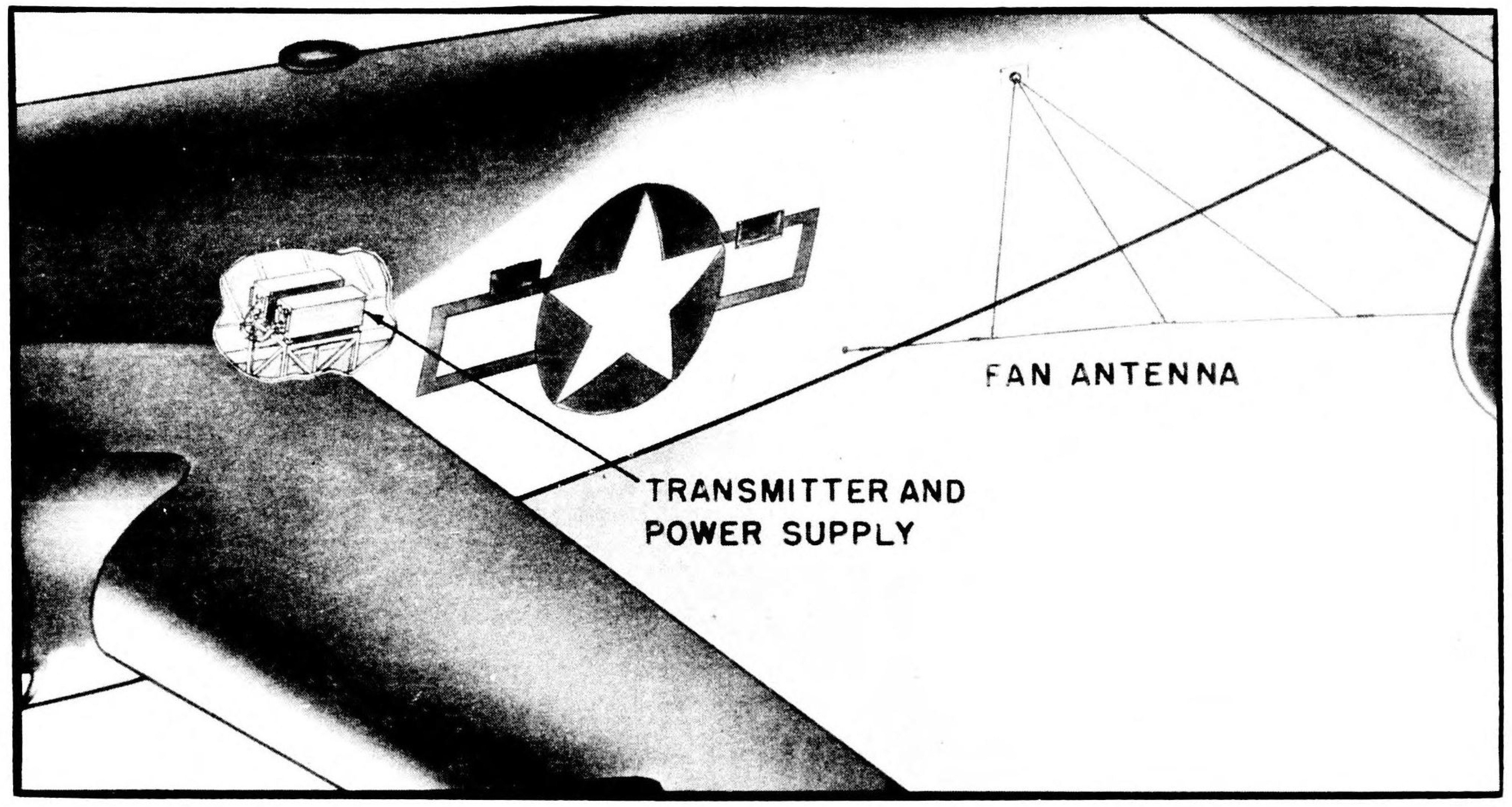
It is often possible, with relatively little effort, to convert an existing radio telephone transmitter into a jammer by the simple expedient of providing suitable modulation. This expedient may prove to be a quick method of obtaining jammers where standard equipment is available that has sufficient output power to be effective and covers all or even a part of an enemy communications band.

There are two simple methods of obtaining a satisfactory signal for modulating the transmitter. One is to place the regular microphone in a noisy location, such as an engine nacelle (the British call this "Tinsel"). A second method is to make use of receiver noise by connecting the output of a convenient receiver to the microphone input terminals on the transmitter and adjusting the modulation controls for a maximum amount of side-band energy. This type of improvisation results in a spot jammer, since the width of the sidebands in a transmitter of this type is generally limited. Under these circumstances it is essential that the transmitter carrier be set as close as possible to that of the victim.

SUMMARY OF TRANSMITTING EQUIPMENT

AN NUMBER	CODE WORD	FREQUENCY (MC)	OUTPUT POWER (WATTS)	TYPE OF MODULATION	COMMENTS	PAGE
ART-7	JACKAL	27-34	125-200	MECHANICAL FM		112
ART-9	JACKAL	37-43	125-200	MECHANICAL FM		112
ART-10	JACKAL	42-48	125-200	MECHANICAL FM		112
ART-11	JACKAL	48-57	125-200	MECHANICAL FM		112
ART-3	HI-POWER JACKAL	27-57 MC (IN 5 BANDS)	1000	MECHANICAL FM		114
TU-60		15-22.5	100	MECHANICAL FM	PLUG-IN UNIT FOR TRANSMITTER BC-375	115
ARQ-8	LOW FREQUENCY DINA	25-105	20-40	DIRECT NOISE AMPLIFIER	HAS RECEIVER FOR ACCURATE SPOT JAMMING	116
ARQ-1	SANDY	14-50	20	DIRECT NOISE AMPLIFIER	HAS RECEIVER FOR ACCURATE SPOT JAMMING	118
ARQ-7	SPOTKIE	38.6-42.2	50	NOISE AM	HAS RECEIVER FOR ACCURATE SPOT JAMMING	120
AM-33/ART		25-105	100-200		AMPLIFIER FOR USE WITH ARQ-8, ETC.	122
ARA-3	GASTON				NOISE SOURCE FOR STANDARD TRANSMITTER	123
APT-3	MANDREL	85-140	9-12	NOISE AM		124
APT-1	DINA	95-210	8-30	DIRECT NOISE AMPLIFIER		126
AM-14/APT		85-150	90-130		AMPLIFIER FOR USE WITH APT-1, ETC.	128
AN-18/APT		140-210	50-100		AMPLIFIER FOR USE WITH APT-1, ETC.	129
APQ-2A	RUG	200-550	5-20	NOISE AM		130
APT-2	CARPET I	450-720	3-8	NOISE AM		132
APQ-9	CARPET III	475-585	15-20	NOISE AM		134
APT-4	AIR BROADLOOM III	165-780	50-150	NOISE AM		136
APT-5	CARPET IV	350-1400	5-60	NOISE AM		138

RADIO TRANSMITTING SET AN/ART- 7, 9, 10 & 11 (JACKAL)

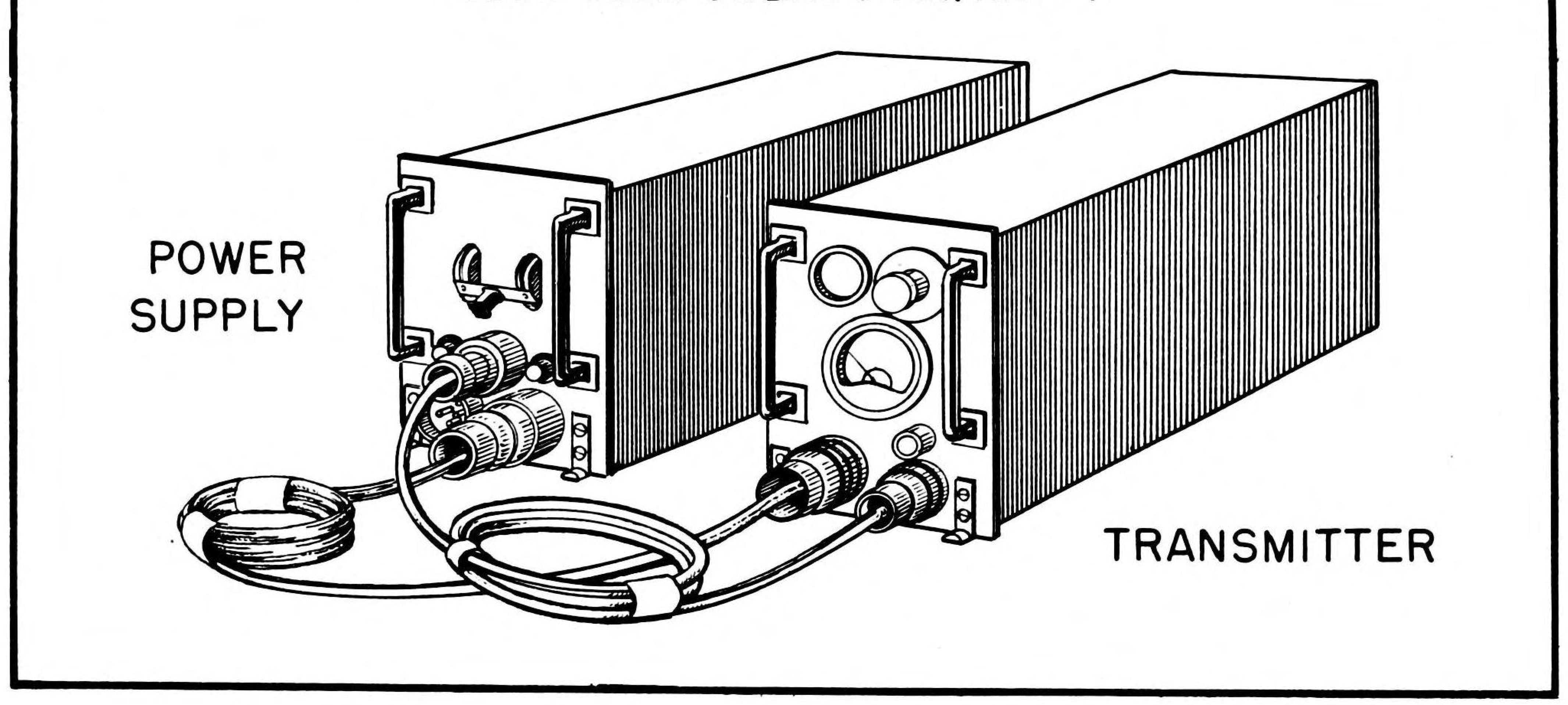


PURPOSE The Jackal series of transmitting equipments (AN/ART-7, 9, 10 and 11) are airborne barrage jammers for use against ground-to-ground or air-to-ground communications links in the frequency range from 27 to 57 Mc. Each transmitter is designed to jam a portion of this band.

DESCRIPTION Each of these equipments consists of a transmitter unit (SARC A1-D) and a power-supply unit (SARC A1-D). The transmitters differ essentially only as to frequency range covered: the power-supply units are identical. A Jackal transmitter emits about 150 watts of frequency-modulated jamming power. Each transmitter sweeps continuously through the frequency band for which it is designed.

PERFORMANCE The FM signal from a Jackal transmitter causes a type of jamming of communications receivers that is known as "sweep through". Tests indicate that the output of these transmitters is effective in the jamming of amplitude-modulated communications receivers not provided with efficient limiters or exhibiting limiting action due to overloading. It is less effective in the jamming of frequency-modulated communications signals. In operation against particular enemy systems the effectiveness depends, of

MAIN COMPONENTS AN/ART- 7



course, upon the characteristics of the enemy equipment and, especially, upon the relative positions of the transmitter and the enemy receiver. These transmitters offer the possibility of jamming enemy tank AM communications without interfering with our own FM tank sets.

INSTALLATION & OPERATION The equipment may be installed at any convenient point within the aircraft and requires no attention other than turning the transmitter on and off. The antenna installation is somewhat different for each transmitter due to the difference in frequency band covered, but will in general be a fan or a whip antenna. Normally only one transmitter is carried at a time.

PERSONNEL No extra personnel is required for operation of this equipment. Regular radio maintenance personnel, properly supervised, can service the equipment.

SPECIFICATIONS FREQUENCY RANGE: AN/ART-7 27 to 34 Mc. AN/ART-9 37 to 43 Mc. AN/ART-10 42 to 48 Mc. AN/ART-11 48 to 57 Mc.

INPUT POWER: 500-800 watts, 80 or 115 volts, 400 to 2600 cps. a.c., and 75 watts, 28 volts d.c.
OUTPUT POWER: 125-200 watts.
MODULATION: Mechanical frequency modulation at 300 cps. With the exception of ART-11, each transmitter frequency sweeps continuously through the entire frequency band for which it is designed. ART-11 can sweep either the entire band or a selected portion of the band.
SIZE AND WEIGHT: Each transmitter - SARC A1-D; 15 pounds.
Each power supply - SARC A1-D; 40 pounds.
TECHNICAL FEATURES: The Jackal Transmitter is a push-pull oscillator, which is frequency modulated by a motor-driven rotating condenser.

STATUS Moderate production under way. Equipment Confidential.

RADIO TRANSMITTING EQUIPMENT AN/ART-3 (HIGH POWER JACKAL)

PURPOSE AN/ART-3 is a high-powered barrage jammer for use in the frequency range from 27 to 57 Mc.

DESCRIPTION AN/ART-3 consists of a 5-band transmitter unit (SARC B2-D), and a power supply unit (SARC B2-D). The transmitter furnishes about 1 kw of jamming power, mechanically frequency modulated over any one of the following bands: 27 to 34 Mc. 32 to 38 Mc, 37 to 43 Mc, 42 to 48 Mc, or 48 to 57 Mc.

PERFORMANCE AN/ART-3 emits a frequency-modulated jamming signal, which causes a type of jamming of communications receivers known as "sweep through". Tests indicate that the output of this transmitter is effective in the jamming of amplitude-modulated communications receivers not equipped with efficient limiters or not exhibiting limiting action due to overloading. The effectiveness is very much less in operation against frequency-modulated communications signals. This transmitter continuously sweeps over the entire frequency band of the tuning unit used. It is believed that the output in the 38.6 to 42.2 Mc band, for instance, is sufficient to prevent communication between a ground station and an AI-radar-equipped fighter which is operating against a high flying bomber carrying the jammer within a range in which the AI radar carried by the enemy fighter will be effective.

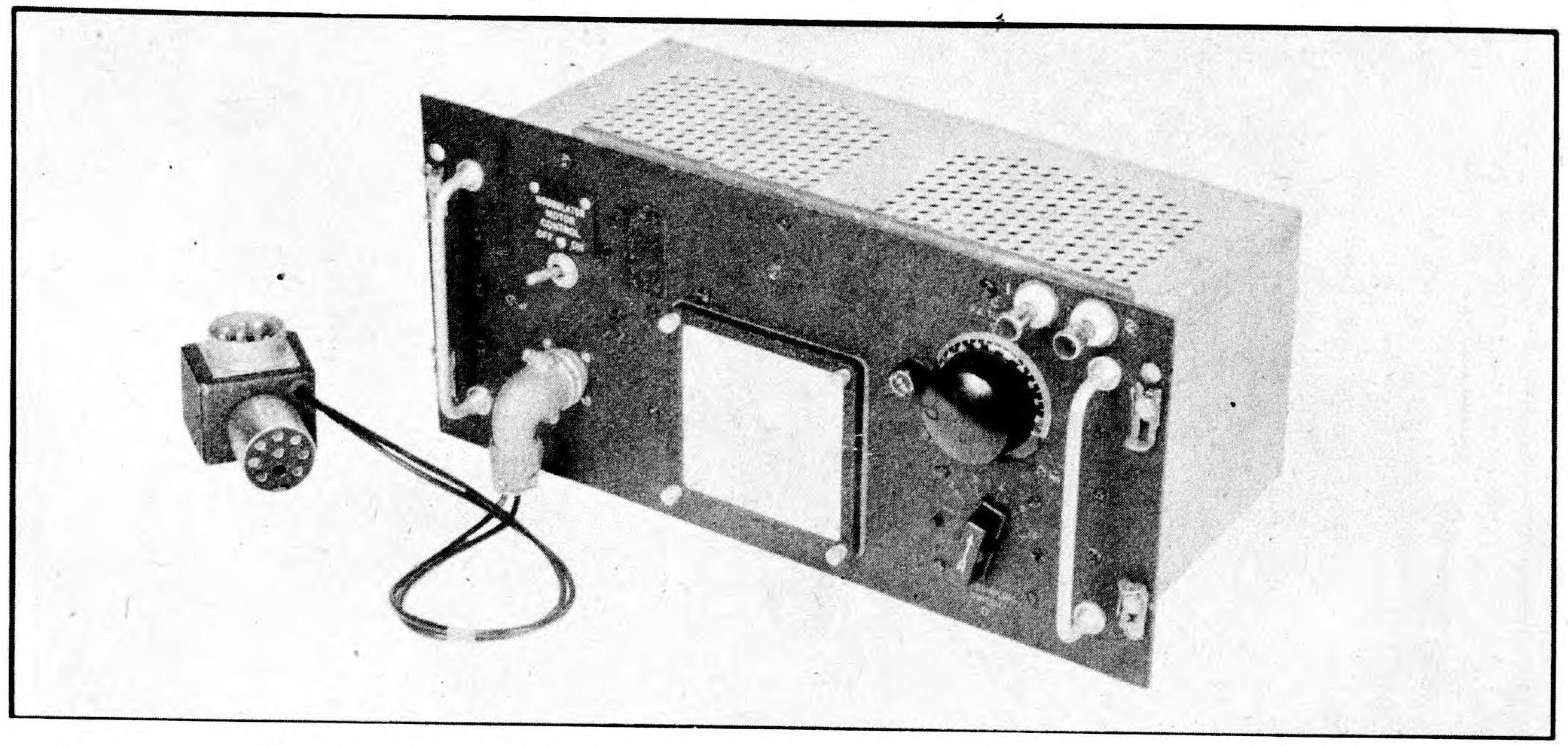
OPERATION & INSTALLATION The equipment may be installed at any convenient point within the aircraft where it may easily be turned on and off. A fan or whip type of antenna installation will in general be used for each band.

PERSONNEL No extra personnel is required for operation of the equipment. Properly supervised radio maintenance personnel can service the set.

SPECIFICATIONS FREQUENCY RANGE: 27 to 34 Mc, 32 to 38 Mc, 37 to 43 Mc, 42 to 48 Mc, 48 to 57 Mc.
INPUT POWER: 2 kw, 80 or 115 volts, 400 to 2600 cps. a.c., and 150 watts, 28 volts d.c.
OUTPUT POWER: Approximately 1 kw.
MODULATION: Mechanical frequency modulation at 300 cps over the entire band of each tuning unit.
SIZE AND WEIGHT: Radio Transmitter SARC B2-D, 45 lbs.
Power Supply SARC B2-D, 65 lbs.
TECHNICAL FEATURES: The transmitter is a push-pull oscillator which is frequency-modulated by a rotating loop within the oscillator inductance.

STATUS Light production under way. Equipment confidential.

TUNING UNIT TU-60



PURPOSE TU-60 is a tuning unit used to convert transmitter BC-375 (part of radio set SCR-287) into a barrage jammer, for operation against enemy communications in the frequency band 15 to 22 Mc.

DESCRIPTION TU-60 is a factory converted TU-10B standard tuning unit for the BC-375 transmitter and may be substituted in place of that unit.

PERFORMANCE At a carrier frequency of 18.5 Mc, the BC-375 transmitter equipped with the TU-60 will deliver an output of 100 watts with a 3-Mc frequency-modulation bandwidth. The performance of the combined equipment should be roughly equivalent to that of the AN/ART-5 transmitter. The chief advantage of the TU-60 over the AN/ART-5 is that BC-375 transmitters are now standard equipment on all bombers. Since the TU-10B can be modified very quickly, the equipment can be procured and put into service rapidly.

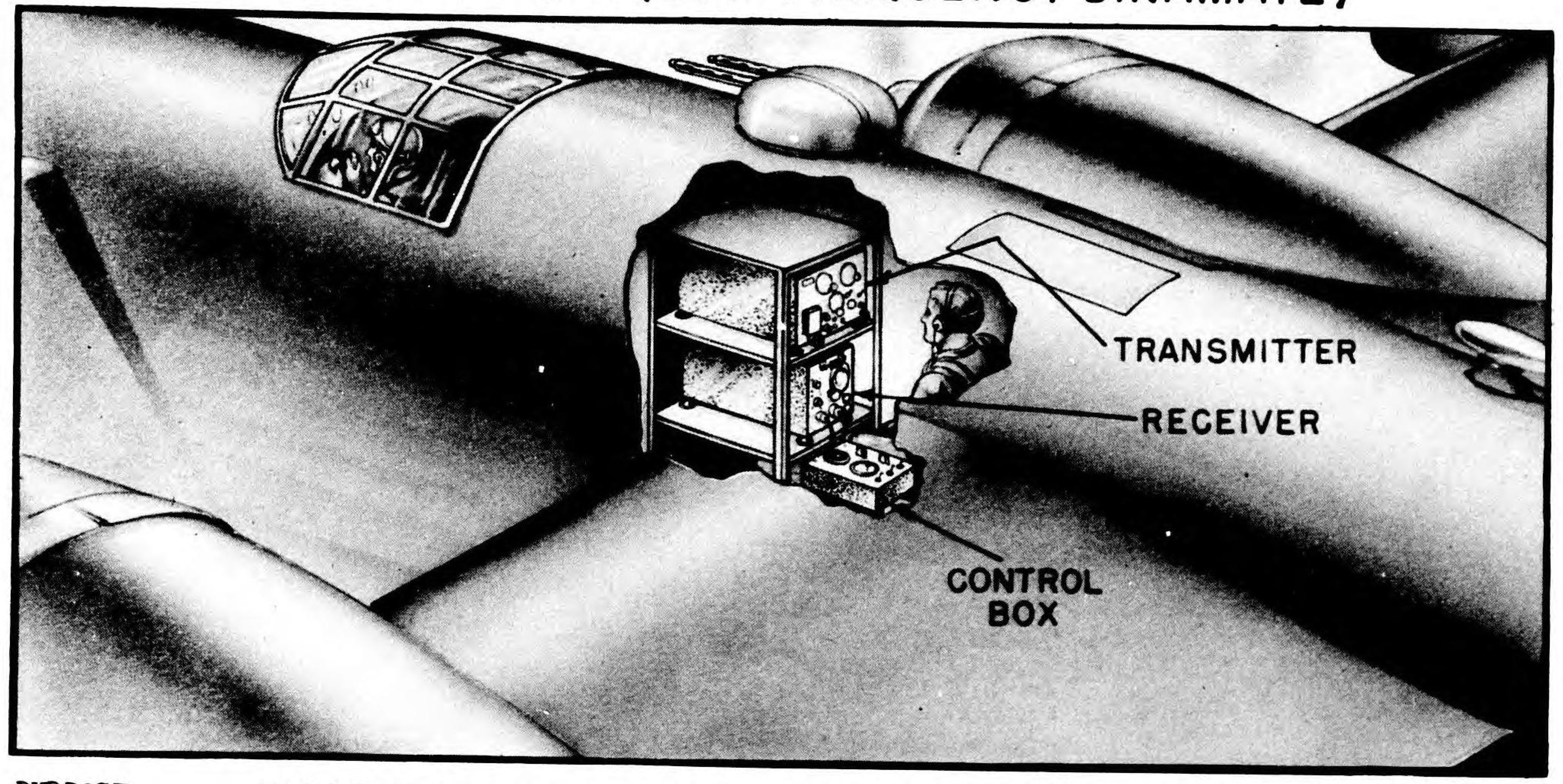
INSTALLATION & OPERATION TU-60 requires no attention other than the original tuning to the frequency band which it is desired to jam. It may be installed in the BC-375 transmitter by plugging in the unit and attaching the adapter plug which supplies 24 volts d.c. for running the tuning motor in the TU-60 unit. The adapter is inserted between the power-supply socket on the BC-375 and the usual connector plug.

PERSONNEL No extra personnel is required for operation and maintenance. The regular operator of the BC-375 transmitter operates TU-60 and regular maintenance crews service it.

SPECIFICATIONS FREQUENCY RANGE: 15 to 22 Mc.
INPUT POWER: Derived from BC-375 transmitter, except for 30 watts, 24 volts d-c for modulating motors.
OUTPUT POWER OF TRANSMITTER WITH TU-60: 100 watts.
MODULATION: Mechanical frequency modulation over a band of 3 Mc. average width at a frequency of 200 cps.
TEST EQUIPMENT: Same as BC-375.
SIZE AND WEIGHT: Same as standard tuning unit for BC-375.
TECHNICAL FEATURES: TU-60 changes the circuit of the BC-375 transmitter to convert the oscillator and the amplifier into a push-pull Hartley oscillator. This is frequency modulated by a motor-driven condenser.

STATUS Light production completed Equipment confidential.

RADAR SET AN/ARQ-8 (LOW FREQUENCY DINAMATE)



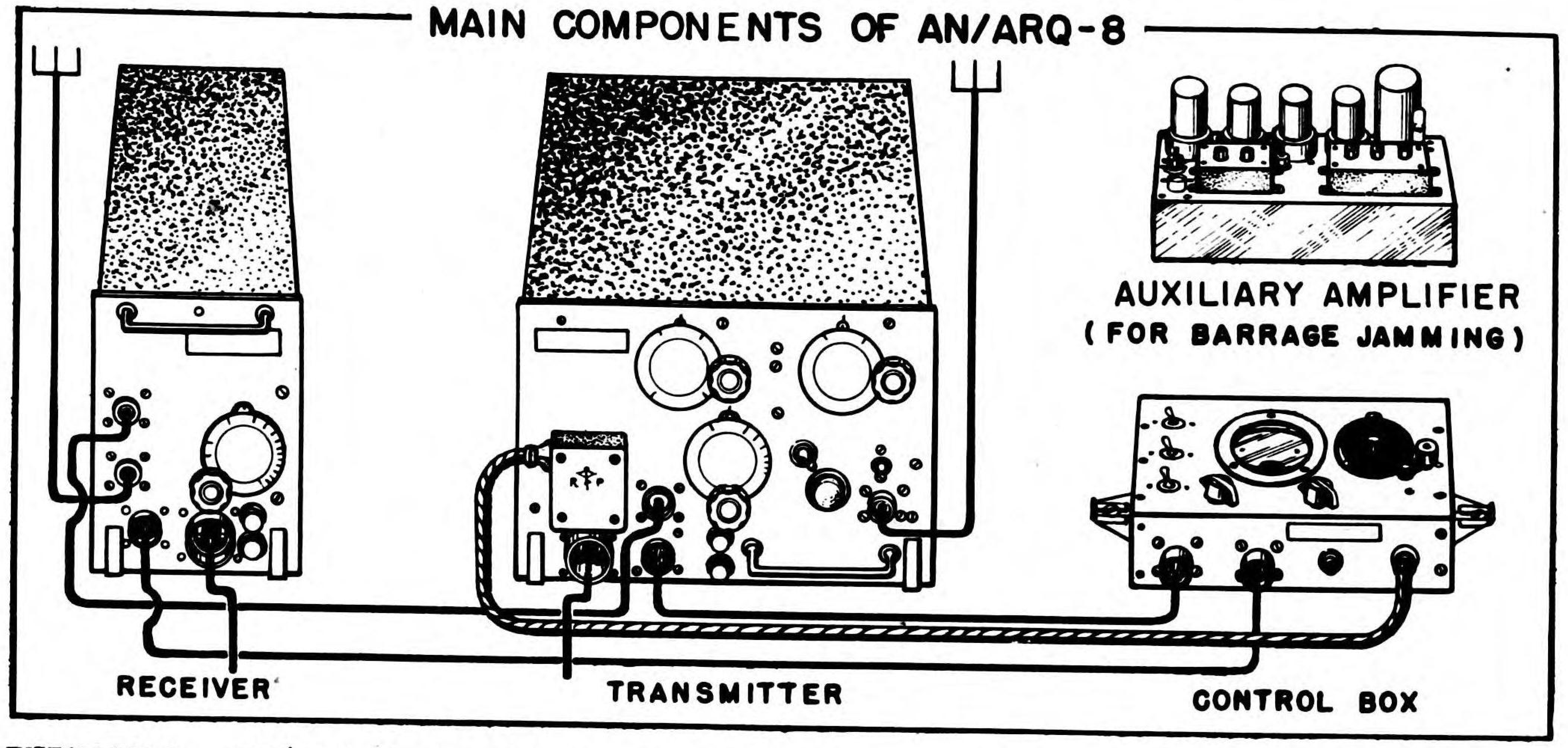
PURPOSE AN/ARQ-8 is an airborne transmitter-receiver combination for spot or barrage jamming of enemy communications installations. It is designed mainly for use against air or ground communications links in the 25 to 105 Mc band, although it has application to guided missile and low frequency radar countermeasures as well.

DESCRIPTION AN/ARQ-8 consists of a transmitting unit (SARC B1-D) plus a receiving unit (SARC A1-D). The transmitter is provided with a narrowband, direct-noise amplifier for use in spot jamming applications, and a wideband, direct-noise amplifier (an interchangeable sub-assembly) for barrage jamming application. Since the transmitter employs a direct noise amplifier* (actually, a suppressed carrier system which accomplishes the same results as a direct noise amplifier) no power is lost in the carrier. As a result the entire output is effective in jamming operations. Use of some of the same circuits for receiving and transmitting insures that the jammer will be exactly on frequency. The bandwidth of the transmitter is great enough, even when used with the narrowband noise amplifier, to enable one transmitter to be used simultaneously against several sets near the same frequency.

PERFORMANCE The effectiveness of the transmitter against a given enemy installation will depend, of course, upon the relative positions of the jammer, the enemy transmitter, and the enemy receiver. The fact that the output power is all sideband power (direct noise) makes the equipment much more effective than AM jammers of the same power output (in terms of carrier power) for semi-barrage or barrage operation.

OPERATION The equipment may be set to cover with single dial control any 5 Mc band in the frequency range from 25 to 105 Mc. It is tuned with the switch in the receiving position to find the signal or group of signals to be jammed, and the switch then thrown to the jamming position. No further adjustment is required.

*A sine wave modulator is also available especially for use in guided missile countermeasures.



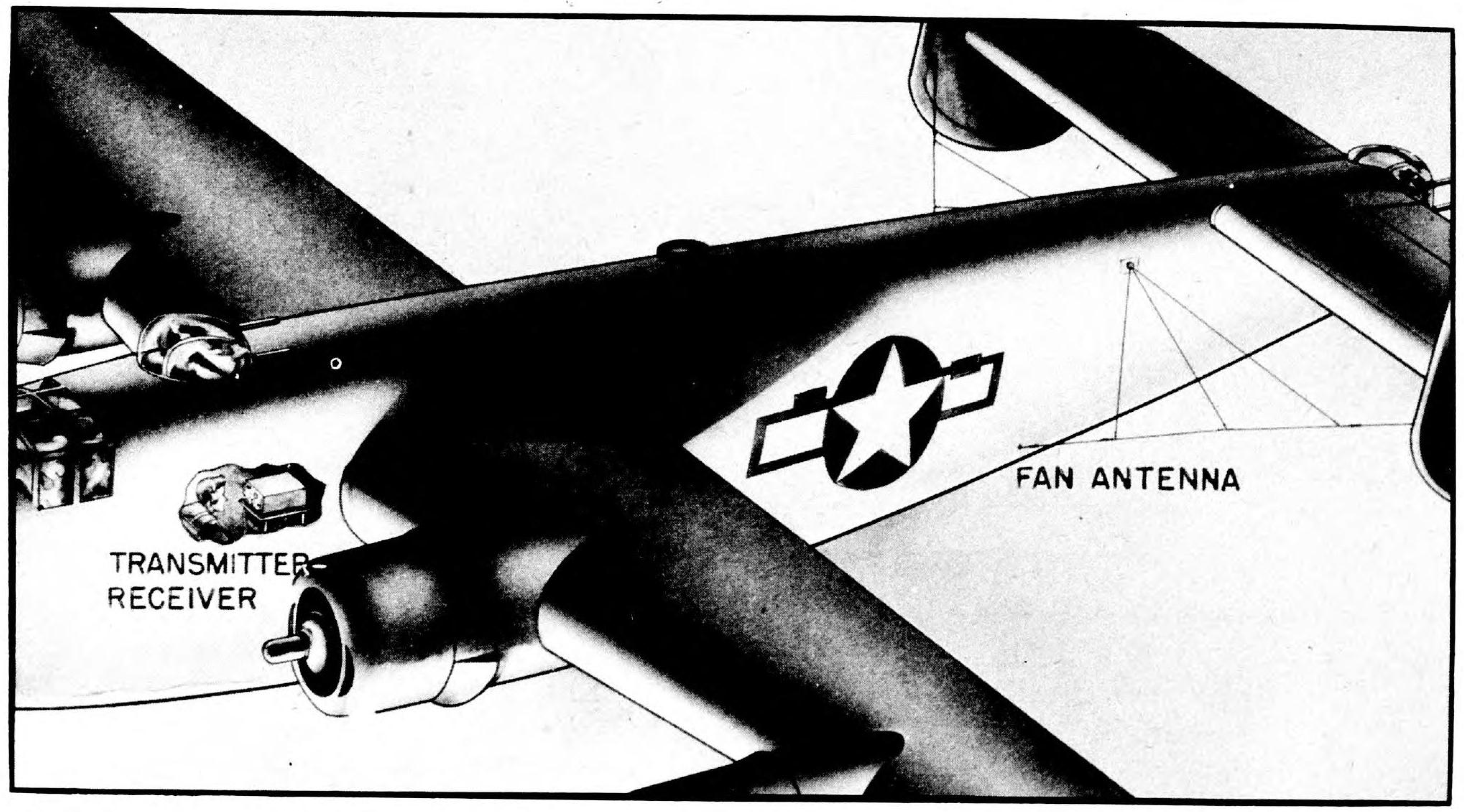
INSTALLATION AN/ARQ-8 should be installed so that it is conveniently located for use by an operator and so that it is approximately level during normal flight. The antenna installation is governed by the frequency band to be jammed, since no single antenna is suitable for use over the entire frequency range. It is expected that the frequency range will be covered by a series of fan and whip antennas, and that probably only the antenna for the frequency band that is of immediate interest will be carried on the plane at a given time. For purely barrage jamming operations in which the receiver is not used, the wideband noise amplifier may be substituted in the transmitter chassis for the narrowband unit ordinarily used.

PERSONNEL A specially trained operator is required for this equipment. Regular maintenance personnel can, with a little training, service it.

SPECIFICATIONS
FREQUENCY RANGE: 25 to 105 Mc.
INPUT POWER: 350 watts, 80 or 115 volts, 40 to 2600 cps, a.c.
OUTPUT POWER: 20 to 40 watts (no carrier, all in sidebands).
MODULATION: None, since the signal consists of direct noise.
TRANSMITTER BANDWIDTH: 150 kc with narrowband noise amplifier.
5 Mc with wideband noise amplifier.
RECEIVER BANDWIDTH: 75 kc.
INCREMENTAL TUNING RANGE: (With single dial) 5 Mc.
SENSITIVITY OF RECEIVER: Better than 0.5 millivolts for full output with 100% modulated signal.
TEST EQUIPMENT: TS-118/AP. TS-131/AP. I-139-A. TS-92/AP GR-804C.
ANTENNAS: AS-89/ART. (37 to 50 Mc) AS-97/ART. (50 to 85 Mc). AT-33/APT (85-105 Mc)
SIZE AND WEIGHT: SARC B1-D + SARC A1-D, 65 pounds.
TECHNICAL FEATURES: The transmitter is a single sideband suppressed carrier noise transmitter using the sum or difference frequencies between a direct noise amplifier and a variable frequency oscillator. The transmitter provides an essentially uniform noise spectrum which may be tuned by setting dials over the range from 25 to 105 Mc; however, the transmitter may be set anywhere in a 5 Mc band simply by tuning the r-f oscillator with a single dial. The receiver attachment uses a superheterodyne circuit with the variable frequency oscillator of the transmitter as local oscillator and i.f. equal to that of the transmitter's direct noise amplifier. The input circuit of the receiver has a bandwidth of 5 Mc. The two units thus form a spot frequency jammer tunable by a single dial. An additional transmitter subassembly is supplied for use as a wideband noise amplifier so that the equipment may be used, with suitable modification, as a barrage jammer.

STATUS Moderate production under way. Equipment Confidential.

TRANSMITTING EQUIPMENT AN/ARQ-1 (SANDY)



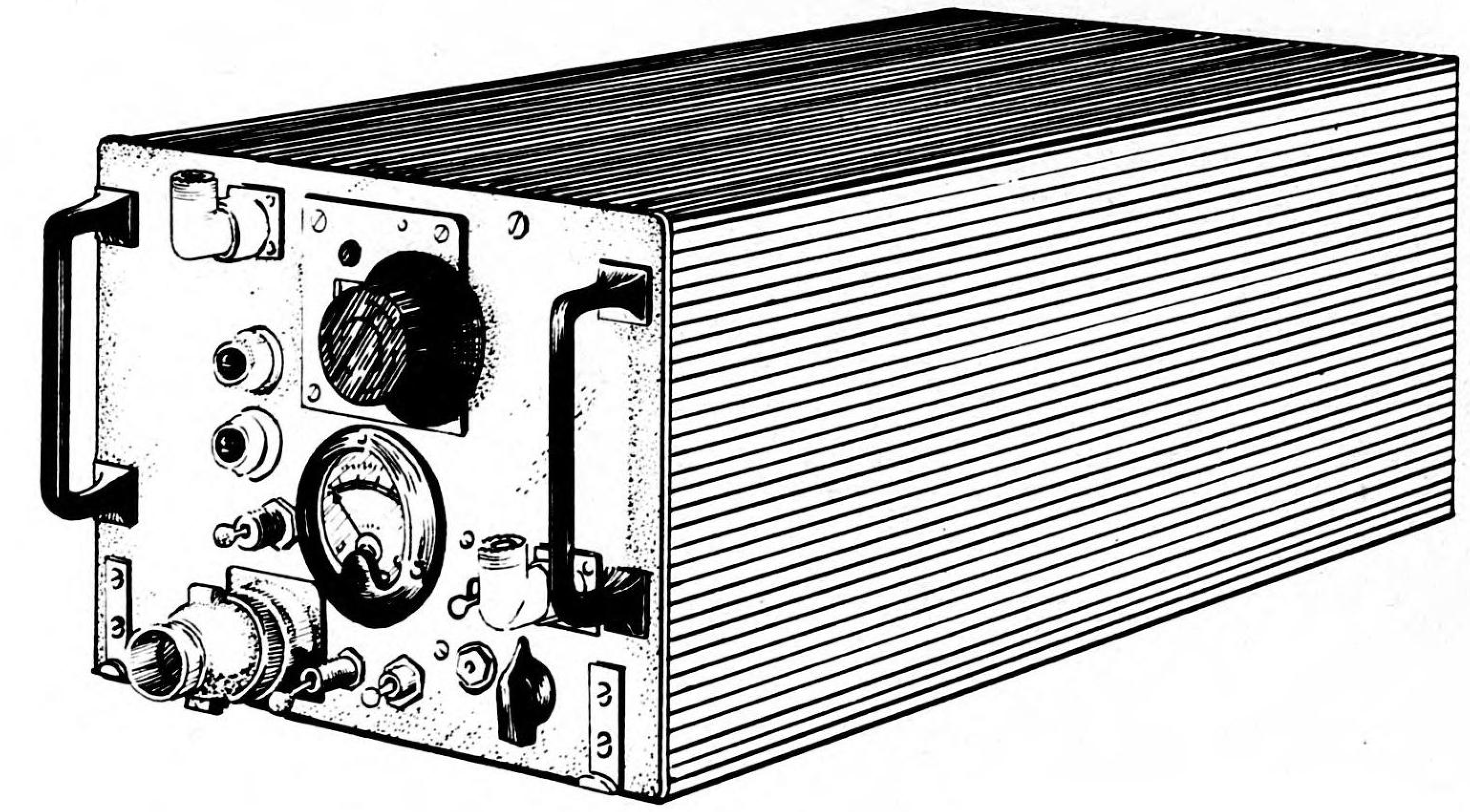
PURPOSE AN/ARQ-1 is an airborne transmitter-receiver combination for spot or semi-barrage jamming of enemy communications installations. It is designed for use mainly against air or ground communication links in the 14 to 50 Mc band.

DESCRIPTION The equipment consists of a single unit (SARC B1-D) which serves as both a receiver and a jamming transmitter. Since the transmitter employs a direct noise amplifier, no power is lost in a carrier. As a result, the entire output is effective in jamming operations. Use of the same tuned-radio-frequency circuits for receiving and transmitting insures that the jammer will be exactly on frequency. The bandwidth of the transmitter is great enough to make possible the use of one transmitter simultaneously against several sets in the same frequency range.

PERFORMANCE The effectiveness of the transmitter in use against a given enemy communication link will depend, of course, upon the relative positions of the jammer, the enemy transmitter, and the enemy receiver. The fact that the output power is all sideband power (direct noise) makes the equipment much more effective than AM jammers of the same power output (in terms of carrier power) for semi-barrage operation.

OPERATION With the switch in the receiving position the operator tunes the equipment to find the signal or group of signals to be jammed, and then throws the switch to the jamming position. No further adjustment is required.

TRANSMITTING EQUIPMENT AN/ARQ-1



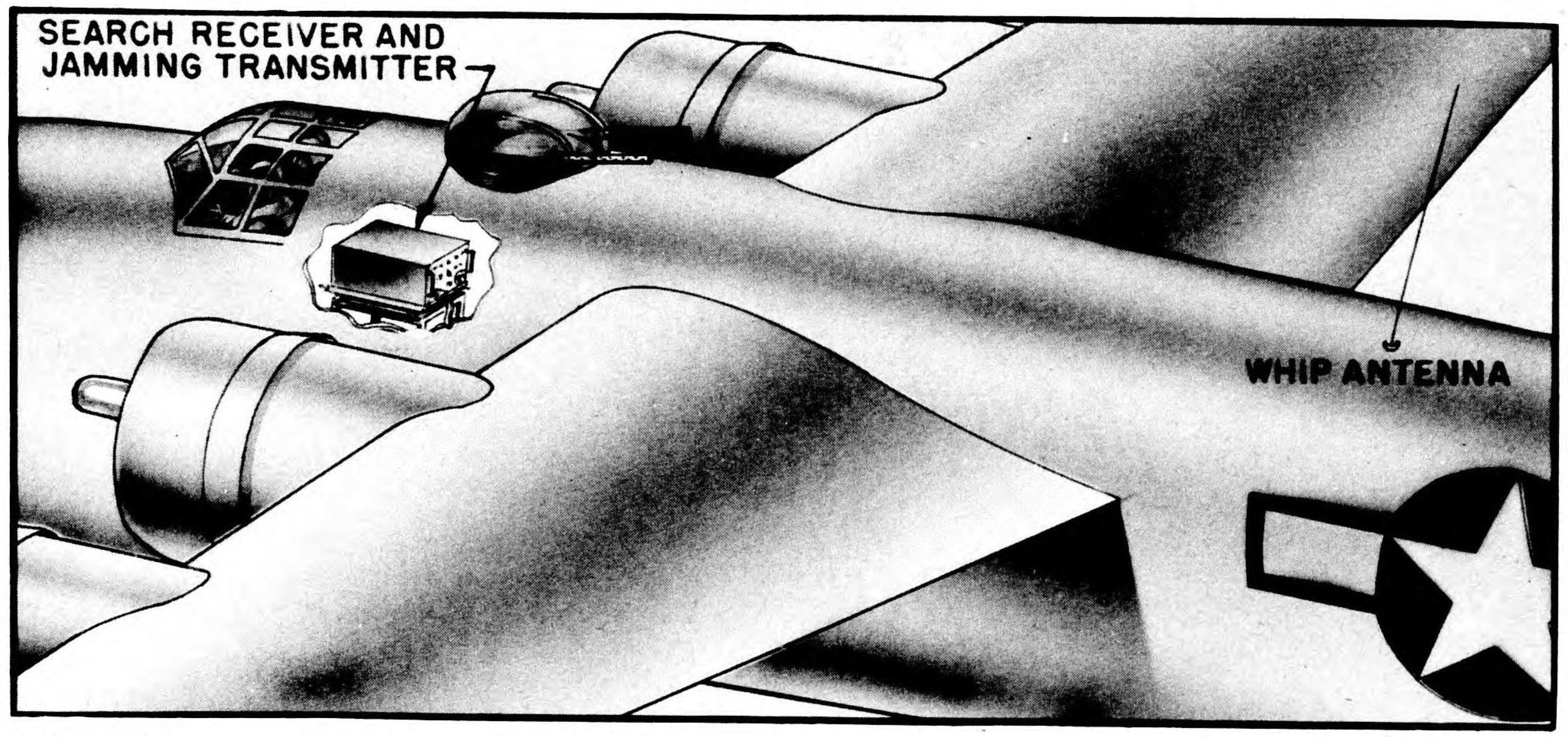
INSTALLATION The equipment should be installed so that it is conveniently located for use by an operator, and so that it is approximately level during normal flight. The antenna installation is governed by the frequency band to be jammed, since no single antenna is suitable for use over the entire frequency range. It is expected that the frequency range will be covered by a series of fan and whip antennas, and that probably only the antenna for the frequency band that is of immediate interest will be carried on the plane at a given time (see Antenna Section for a discussion of fan and whip antennas).

PERSONNEL A special trained operator is required for this equipment. Regular maintenance personnel can, with a little training, service the equipment.

SPECIFICATIONS
FREQUENCY RANGE: 14 to 50 Mc.
INPUT POWER: 300 watts, 80 or 115 volts, 400 to 2600 cps, a.c. and 50 watts, 28 volts, d.c.
OUTPUT POWER: At least 20 watts (no carrier, all in sidebands).
MODULATION: There is no modulation since the signal consists of direct noise.
TRANSMITTER BANDWIDTH: 25 kc at 14 Mc and 150 kc at 50 Mc.
SENSITIVITY OF RECEIVER: 25 microvolts for 50 mw output signal.
SIZE AND WEIGHT: SARC B1-D, 35 lbs. (without antenna)
TECHNICAL FEATURES: The set uses the same tuned-radio-frequency amplifier, serving both as a receiver and as a jammer. When the switch is in the receiving position the r-f amplifier is fed by the antenna and followed by a detector, an audio-frequency amplifier, and earphones. When the switch is in the jamming position the r-f amplifier is preceded by a noise source and followed by a power amplifier exciting the antenna.

STATUS Moderate production under way. Equipment Confidential.

RADIO SET AN/ARQ-7 (SPOTKIE)

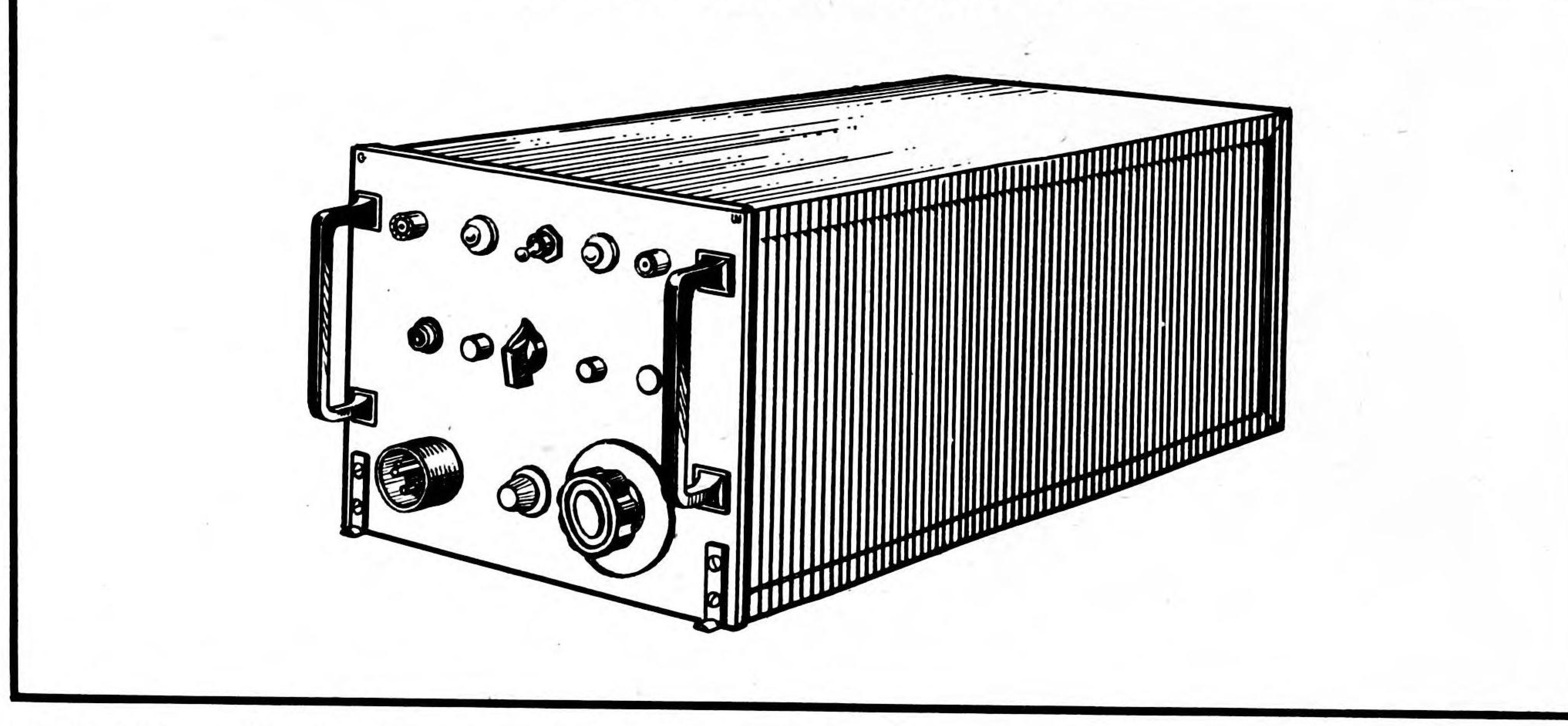


PURPOSE AN/ARQ-7 is an airborne combination receiver and spot-jamming transmitter for use against enemy communications installations. It is designed particularly to operate against the VHF (very-high-frequency) communications link of enemy radar ground-controlled-interceptor (GCI) operations in the frequency range from 38.6 to 42.2 Mc.

DESCRIPTION AN/ARQ-7 consists of a single unit (SARC B1-D) which performs the function of search receiver and jamming transmitter. Use of some of the same tuned circuits for receiving and for transmitting insures that when the jammer is operated it will be exactly on the frequency of the victim signal that has been tuned in. The transmitter is amplitude modulated by noise and provides a power output of 50 watts, concentrated in a band that is just wide enough to insure effective jamming of a single enemy communication channel.

PERFORMANCE The effectiveness of the transmitter in use against the enemy ground-to-air communications link for radar ground-controlled interception operations will depend, of course, upon the relative positions of the jammer, the enemy transmitter, and the enemy receiver. It is believed that with the use of AN/ARQ-7 by high-flying bombers, the receipt of instructions by enemy fighters from GCI headquarters will be prevented to the extent that the fighters will be unable to approach near enough to complete the attack with the aid of their aircraft interception radar.

RADIO SET AN/ARQ-7



OPERATION With the switch in the receiving position the operator tunes the equipment to find the signal to be jammed and then throws the switch to the jamming position. No further adjustment is required.

INSTALLATION The equipment should be installed so that it is conveniently located for use by an operator, and so that it is approximately level during normal flight. The antenna installation requires a three-wire fan type antenna (see Antenna Section for details), or a whip antenna.

PERSONNEL A specially trained operator is required for this equipment. Maintenance can be performed by properly supervised radio maintenance personnel.

SPECIFICATIONS. **FREQUENCY RANGE:** 38.6 to 42.2 Mc (This is the range of the German Fug-16 Aircraft Transmitter-Receiver).
INPUT POWER: 300 watts, 80 or 115 volts, 400 to 2600 cps, a.c. and 100 watts, 28 volts d.c.
OUTPUT POWER: 50 watts.
MODULATION: Amplitude with noise (buzzers).
TRANSMITTER BANDWIDTH: Sideband energy not more than 3 db down at 10 kc nor less than 6 db down at 20 kc off carrier.
SENSITIVITY OF RECEIVER: Approximately 50 milliwatt output for 100 micro olts at input terminals.
SIZE AND WEIGHT: SARC B1-D, 45 lbs.
TECHNICAL FEATURES: The equipment incorporates a 38.6 to 42.2 Mc oscillator which functions both as a receiver beat-frequency oscillator and transmitter master-oscillator. Exact setting of jamming frequency setting is assured by tuning the oscillator to zero beat with the received signal. The transmitter is straight-forward in design, using a power amplifier which is modulated by noise derived from a set of three buzzers used in such a way as to employ the higher-frequency components of their output, which are more random than the lower-frequency components.

STATUS Moderate production planned. Equipment Confidential.

RADIO FREQUENCY AMPLIFIER AM-33/ART

PURPOSE

AM-33/ART is an airborne wideband power amplifier that can be tuned to cover the frequency range from 25 to 105 Mc. It is designed primarily to enhance the jamming effectiveness of AN/ARQ-8, but may also be used with a number of other jamming transmitters in its frequency range.

DESCRIPTION & PERFORMANCE

The amplifier with its power supply unit is assembled in one box (SARC B1-D). Its installed weight is about 50 pounds. AM-33/ART will increase the jamming effectiveness of the AN/ARQ-8 at least three times in the 25 to 105 Mc frequency band. Its output bandwidth of 1.5 to 4 Mc permits the use of the AN/ARQ-8 equipment over this bandwidth with single dial control.

OPERATION & INSTALLATION

No attention is required during flight if the amplifier is pretuned while the transmitter is being adjusted to the selected incremental band. The amplifier should be placed as close as possible to the transmitter. The antenna installation is the same as that specified for the transmitter when operating in the frequency range mentioned.

PERSONNEL

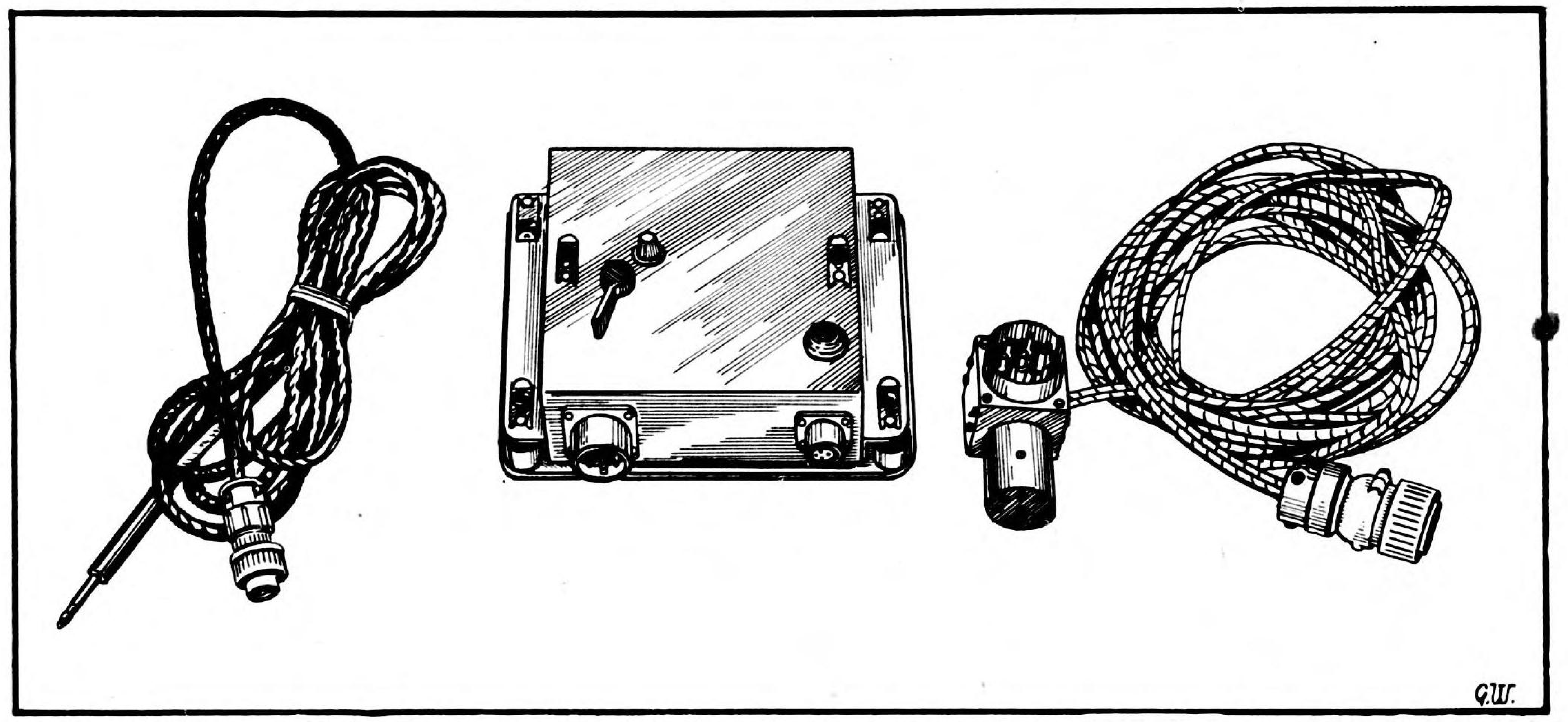
No extra personnel is required for operation or maintenance. Men who are qualified to operate and service the transmitter are also qualified to operate and service the amplifier.

SPECIFICATIONS

FREQUENCY RANGE: 25 to 105 Mc.
INPUT POWER: 600 watts, 80 or 115 volts, 400 to 2600 cps, a.c.
R-F DRIVING POWER: 10 to 15 watts through 50 ohm cable.
OUTPUT POWER: 100-200 watts.
MODULATION BANDWIDTH: 1.5-4 Mc.
SIZE AND WEIGHT: SARC B1-D, 50 pounds.

STATUS Laboratory development complete. Equipment confidential.

MODULATOR ASSEMBLY AN/ARA-3 (GASTON)



PURPOSE AN/ARA-3 is a noise source for use with standard communications transmitters in order to convert these transmitters to spot jammers. AN/ARA-3 is especially designed for use with radio transmitter BC-375 but may be used with other radio transmitters providing the interconnecting cables are suitably modified.

DESCRIPTION AN/ARA-3 consists of a single unit (7¼" x 6¾" x 7¼") plus a small control box and suitable interconnecting cables and adapters.

PERFORMANCE AN/ARA-3 furnishes noise modulation voltage which supplies a modulation spectrum wide enough to permit satisfactory operation of BC-375 as a spot jammer. The bandwidth of the noise spectrum output is limited by the input bandwidth of the transmitters. The noise source is suitable for use with any transmitter employing a single button carbon microphone. The combination of AN/ARA-3 noise source, BC-375 transmitter, and BC-348 radio receiver makes a convenient and effective jamming and monitoring combination.

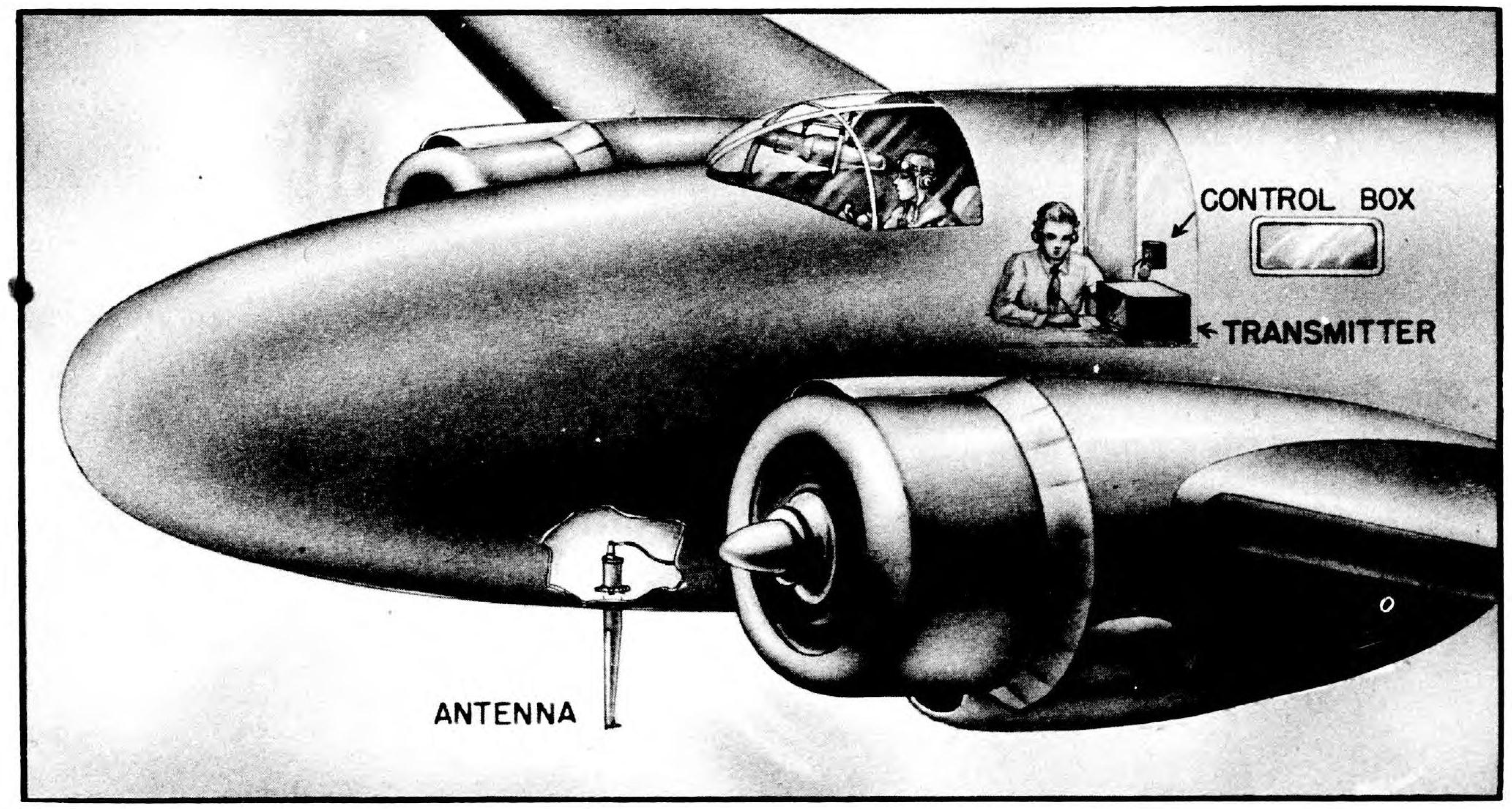
INSTALLATION & OPERATION AN/ARA-3 is provided with its own shock mounting and may be installed quite simply near the transmitter with which it is to be used. No particular installation problem should arise as this unit is entirely self-contained and may be plugged into the transmitter without modification of the set.

PERSONNEL No personnel in addition to the regular transmitter operator is required during operation.

SPECIFICATIONS
INPUT POWER: 50 watts, 28 volts, d.c.
OUTPUT POWER: Sufficient to modulate transmitter at maximum level.
SIZE AND WEIGHT: Several small units, total weight about 11 pounds.
TECHNICAL FEATURES: AN/ARA-3 consists of a gas tube operated as a diode with the plate, screen grid and cathode tied together, followed by an amplifier. The interference signal is generated by applying a voltage to the control grid through a resistor network. This voltage causes the capacitor to charge until ionization of the tube takes place, at which time the capacitor discharges through the tube. Immediately the capacitor starts to charge again and through this repetitive action generates an interference signal consisting of audio and other higher frequencies. This signal is then amplified and used as the transmitter input.

STATUS Light production under way. Equipment Confidential.

RADAR SET AN/APT-3 (MANDREL)



PURPOSE AN/APT-3 is an airborne transmitter for jamming enemy radar systems operating in the frequency range from 85 to 140* Mc. This frequency range includes the majority of the enemy early warning radars. AN/APT-3 is designed for either spot or semi-barrage jamming.

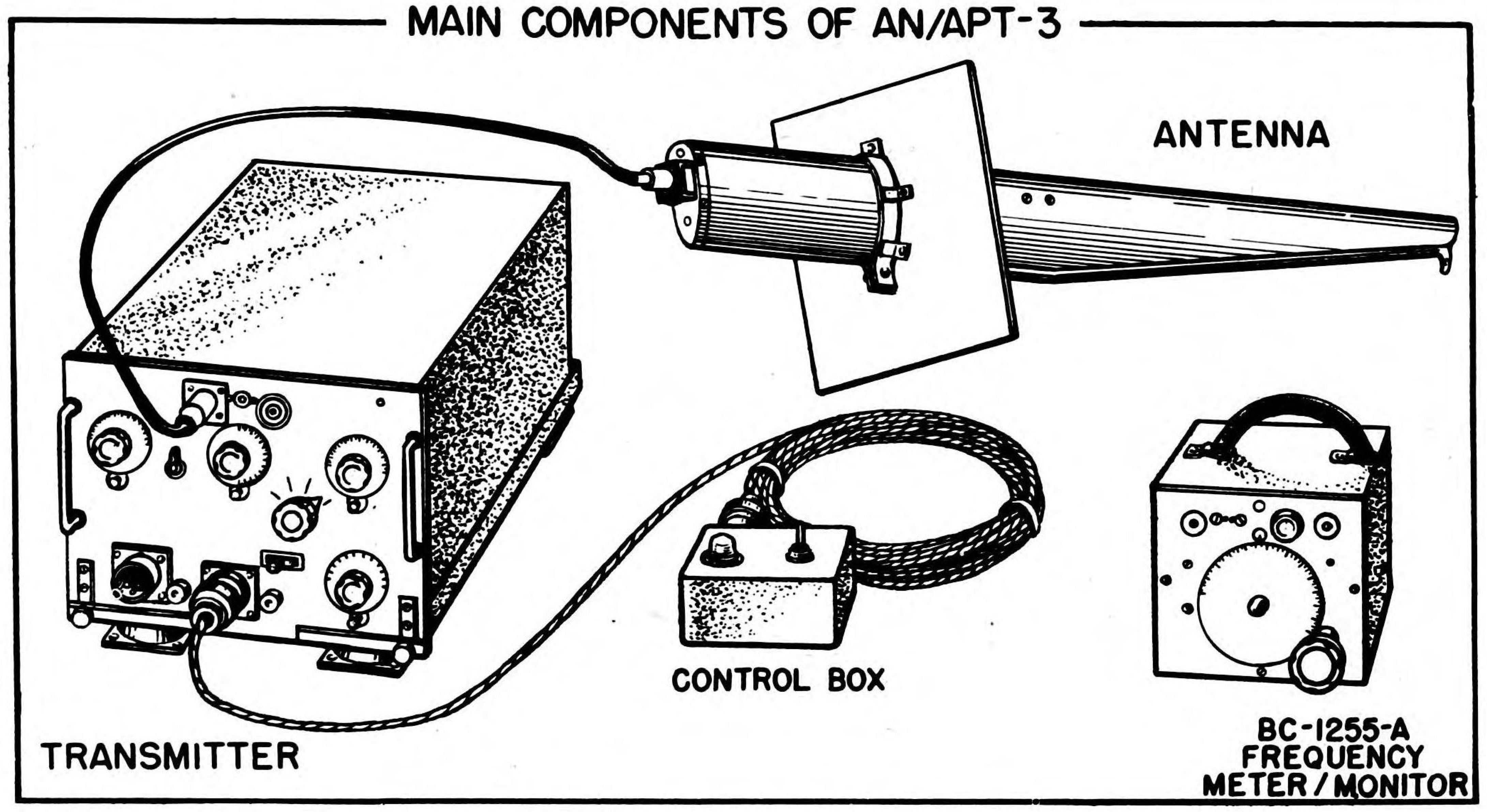
DESCRIPTION The transmitter consists of a single unit (SARC B1-D) plus a small control box which is placed near the radio operator. Its output is modulated by noise and has a bandwidth of from 1 to 2 Mc. The total output power is about 10 watts. The antenna projects 22½ inches outside the skin.

PERFORMANCE The equipment is considered sufficient to screen a heavy bomber to within at least 6 miles from a spot-jammed Freya. This type of jamming transmitter has been used by the British for some time with considerable success. The equipment is most useful in the spot jamming of early warning sets to disguise the exact size of the incoming raid. It may also be employed against radar sets in its frequency band which are being used for purposes other than early warning (such as the German use of Freya equipment for GCI). The performance of the set can be improved (higher output obtained) by use of the power amplifier AM-14/APT.

OPERATION For operation as a barrage jammer, the transmitter is pre-tuned to the required frequency band prior to take-off. The only attention required during flight then consists of turning the transmitter on or off and adjusting the modulator knob on the control box to secure maximum modulation, as indicated by the brilliance of the pilot light on the control box. When AN/APT-3 is used as a spot-jammer, however, tuning to the victim frequency must be done during flight.

*Range may later be extended to 150 Mc by a modification.

MAIN COMPONENTS OF AN/APT-3



INSTALLATION The transmitter should be installed so that it is approximately level when the plane is in normal flight. It may be mounted at any convenient point within the aircraft, with front panel accessible for tuning (if spot jamming is to be used) and within sight of the control box. The control box should be placed within the radio operator's reach. The antenna required for the frequency band to be covered should be mounted so as to project from the lower part of the aircraft, being so located that its view of the radar system to be jammed is not obscured by aircraft surfaces during normal flight. The antenna should be mounted vertically to jam vertically polarized radars, or may be mounted at a 45 degree angle with some loss in jamming efficiency for use against systems which use other polarizations.

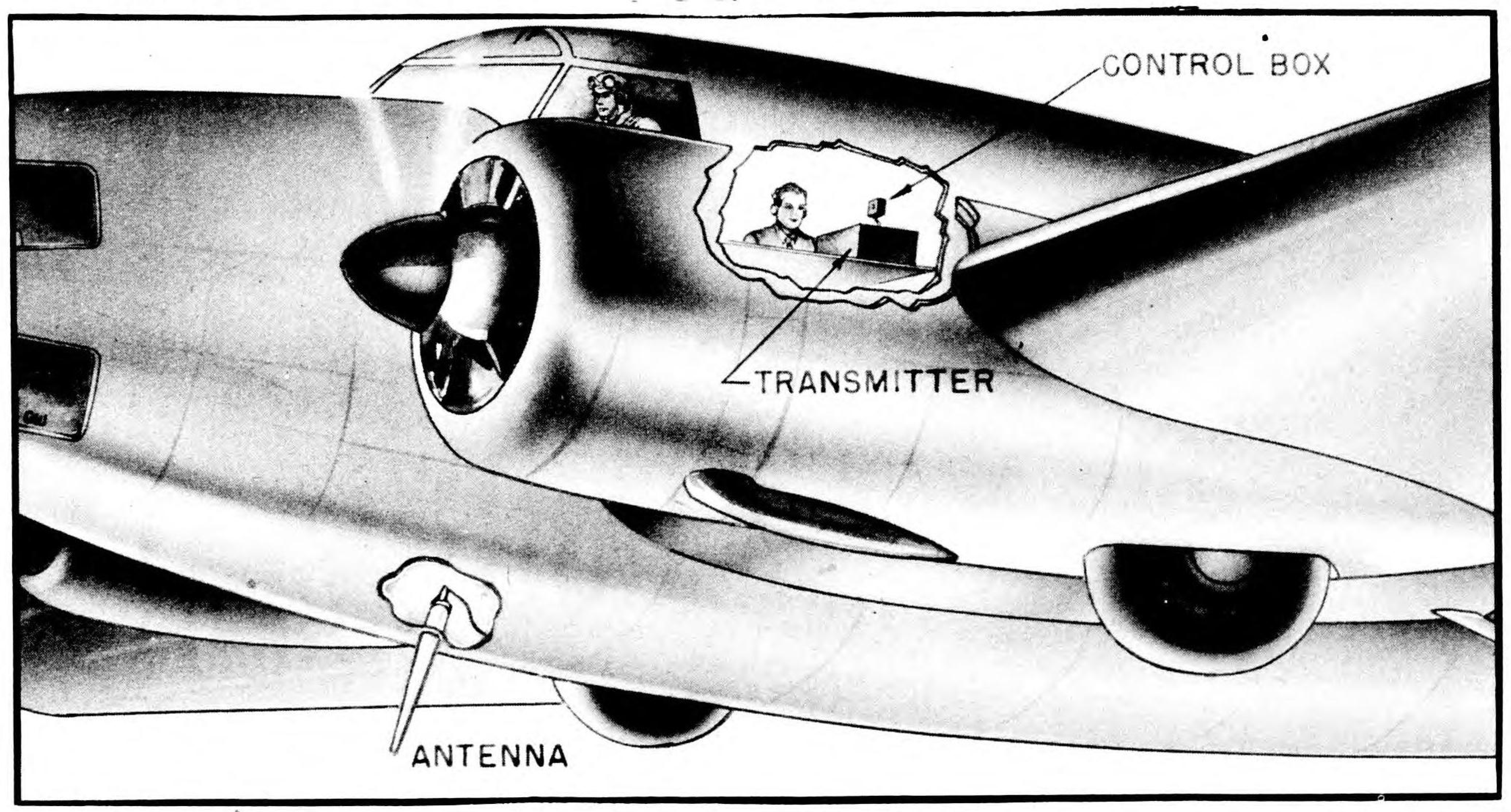
PERSONNEL For barrage jamming operations no extra personnel is required except for pre-tuning of the transmitter on the ground. For spot jamming operations an experienced operator will be required when this equipment is in use. It can be maintained by a properly supervised radar mechanic.

SPECIFICATIONS
FREQUENCY RANGE: 85 to 140 Mc.
INPUT POWER: 280 watts, 115 or 80 volts, 400 to 2600 cps.
OUTPUT POWER: 10 watts
MODULATION: Amplitude with noise.
MODULATION BANDWIDTH: 1 to 2 Mc, depending upon output circuit tuning.
SIDEBAND POWER: 2½ watts.
ANTENNA: AT-37/APT (114 to 150 Mc) and AT-38/APT (95 to 114 Mc) fed by 50-ohm line and providing vertical polarization. (See Stub Antenna in ANTENNA SECTION).
TEST EQUIPMENT: TS-174/U, TS-87/AP, TS-131/AP, I-139-A.

SIZE AND WEIGHT: SARC B1-D, 45 pounds (installed).
TECHNICAL FEATURES: The transmitter consists of a master oscillator followed by a power amplifier. The equipment is amplitude noise modulated by power amplifier grid modulation.

STATUS Moderate production completed. Equipment Restricted;
T. O. # AN-08-30APT3-2 and AN-08-30APT3-3.

TRANSMITTING EQUIPMENT AN/APT-I (DINA)



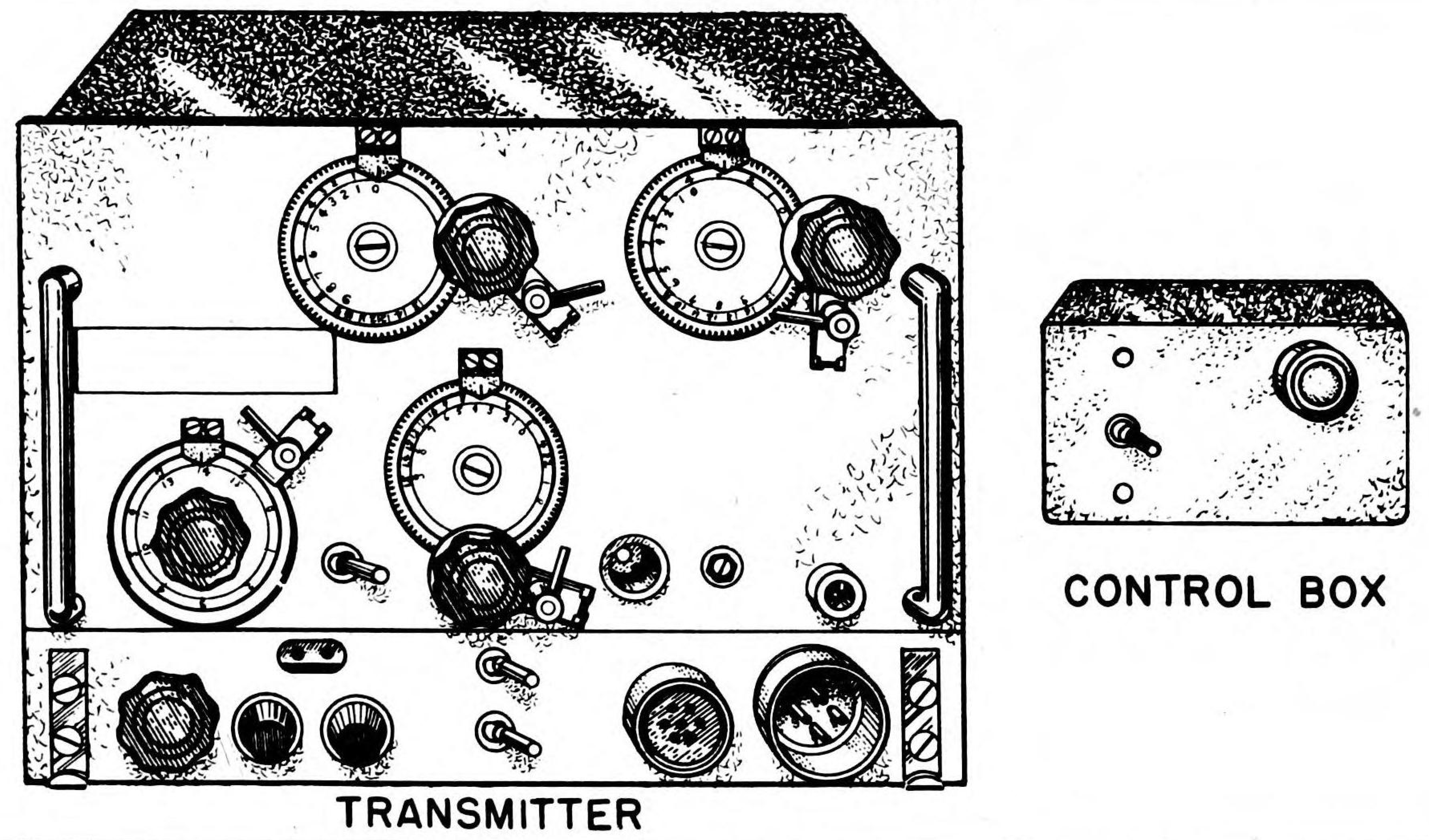
PURPOSE AN/APT-1 is an airborne transmitter for jamming enemy radar systems operating in the frequency range from 95 to 210 Mc. This frequency range includes most of the enemy early warning radars, such as the German Freya and Hoardings, or the Jap equivalent types. The equipment can be used for either barrage or spot jamming.

DESCRIPTION AN/APT-1 embodies the DINA (DIrect Noise Amplifier) type of transmitter discussed in the Introduction to Jamming Transmitters. It consists of a transmitting and power unit in one box (SARC B1-D) and an (optional) remote control box. The latter includes on-off switches, with indicating pilot light, and a knob for regulating power output, as indicated by a meter. The outfit weighs 45 lbs., including antenna but excluding cable.

PERFORMANCE For barrage jamming, this equipment is considered sufficient to self-screen a heavy bomber to within at least two miles from a Freya radar. It blankets any desired frequency in its range with a 5 Mc band of noise. The jamming power output varies from 30 watts at 95 Mc to 8 watts at 210 Mc. The effectiveness of this equipment may be greatly increased by means of power amplifiers AM-14/APT and AM-18/APT (described elsewhere). AN/APT-1 transmits only a noise spectrum without a carrier. It is, consequently, more effective than a transmitter having an equivalent power rating in terms of carrier power.

OPERATION The transmitter should be adjusted before take-off so that its output energy embraces the frequency or frequencies to be jammed, as pre-determined with a search receiver*. For barrage jamming the only control to be adjusted during flight is the power output This may be done either from the front panel or from the remote control box.

MAIN COMPONENTS AN/APT-I



INSTALLATION The transmitter should be approximately level when the plane is in normal flight. It may be installed at any convenient place within the aircraft where either the front panel or the remote control box is within the operator's reach. The antenna should be mounted on the lower part of the aircraft so that its view of the radar system to be jammed is not obscured by aircraft surfaces during normal flight. Three types of antenna are needed for complete frequency coverage, but only one need be installed for a given mission. The longest antenna projects 29 inches outside the skin.

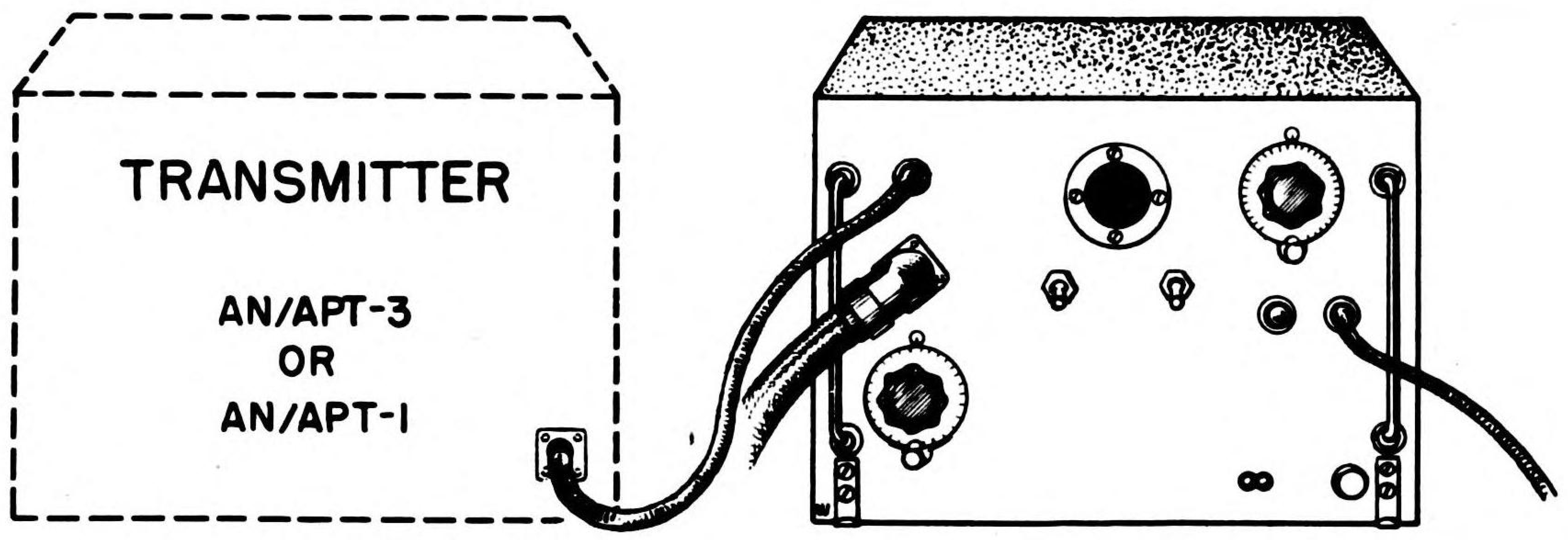
PERSONNEL No extra personnel is required to operate the equipment. Maintenance can be done by a radar mechanic, properly supervised.

SPECIFICATIONS FREQUENCY RANGE: 95 to 210 Mc.
INPUT POWER: a.c.: 300 watts, 80 or 115 volts, 400 to 2600 cps. and
d.c.: 25 watts, 28 volts.
OUTPUT POWER: 30-8 watts, all in the sidebands.
MODULATION: Direct noise.
MODULATION BANDWIDTH: 5 Mc.
ANTENNA: AT-36/APT (150 to 220 Mc), AT-37/APT (114 to 150 Mc),
AT-38/APT (95 to 114 Mc) vertical polarization.
TEST EQUIPMENT: TS-69/AP, TS-70/AP, TS-131/AP, I-139-A.
SIZE AND WEIGHT: SARC B1-D, 45 lbs. including antenna.

TECHNICAL FEATURES: The transmitter comprises a local oscillator, a noise generator and a wide-band pre-amplifier, a mixer, an output amplifier, and a power supply unit. The oscillator consists of two tubes in a push-pull circuit which is tuned in conjunction with the mixer and output amplifier to the desired output frequency. The oscillator output is fed to the mixer, as is also a selected band of noise frequencies from the noise generator and four-stage wide-band (27 to 33 Mc) pre-amplifier. The two sets of frequencies heterodyne (beat) in the mixer to produce two widely separated side-bands whose frequency components are equal to the sum and difference of those from the pre-amplifier and that from the variable frequency oscillator. The output amplifier is then tuned to either the upper or lower sideband to provide a 5 Mc band of noise at the desired output frequency.

STATUS Heavy production under way. Equipment Confidential;
T.O. #AN-08-30APT1-2.

RADIO FREQUENCY AMPLIFIER AM-14/APT



AM-14/APT

PURPOSE

AM-14/APT is an airborne, wide-band power amplifier that can be tuned to cover the frequency range between 85 and 150 Mc. It is intended to increase the power output, and thus enhance the jamming effectiveness, of a jamming transmitter. Designed primarily for use with AN/APT-1, it may also be used with AN/APT-3.

DESCRIPTION & PERFORMANCE

The two-stage amplifier with its power supply unit is assembled in one box (SARC B1-D). Its installed weight is 50 pounds. When used for barrage-jamming in conjunction with AN/APT-1 the equipment is considered to be sufficient to self-screen a large bomber to within less than one mile from a Freya or less than three miles from a Hoardings radar. It is rated at 100 watts. Its actual power output and bandwidth depends upon the associated transmitter.

OPERATION & INSTALLATION

No attention is required during flight if the amplifier is pretuned while the transmitter is being adjusted. The amplifier should be placed as close as possible to the transmitter. The antenna installation is the same as that specified for the transmitter with which the amplifier is used.

PERSONNEL

Personnel qualified to operate and service the transmitter can also operate and service the amplifier.

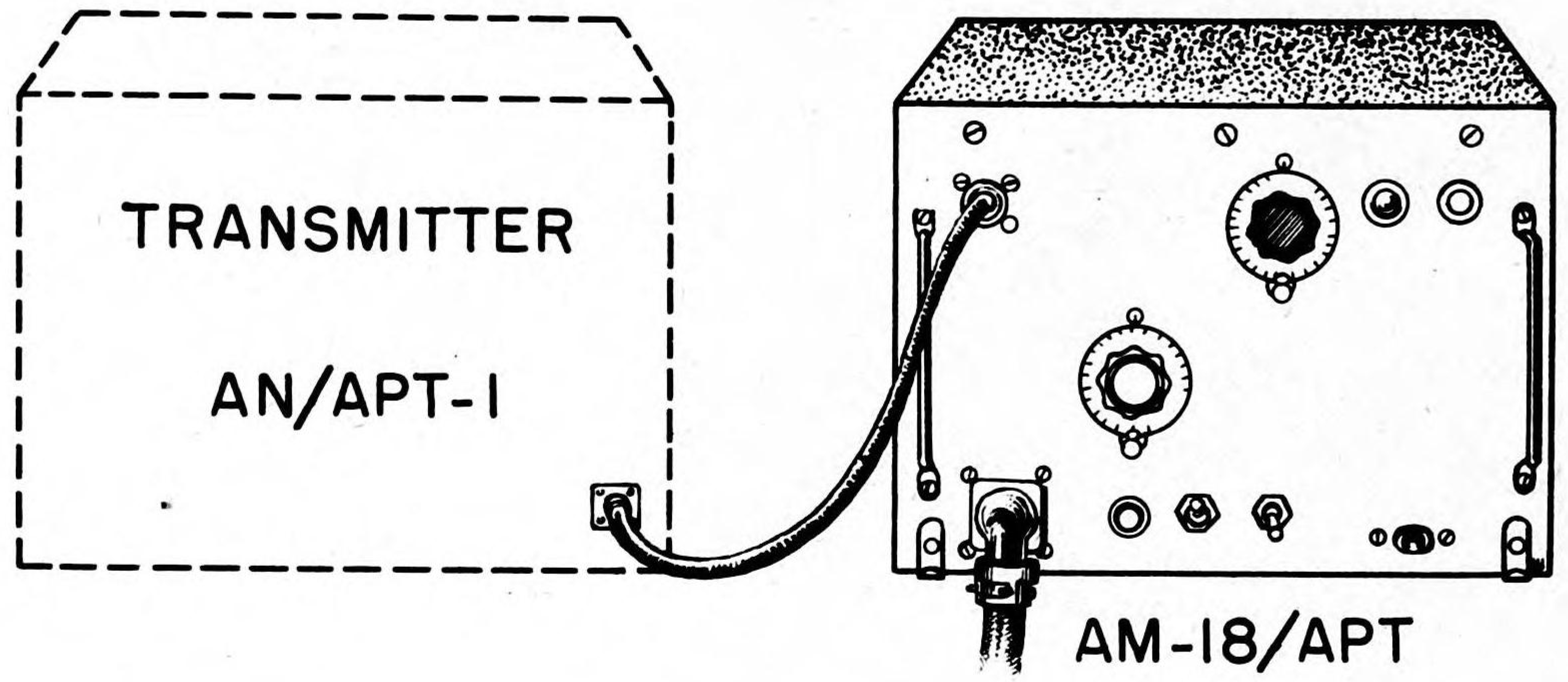
SPECIFICATIONS

FREQUENCY RANGE: 85 to 150 Mc.
INPUT POWER: 550 watts, 80 or 115 volts, 400 to 2600 cps.
R-F DRIVING POWER: 5 to 10 watts, thru 50 ohm cable.
OUTPUT POWER: 90-130 watts.
MODULATION BANDWIDTH: 3 to 4 Mc with APT-1; 1.5 to 2 Mc with APT-3.
ANTENNA: AT-37/APT (114 to 150 Mc), AT-38/APT (85 to 114 Mc).
RECOMMENDED TEST EQUIPMENT: Same as for associated transmitter.
SIZE AND WEIGHT: SARC B1-D, 50 pounds.

STATUS

Moderate production under way. Equipment Restricted; T. O. #: AN-08-35AM14-2 and CO-AN-08-35AM14-2.

RADIO FREQUENCY AMPLIFIER AM-18/APT



AM-18/APT

PURPOSE

AM-18/APT is an airborne, wide-band, power amplifier that can be tuned to cover the frequency range between 140 and 210 Mc. It is designed primarily to enhance the jamming effectiveness of AN/APT-1 at the upper end of its frequency range. A number of German and Jap ground and ASV radars are now operating in this upper range.

DESCRIPTION & PERFORMANCE

The two-stage amplifier with its power supply unit is assembled in one box (SARC B1-D). Its installed weight is 45 pounds. AM-18/APT will at least treble the jamming effectiveness of AN/APT-1 for the 140 to 210 Mc frequency range.

OPERATION & INSTALLATION

No attention is required during flight if the amplifier is pretuned while the transmitter is being adjusted. The amplifier should be placed as close as possible to the transmitter. The antenna installation is the same as that specified for the transmitter when operating in the 140 to 210 Mc range.

PERSONNEL

No extra personnel is required for operation or maintenance. Men who are qualified to operate and service the transmitter are also qualified to operate and service the amplifier.

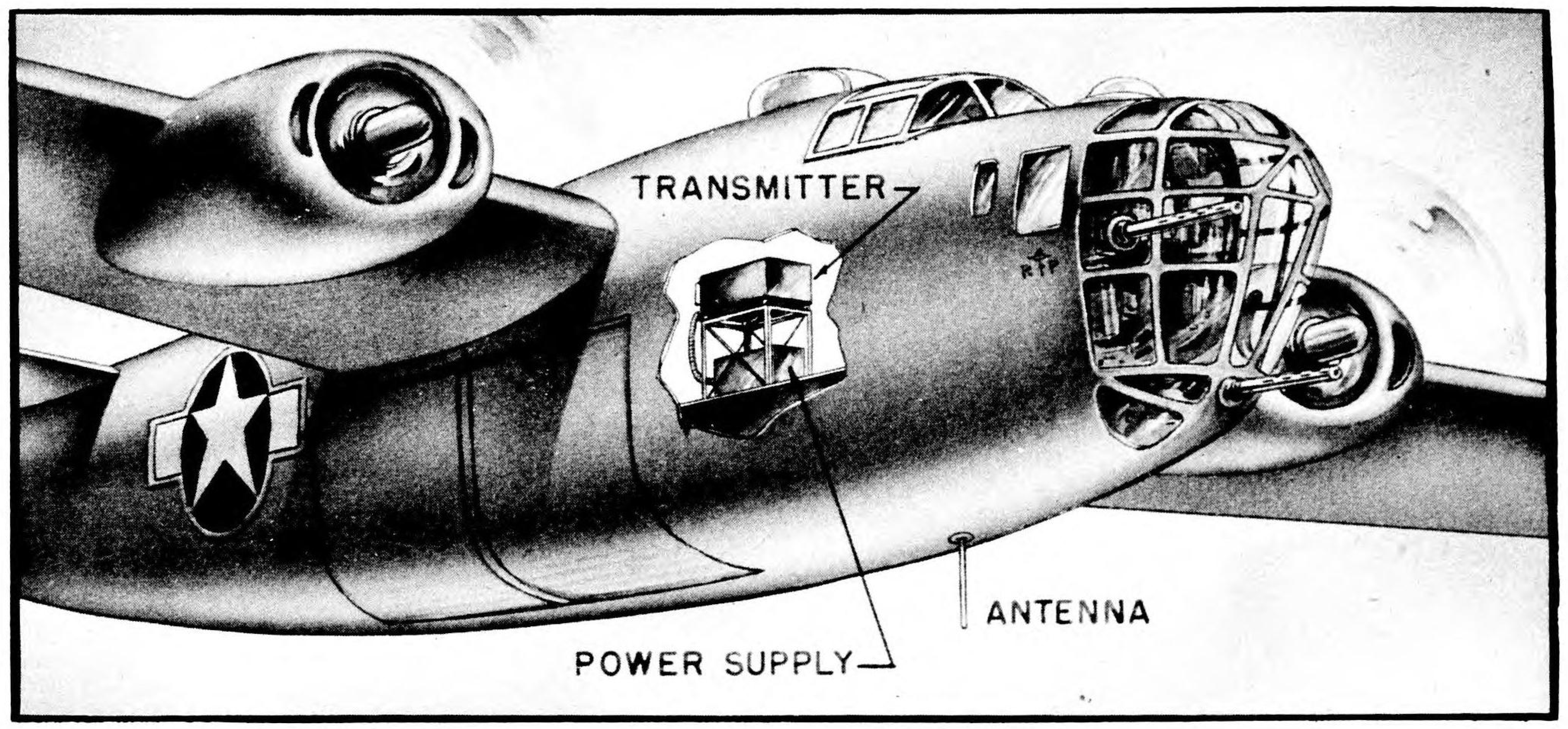
SPECIFICATIONS

FREQUENCY RANGE: 140 to 210 Mc.
INPUT POWER: 500 watts, 80 or 115 volts, 400 to 2600 cps.
R-F DRIVING POWER: 5-10 watts through 50 ohm cable.
OUTPUT POWER: Rated at 50 watts to 100 watts.
MODULATION BANDWIDTH: Not less than 3.5 Mc.
ANTENNA: AT-36/APT.
RECOMMENDED TEST EQUIPMENT: Same as for associated transmitter.
SIZE AND WEIGHT: SARC B1-D, 45 pounds.

STATUS

Moderate production under way. Equipment Restricted; T. O. #: AN-08-35AM14-2.

TRANSMITTING EQUIPMENT AN/APQ-2A (RUG)



PURPOSE

AN/APQ-2A is an airborne transmitter for jamming enemy radar systems operating in the frequency range from 200 to 550 Mc. This range includes some enemy early warning radar and enemy coast watching radar as well as most of the enemy aircraft interception radar systems. It can be used for either barrage or spot jamming.

DESCRIPTION

AN/APQ-2A consists of a transmitter (size SARC B1-D) and a power unit (size SARC A1-D). The transmitter is a line type oscillator amplitude modulated with noise.

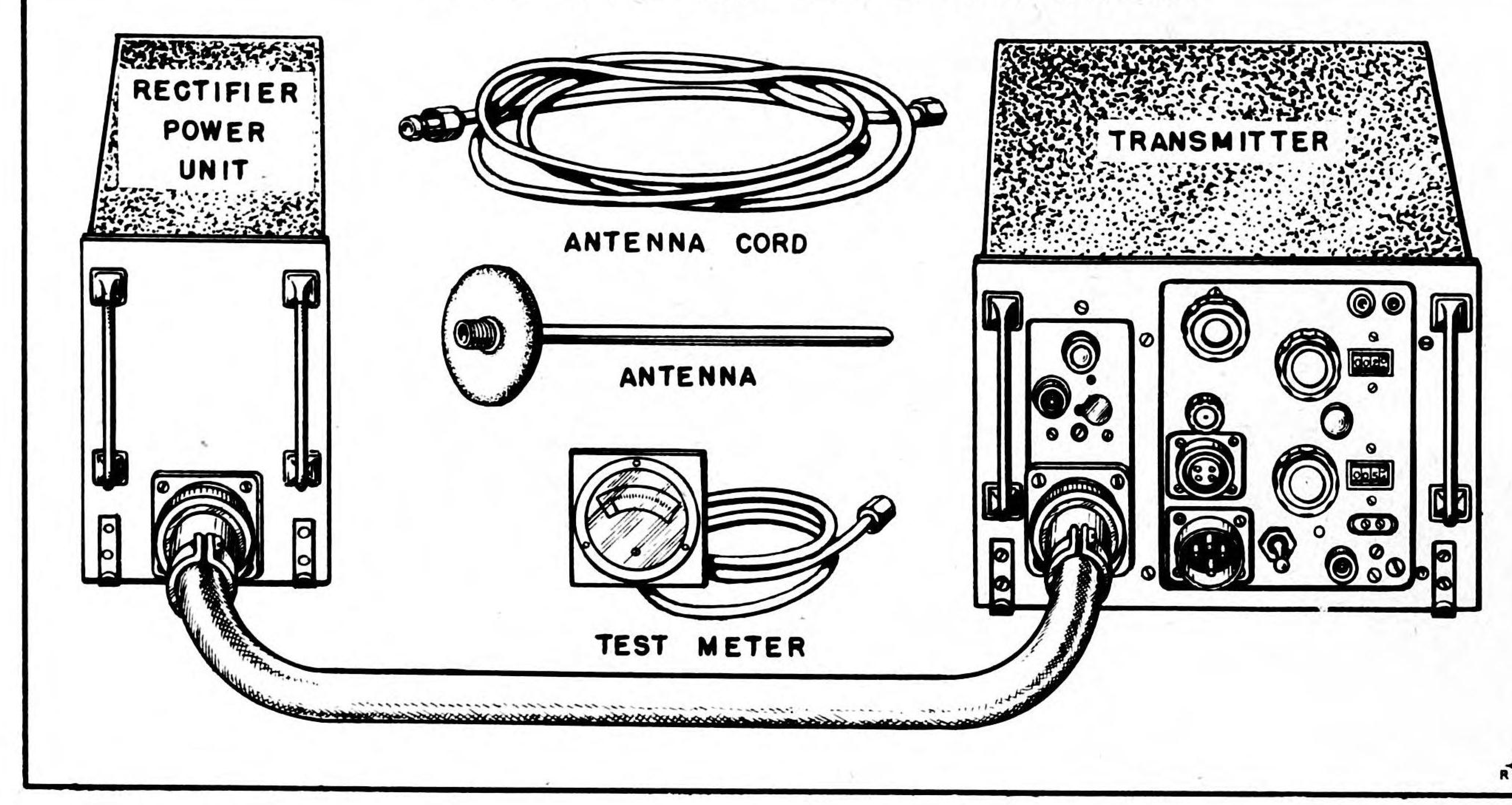
PERFORMANCE

AN/APQ-2A has a sufficient power output to screen a large bomber to within a reasonable distance of most of the radar systems in its frequency band; the exact screening power depends on the type of radar encountered. The equipment is especially useful in creating confusion as to the number of planes approaching a coastal watching radar or in preventing successful night fighter interception. For a bandwidth of 7 Mc its power output varies from 20 watts at 200 Mc to 5.5 watts at 550 Mc.

OPERATION

The equipment is usually pre-tuned before take-off, thereby obviating need for adjustment of the controls during flight. It is possible, however, for a specially trained operator to tune the transmitter over a fairly large frequency band during flight in order to jam radar sets whose frequencies are being determined with the aid of a search receiver, such as AN/APR-4.

MAIN COMPONENTS OF AN/APQ-2A



INSTALLATION

The antenna for the equipment should project from the underside of the aircraft, being so placed that its view of the radar system to be jammed is not obscured by aircraft surfaces during normal flight. The transmitter should be approximately level when the plane is in level flight. The distance between the transmitter and the antenna should be kept small, and the transmitter should be located so as to be accessible to an operator.

PERSONNEL

No extra personnel is required for barrage jamming operations. For spot jamming, a specially trained operator is required. Properly supervised radar mechanics can maintain the equipment.

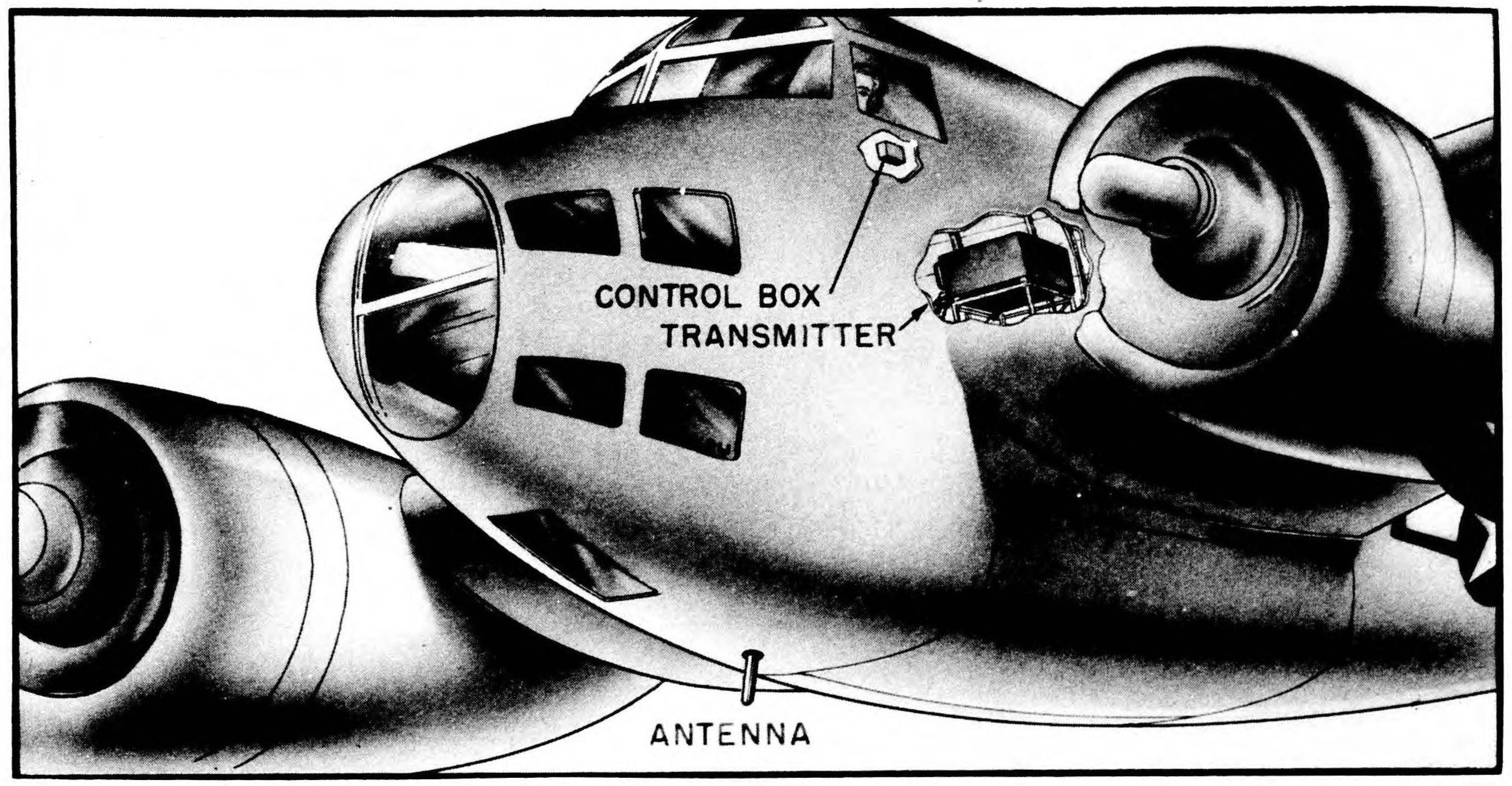
SPECIFICATIONS

FREQUENCY RANGE: 200 to 550 Mc.
INPUT POWER: 400 watts, 80 or 115 volts, 400 to 2600 cps, a.c., and 30 watts, 24 to 28 volts d.c.
OUTPUT POWER: 20 to 5 watts.
MODULATION: Amplitude with noise plus incidental FM.
MODULATION BANDWIDTH: 7 Mc.
SIDEBAND POWER: 5 to 1.25 watts.
ANTENNA: AS-65/APQ-2A; vertical polarization.
TEST EQUIPMENT: TS-53/AP, TS-70/AP, TS-131/AP, I-139-A.
SIZE AND WEIGHT: SARC B1-D plus SARC A1-D, about 90 pounds.
TECHNICAL FEATURES: The transmitter comprises an oscillator which is modulated by the amplified output of an electronic noise source. The oscillator consists of two triodes and a push-pull circuit. The frequency depends on the positions of shorting bars on the plate and grid lines of the tube.

STATUS

Heavy production under way. Equipment Restricted: T. O. #: AN-08-10-204 and CO-AN-08-30AIQ2-2.

RADAR SET AN/APT-2 (CARPET-I)

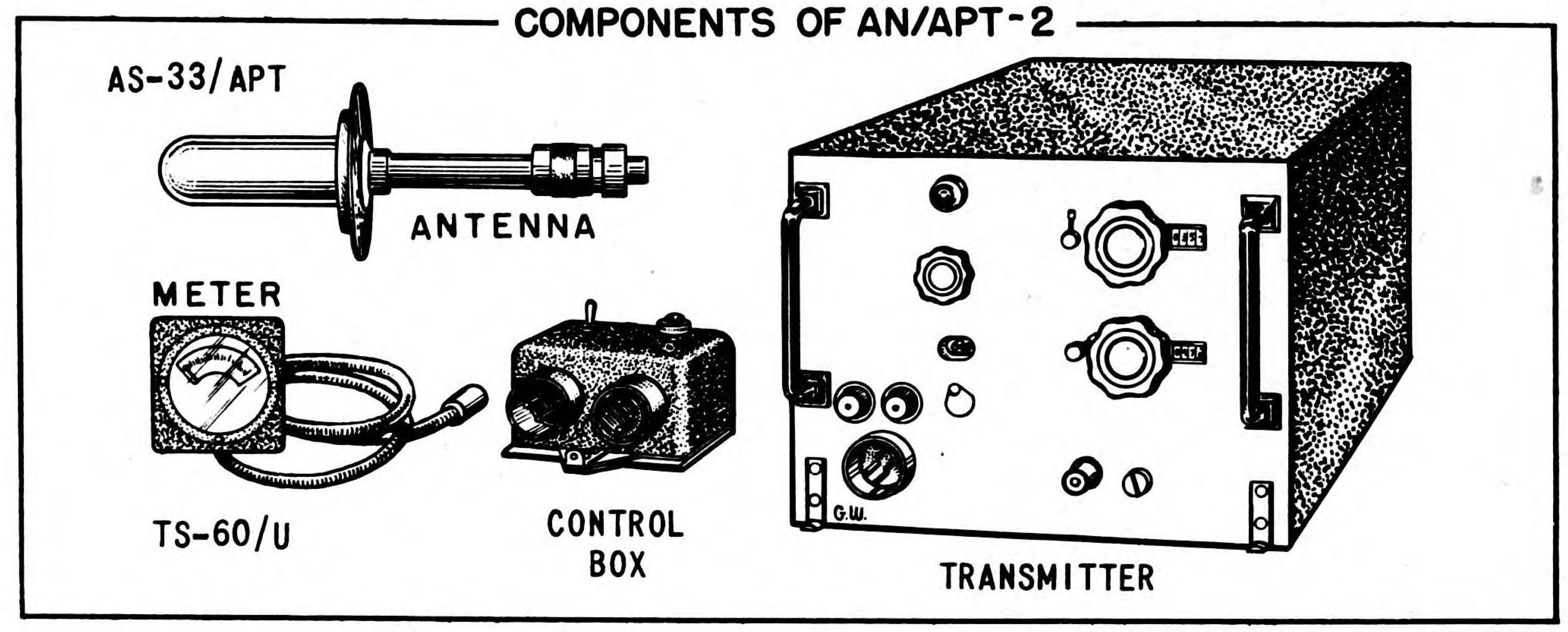


PURPOSE AN/APT-2 is an airborne transmitter for jamming enemy radar systems operating in the frequency range from 450 to 720 Mc. This range is much used for medium range aircraft detection, ground-controlled interception, night fighter interception, anti-aircraft fire, searchlight control, and air to surface vessel radar. The transmitter blankets any frequency in its range with a wide noise spectrum. It can be used for either barrage or spot jamming.

DESCRIPTION AN/APT-2 consists of a transmitter (size SARC B1-D) plus a small control box. The transmitter is a line type oscillator which is amplitude modulated with noise.

PERFORMANCE For spot jamming the equipment is considered sufficient to screen a heavy bomber to within less than 7 miles from a Giant Wurzburg. Better performance against most other radar sets can be expected. The total output power of the transmitter depends on frequency, varying from 8 watts at 450 Mc to 4 watts at 710 Mc. The side-band energy depends upon the degree of modulation and clipping. Extremely effective use can be made of this jamming transmitter by carrying a large number of the transmitters spread through a group of bombing planes. In this type of operation the frequencies of the individual jammers are spaced across a wider band than the 7 Mc provided by a single AN/APT-2. Operational results from this use of the transmitter indicate that losses may be cut by as much as one-half by using the transmitter against gun-laying and ground-controlled interception radar.

OPERATION When the jamming tactics in the frequency or frequencies to be jammed are known, the transmitter should be pre-tuned before take-off. For barrage jamming the controls are set so that the frequency of the transmitter is as close as possible (at



least within 3½ Mc) to the frequency to be jammed. The 7 Mc bandwidth provides a factor of safety to compensate for inaccuracy in tuning, or in knowledge of the radar frequencies. If several jammers were to be used to barrage a band wider than 7 Mc, their frequencies should be spread fairly evenly across the band. In operation of the pre-tuned device the transmitter requires only turning on and off during flight. If the transmitter is used as a spot jammer in conjunction with a search receiver, it may be tuned over a range of about 20 Mc by adjusting only one control.

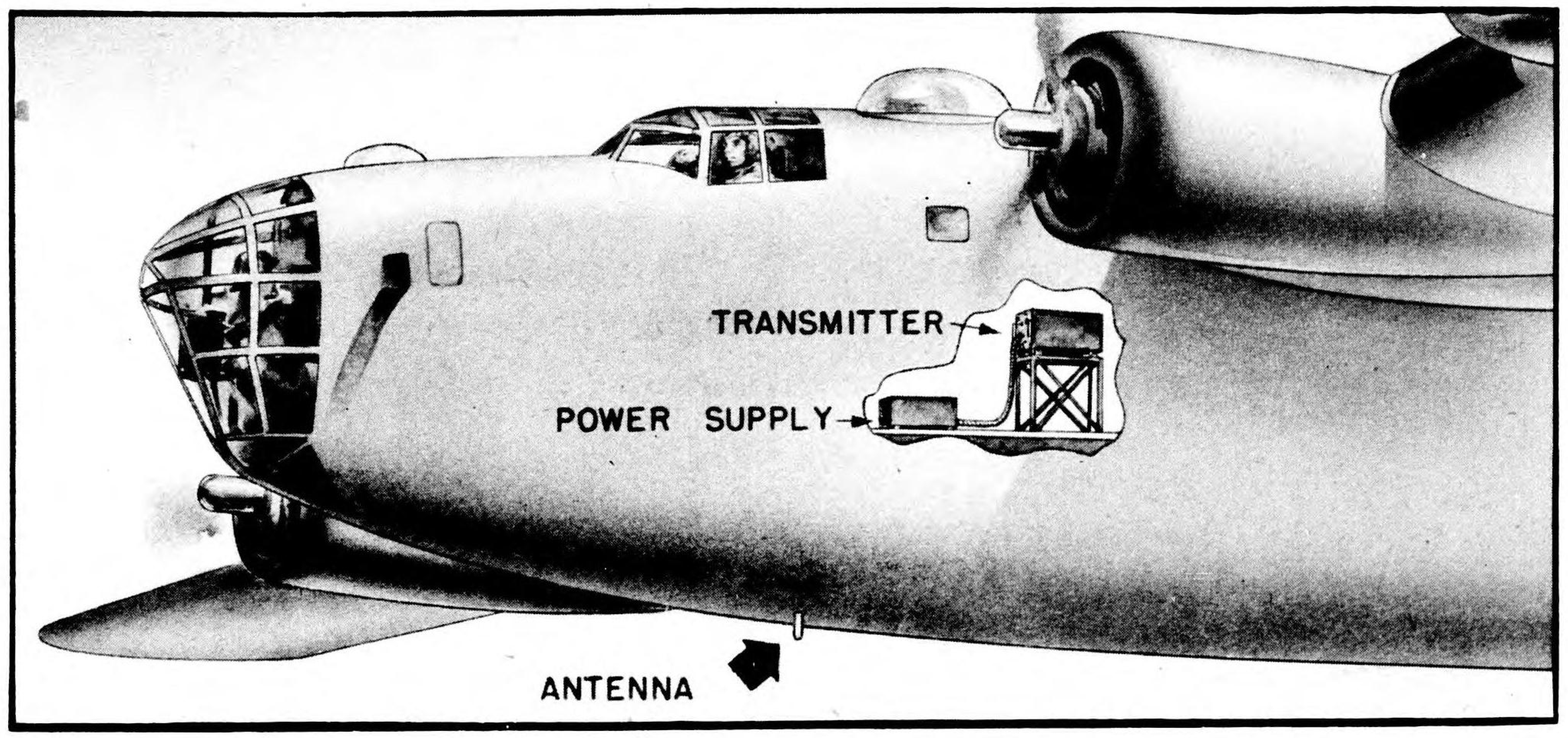
INSTALLATION The antenna should project from the underside of the aircraft, being so placed that its view of the radar system to be jammed is not obscured by aircraft surfaces during normal flight. The transmitter should be mounted relatively close to the antenna in such a position so as to be accessible to the operator if spot jamming is to be used.

PERSONNEL No extra personnel is required for barrage jamming use. A specially trained operator is required if the equipment is to be used for spot jamming. Maintenance can be performed by radar mechanics properly supervised.

SPECIFICATIONS
FREQUENCY RANGE: 450 to 720 Mc.
INPUT POWER: 250 watts, 80 or 115 volts, 400 to 2600 cps, a.c.
OUTPUT POWER: 8 to 4 watts.
MODULATION: Amplitude with noise and incidental FM.
MODULATION BANDWIDTH: 7 Mc.
SIDEBAND POWER: Depends on degree of modulation and clipping; usually about one-fourth of total power.
ANTENNA: AS-33/APT or AS-65/APQ-2, vertical polarization, AS-69/APT for circular.
TEST EQUIPMENT: TS-69/AP, TS-70/AP, TS-131/AP, I-139-A
SIZE AND WEIGHT: SARC B1-D, 45 pounds.
TECHNICAL FEATURES: The transmitter consists of an oscillator which is modulated by the amplified output of an electronic noise source. The oscillator consists of two triodes and a push-pull circuit which includes a resonant transmission line to the antenna. The frequency is adjusted by the positions of shorting bars on the plate and grid lines of the tube.

STATUS Heavy production under way. Equipment Confidential; T. O. #: AN-08-30APT2-2 and CO-AN-08-15SC-1.

RADIO SET AN/APQ-9 (CARPET III)

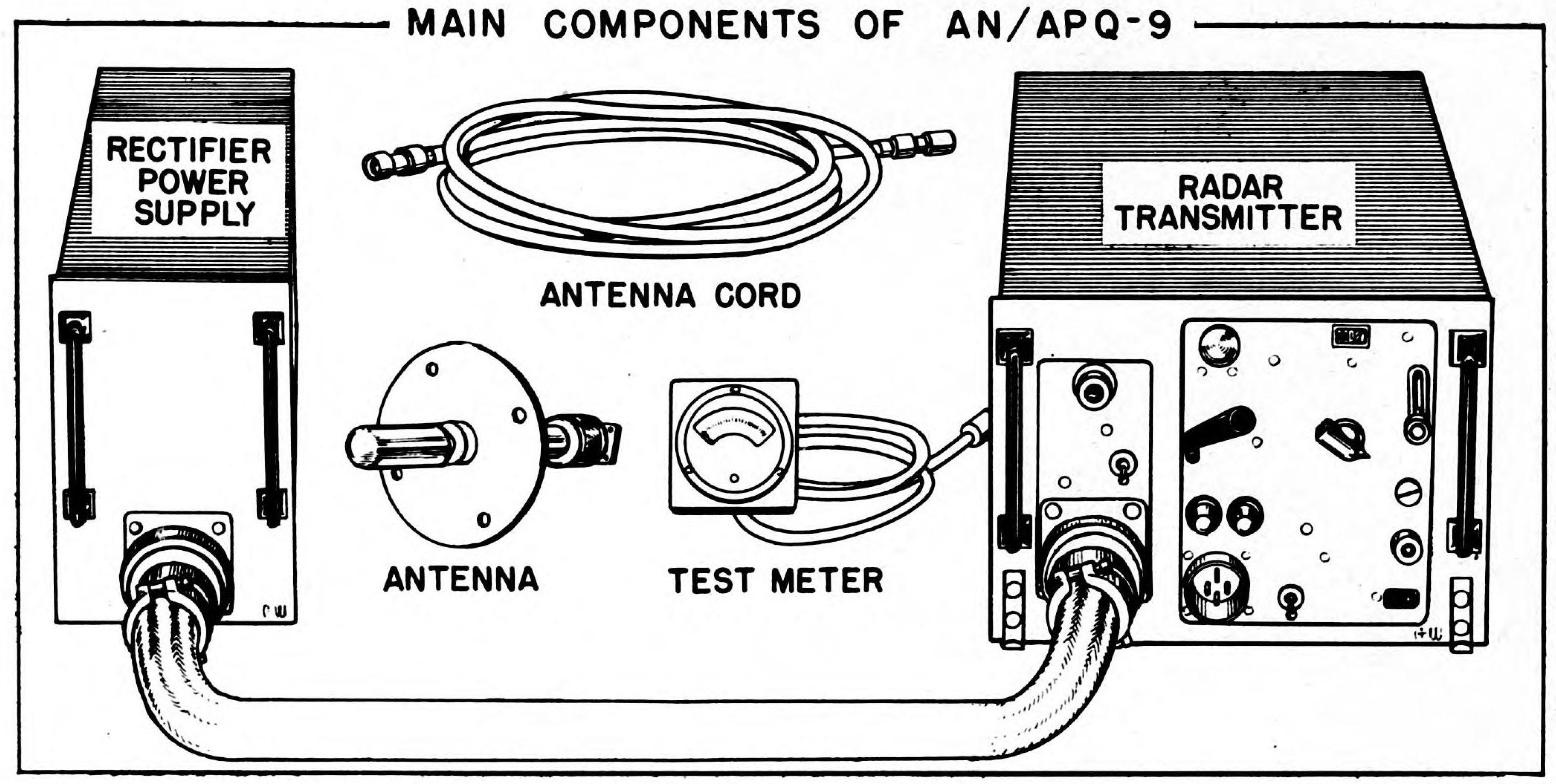


PURPOSE AN/APQ-9 is an airborne transmitter for jamming enemy radar systems operating in the frequency range from 475 to 585 Mc. This frequency range is much used for gun-laying, searchlight control, ground control of interception, and aircraft interception radar. AN/APQ-9 is designed primarily as a barrage jammer, but may also be used effectively as a spot jammer.

DESCRIPTION AN/APQ-9 consists of two units (size SARC B1-D and SARC A1-D). The transmitter has a noise amplitude modulated output. AN/APQ-9 is a later development than the AN/APT-2 jamming transmitter (described elsewhere). AN/APQ-9 covers only the most used part of the larger frequency range covered by AN/APT-2; but AN/APQ-9 has approximately four times as much output power as AN/APT-2 and hence is more effective in the frequency range covered.

PERFORMANCE When used as a barrage jammer AN/APR-9 has sufficient output power to screen a heavy bomber to within 6 miles (or closer) of a Giant Wurzburg radar system. The screening will be within a considerably closer distance for all other enemy radars known to operate within its frequency range. The noise modulated output bandwidth is 7 Mc. When used in a team with many jammers scattered throughout a formation of aircraft, the performance of this transmitter should be decidedly superior to that of AN/APT-2, since the power output is higher.

OPERATION No attention to the transmitter is required during flight, if it is used as a pre-set barrage jammer. The transmitter may, however, be used to considerable advantage in conjunction with a receiver (such as AN/APR-4) for spot jamming of radar systems in its frequency range. It may be tuned over an 80 Mc range by means of a single control.



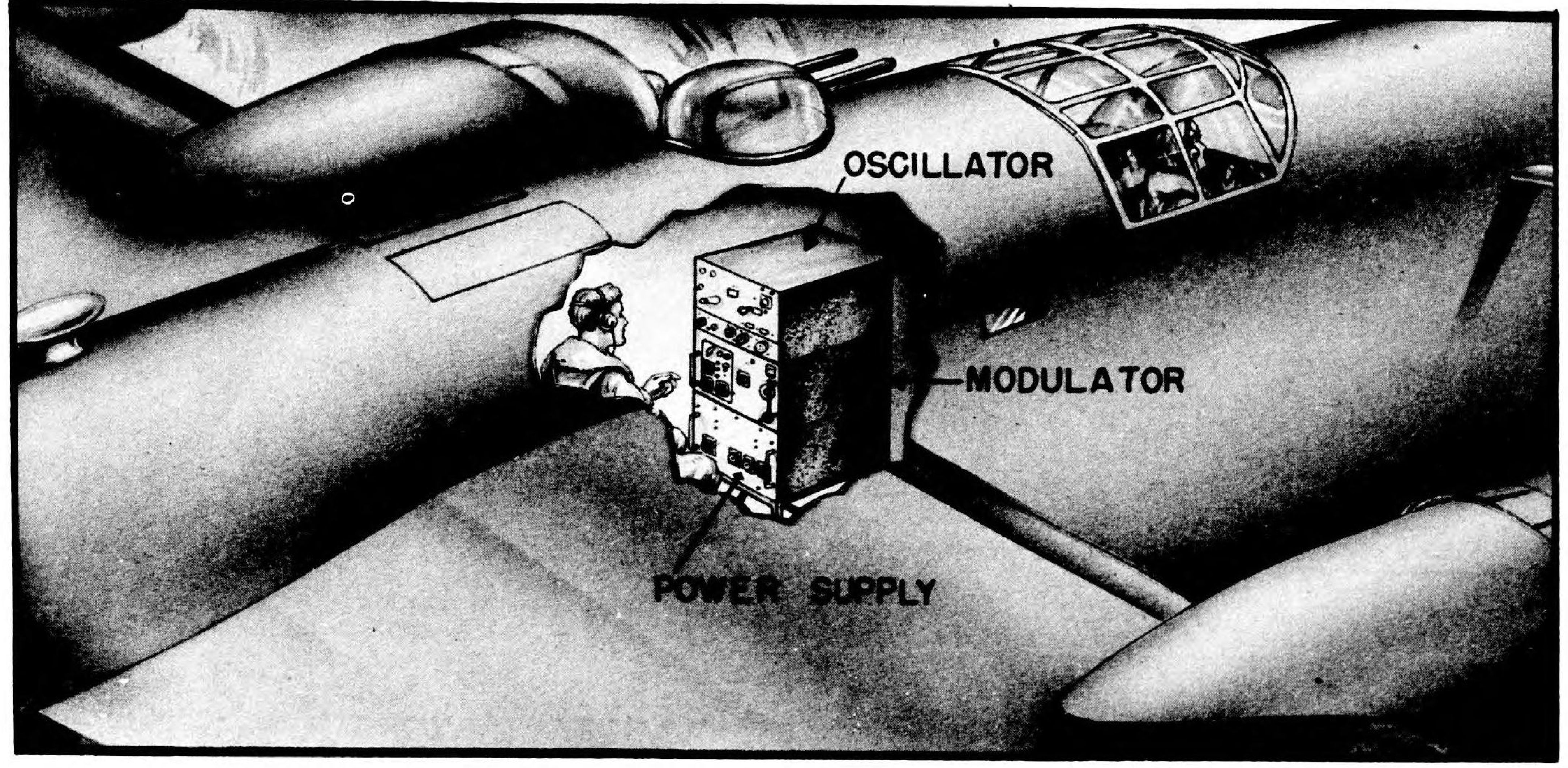
PERSONNEL No extra personnel is required in flight for barrage jamming use. A specially trained operator is required if it is desired to use the equipment as a spot jammer. Radar mechanics, properly supervised, can maintain the equipment.

INSTALLATION The transmitter should be mounted so as to be approximately level when the plane is in level flight. It should be within the reach of an operator. The power supply unit may be mounted at any place reasonably close to the transmitter. The antenna should be mounted so as to have an unobstructed view of the radar set to be jammed.

SPECIFICATIONS
FREQUENCY RANGE: 475 to 585 Mc, any 80 Mc band of which may be covered by a single dial frequency adjustment on the front panel.
INPUT POWER: 450 watts, 115 or 80 volts, 400 to 2600 cps, a.c., and 30 watts, 28 volts d.c.
OUTPUT POWER: At least 25 watts at 475 Mc, and 15 watts at 585 Mc.
MODULATION: Amplitude with noise and incidental FM.
MODULATION BANDWIDTH: 7 Mc.
ANTENNA: AS-33/APT or AS-69/APT.
TEST EQUIPMENT: TS-69/AP, TS-70/AP, TS-131/AP, I-139-A.
SIZE AND WEIGHT: SARC B1-D plus SARC A1-D; 90 pounds.
TECHNICAL FEATURES: The r-f oscillator employs two high frequency triodes in a push-pull circuit in which two parallel plates are used in place of the more conventional grid and plate lines. The oscillator is plate-circuit amplitude modulated by means of a photoelectric electron multiplier noise source (type 931 tube) followed by a wideband amplifier.

STATUS Heavy production under way. Equipment Confidential; T. O. #: AN-08-30APQ9 and CO-AN-08-30APQ9-2.

RADAR SET AN/APT-4 (AIR BROADLOOM III)

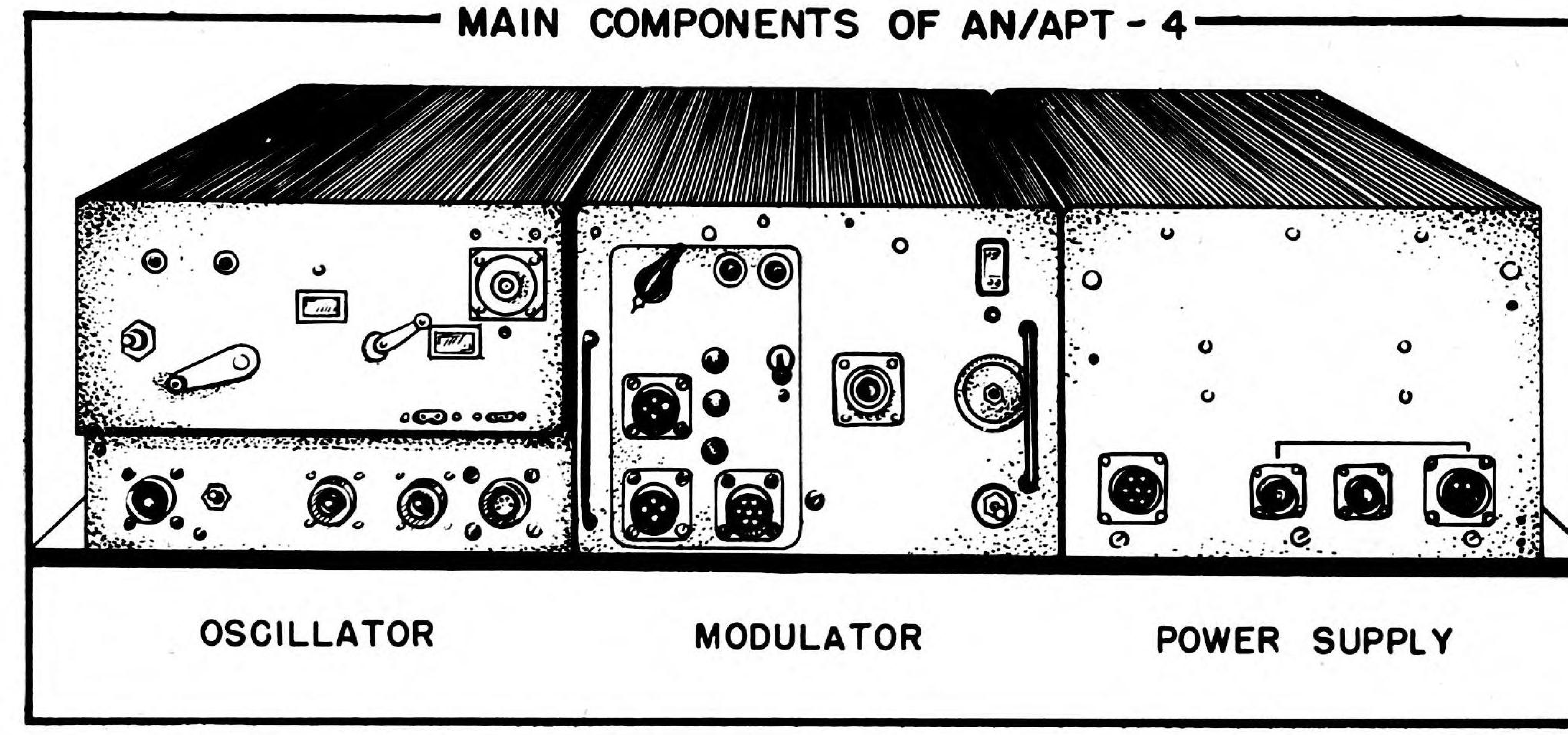


PURPOSE AN/APT-4 is a powerful airborne transmitter for jamming enemy radar systems operating in the frequency range from 165 to 780 Mc. AN/APT-4 uses special magnetron tubes which have a power output greater than that obtained by conventional tubes in the AN/APT-2, AN/APQ-9 or AN/APQ-2A transmitters. The equipment is primarily intended for barrage jamming, but may also be used for spot jamming.

DESCRIPTION AN/APT-4 is contained in three units (each SARC B1-D) and weighs about 190 lbs. A 1500 watt power supply is required. The transmitting equipment consists of an oscillator-cooling unit, a high-voltage power supply, and a low voltage power supply-modulator unit. The frequency range from 165 to 350 Mc is covered by the use of the GL-590 magnetron tube in the oscillator. To cover the range above 350 Mc it is necessary to change to the GL-579 magnetron tube.

PERFORMANCE The equipment is considered sufficient to screen a large bomber to within 2 miles or less from any known radar operating in its frequency range. It has a power output of 150 watts at 350 Mc, and 50 watts at 800 Mc. Its bandwidth is variable from 7 Mc to 10 Mc, depending upon the degree of modulation and clipping.

OPERATION The transmitter may either be pre-tuned before take-off to the frequency to be jammed, or it may be tuned to the approximate frequency to be jammed, and final adjustment made in flight, with the aid of a receiver (such as AN/APR-4).



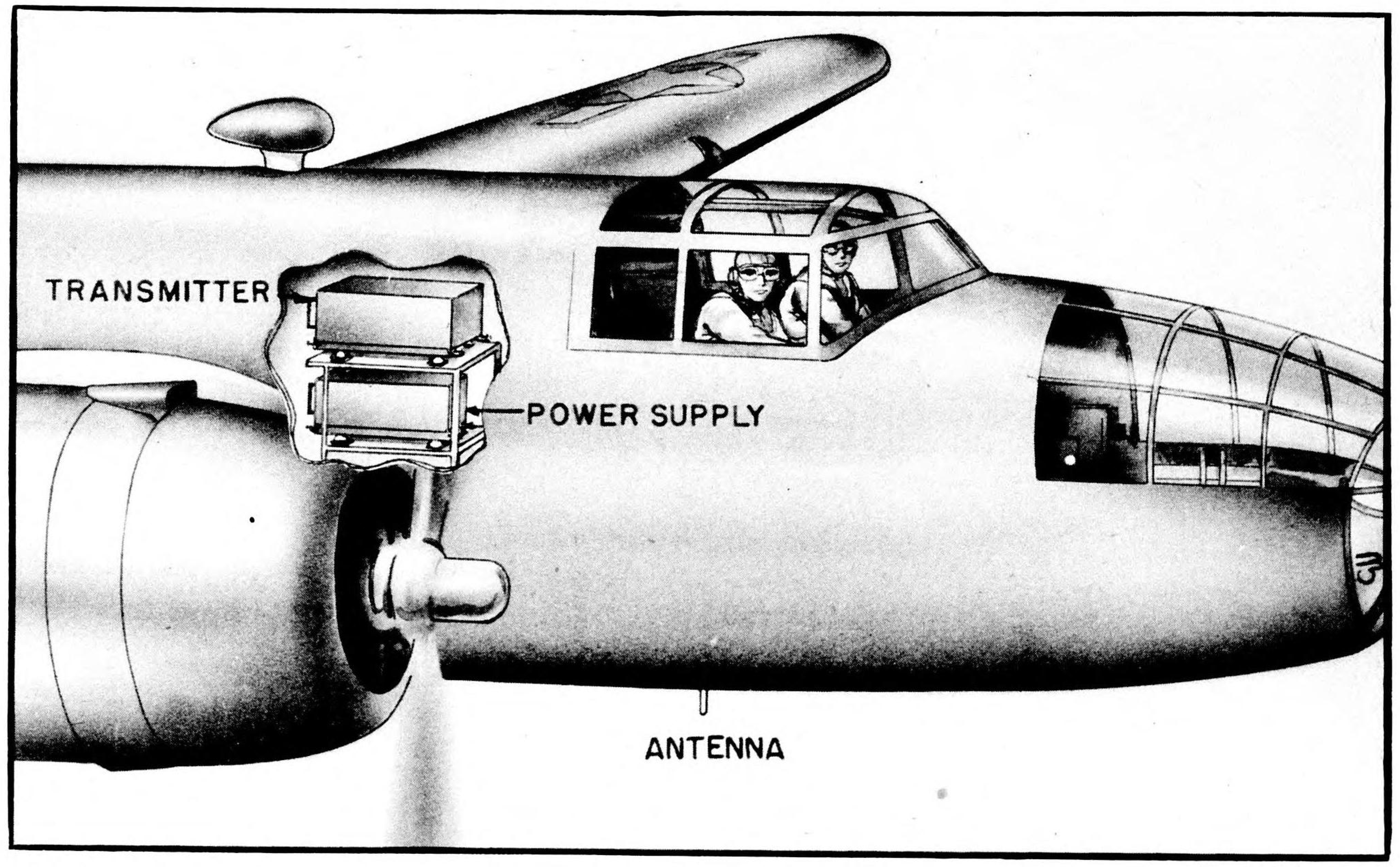
INSTALLATION The antenna for the equipment should project from the underside of the aircraft, being so placed that its view of the radar system to be jammed is not obscured by aircraft surfaces during normal flight. The transmitter should be approximately level when the plane is in level flight and should be mounted within reach of the operator.

PERSONNEL No operator is required for pre-set operation. A specially trained operator is required, however, if it is desired to set the transmitter frequency while in flight. Properly supervised radar mechanics can maintain the equipment.

SPECIFICATIONS
FREQUENCY RANGE: 165 to 780 Mc.
INPUT POWER: 1500 watts, 80 or 115 volts, 400 to 2600 cps, a.c., and 150 watts, 28 volts d.c.
OUTPUT POWER: 150 to 50 watts.
MODULATION: Amplitude with noise and incidental FM.
MODULATION BANDWIDTH: 7 Mc to 10 Mc.
SIDEBAND POWER: Depends on the degree of modulation and clipping.
ANTENNA: Under development.
TEST EQUIPMENT: TS-175/U, TS-118/AP, TS-131/AP, I-139-A, TS-15/AP.
SIZE AND WEIGHT: 3 SARC B1-D, 190 pounds.
TECHNICAL FEATURES: The oscillator unit is a water-cooled magnetron in an open line circuit. Single dial frequency control varies the lengths of the tuning lines. Conventional power supplies and noise modulator are also included.

STATUS Light production under way. Equipment confidential.

RADAR SET AN/APT-5 (CARPET IV)

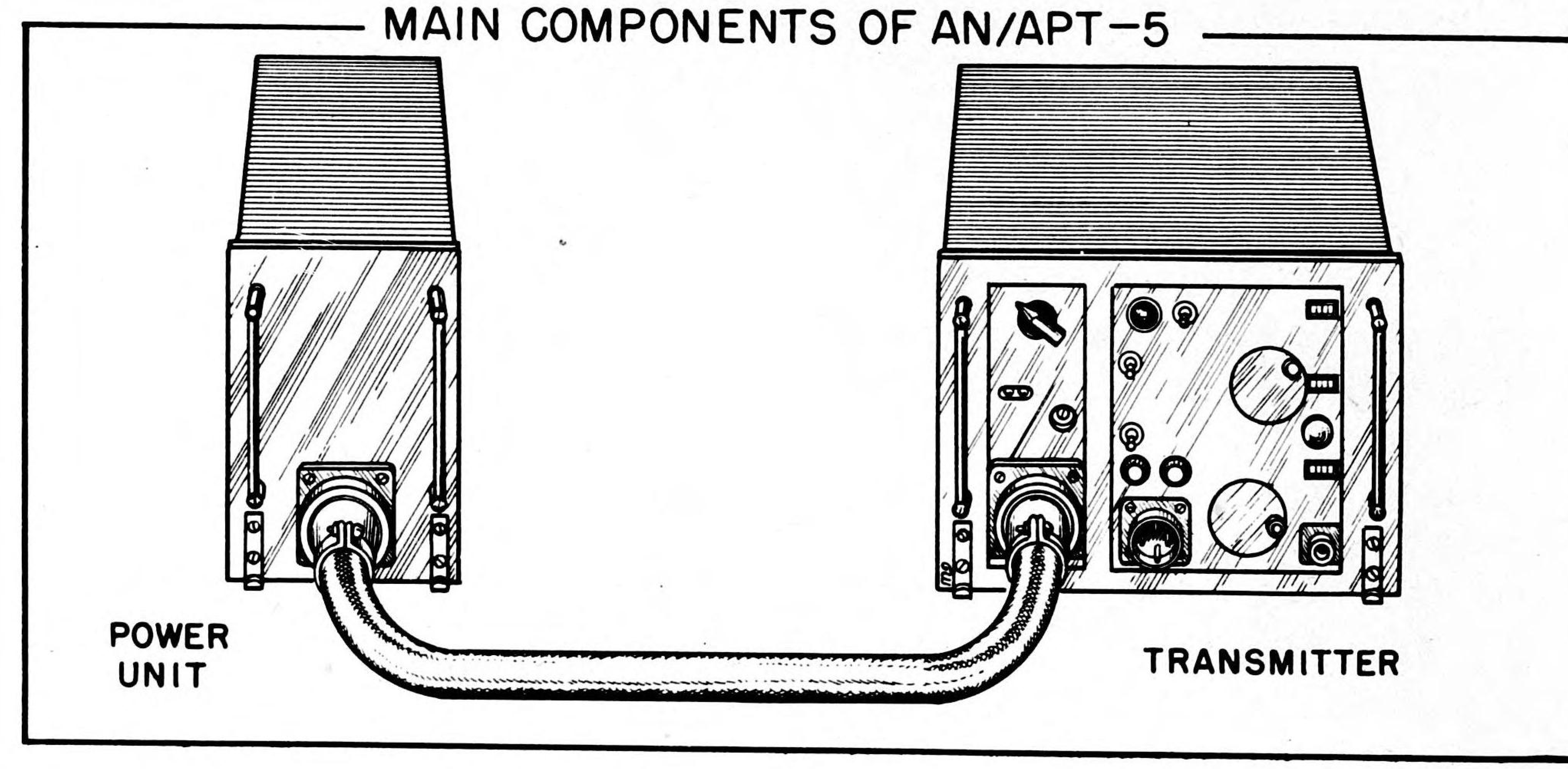


PURPOSE AN/APT-5 is an airborne transmitter for jamming enemy radar systems operating in the frequency range from 350 to 1400 Mc. Although no German or Jap radars have yet been reported as operating at a frequency higher than 750 Mc, the higher frequencies are likely to be used for accurate gun laying and searchlight control. The equipment thus provides insurance against probable future developments, while also being able to jam many known systems. It is primarily intended for spot or semi-barrage jamming.

DESCRIPTION AN/APT-5 is contained in two boxes (SARC B1-D, and A1-D) and weighs 70 pounds. It is a noise amplitude modulated transmitter.

PERFORMANCE Definite figures on performance are not yet available. The power output of the transmitter varies from about 60 watts at 350 Mc to 5 watts at 1400 Mc. The bandwidth is not less than 2 Mc at any point in the frequency range.

OPERATION The transmitter should be pre-tuned before take-off as closely as possible to the victim frequency. No attention is required during flight, aside from throwing switch to start or stop jamming. The



transmitter may also be used with a search receiver (such as AN/APR-4) for very accurate spot jamming. This type of operation requires that the transmitter be tuned during flight.

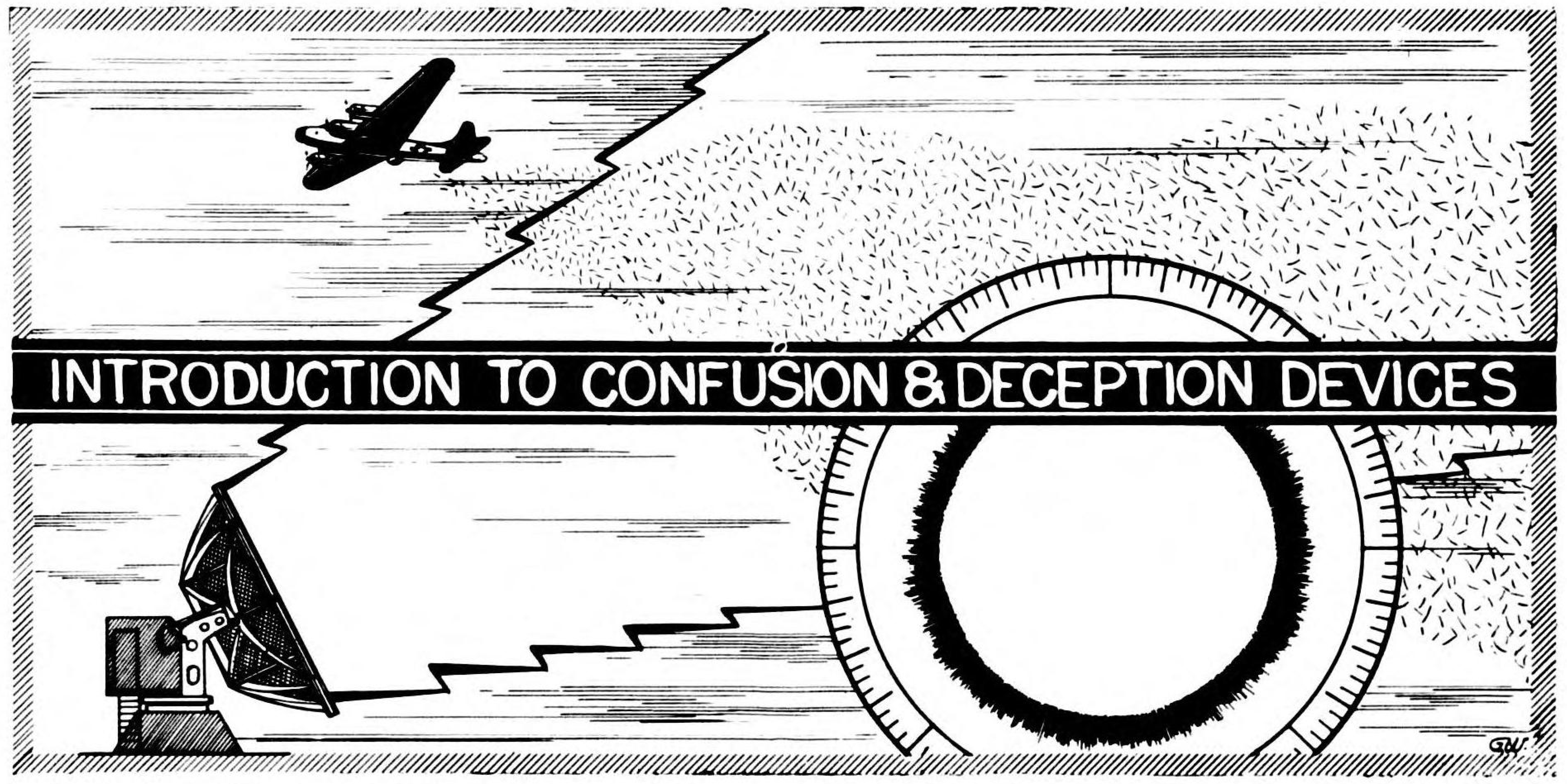
INSTALLATION The antenna should project from the underside of the aircraft, being so placed that its view of the radar system to be jammed is not obscured by aircraft surfaces during normal flight. The transmitter should be approximately level when the plane is in level flight. It should be mounted within reach of the operator.

PERSONNEL No extra personnel is required for operation when pre-tuned. An operator is required when used with a search receiver. Maintenance can be performed by properly supervised radar mechanics.

SPECIFICATIONS
FREQUENCY RANGE: 350 to 1400 Mc.
INPUT POWER: 500 watts, 80 or 115 volts, 400 to 2600 cps, a.c. and 35 watts, 28 volts, d.c.
OUTPUT POWER: 60 to 5 watts
MODULATION: Amplitude with noise and incidental FM.
MODULATION BANDWIDTH: Not less than 2 Mc.
SIDEBAND POWER: Depends upon degree of modulation and clipping.
ANTENNA: Under development.
RECOMMENDED TEST EQUIPMENT: TS-175/U, TS-118/AP, TS-131/AP, I-139-A.

SIZE AND WEIGHT: SARC B1-D and A1-D, 90 pounds.
TECHNICAL FEATURES: R-F output obtained from light-house type triode oscillator, tuned by adjustment of three panel controls, calibration accuracy within ± 3%, noise source 931-A.

STATUS Moderate production under way. Equipment confidential.



The application of confusion and deception methods to communications channels requires no special equipment other than transmitters and receivers that cover the proper frequency bands. Since it is not the purpose of this book to discuss operational practices on communications channels (but rather to cover the application of equipment especially developed for RCM purposes) the discussion of communications confusion and deception methods is confined to a description of the types generally practiced. In radar countermeasures, on the other hand, special equipment is required to create confusion and deception. Consequently, this equipment is catalogued herein and its application discussed.

COMMUNICATIONS DECEPTION METHODS

Communications deception may be classified as either imitative or manipulative. Imitative deception is the use of radio to simulate enemy operation in order to confuse or deceive the enemy in his own communication channels. This is extraordinarily difficult, and requires an intimate and exact knowledge of enemy procedure, organization, method of keying, and cryptographic systems. In general, only specially trained personnel with long and thorough experience is capable of attempting this type of operation. Imitative deception may be practiced on tactical circuits to disorganize the enemy's communications during an engagement or melee. Specially trained deception units should be provided for this work.

Manipulative deception, on the other hand, is the use of radio to deceive the enemy as to the location, movements and strength of our forces by the use of misleading material in our own communications channels. This material aims to misguide enemy analysis and, in designated cases, to make false text information recoverable from a weak or previously compromised cryptographic system. Like imitative radio deception, it is fraught with difficulties,

but of a less formidable nature. First, it must depend mainly upon inferences as to which of our circuits the enemy is intercepting, what the enemy already knows about our cryptographic and communications systems, and what he has deduced from our operations. Second, the plans must be worked out with the most painstaking attention to detail or the scheme will become weakened and fail. Third, it is impossible to determine immediately, with accuracy, the success attained.

RADAR DECEPTION METHODS

Various imitative methods designed to create confusion or deception of the enemy radar operation have been (or are being) developed. For convenience, these devices may be classified into mechanical and electrical means. In addition, just as in the communications field, manipulative countermeasures deception may also be practiced.

Under the category of mechanical confusion there are various reflector devices which act as decoy targets. They serve to confuse (and sometimes deceive) the radar operator by creating false signals which closely resemble those from a legitimate target. Classified according to physical form, these reflecting surfaces are generally known as Chaff, and as Ropes. The use of such material for creating confusion is known as a Window operation. These devices are discussed in detail below and the forms in which they are currently available are catalogued at the end of this section.

Electrical deception may be carried out by using the jammers previously described in this publication. To do this a small diversionary force carries sufficient jammers so that is indistinguishable from the genuine attacking force which carries jammers for its own protection. This will be elaborated upon later.

Manipulative radar countermeasures deception, as the name implies, is the use of countermeasures devices to mislead the enemy as to our intentions by creating such activity at times other than when an actual offensive operation is underway. The importance of countermeasures at times other than during an actual operation cannot be too strongly emphasized. Prisoner-of-war reports indicate that, in certain theatres, advance notice of impending operations was always given to the enemy by the appearance of intensive countermeasures activity.

Like communication manipulative deception, the radar manipulative deception requires careful attention to details although, in general, it is not necessary to depend so much on inferences as to what circuits the enemy is monitoring. Search receivers can readily determine the enemy radar equipment that is in operation and countermeasures activity may then be directed against it in order to attract attention. Furthermore, it may be possible to determine the success of such activity by observing whether the enemy radar ceases operation, shifts to another frequency, or otherwise changes its normal plan of operation.

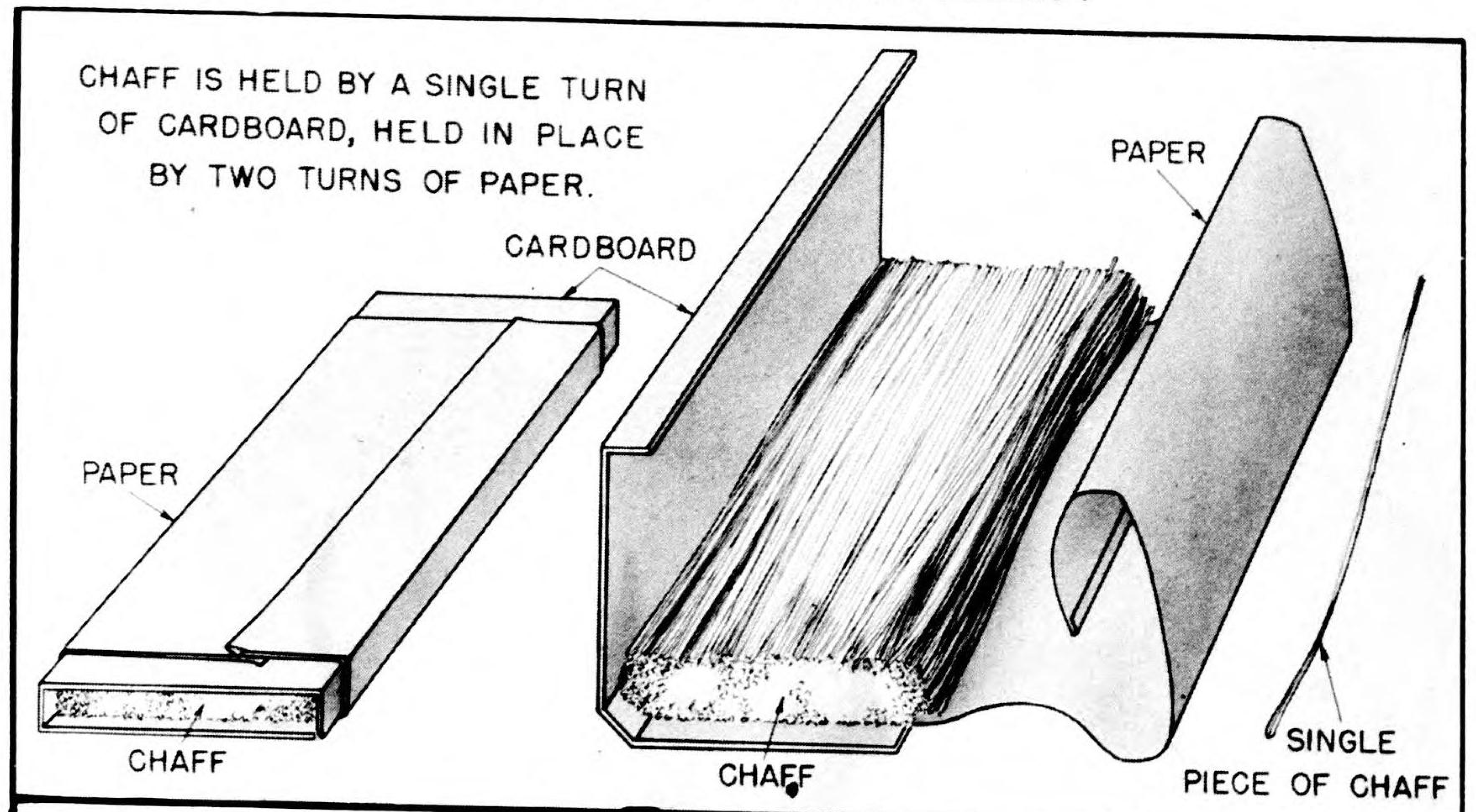
MECHANICAL RADAR CONFUSION DEVICES

Radar systems may be confused by means of decoy targets that create radar echoes similar to those from airplanes, surface vessels, landing craft or submarines. Small, light-weight conducting surfaces of appropriate size and shape can be used for this purpose. Such devices are known as confusion reflectors and have been used with marked success by both ourselves and the enemy.

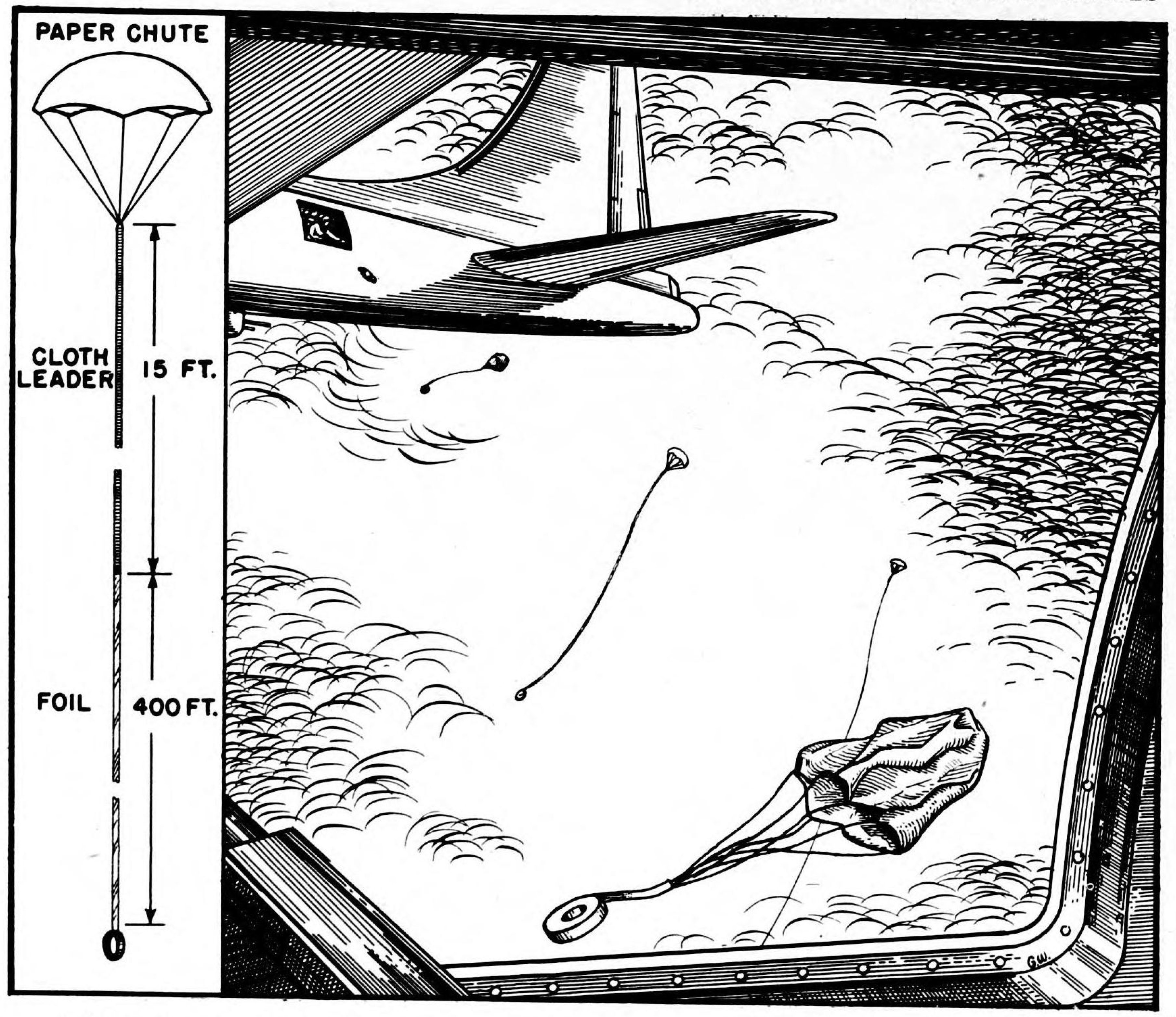
These decoy reflectors are effective in creating confusion since, if they are dispersed in sufficient quantity in the area around the target, the echo produced by the target merges with that produced by the reflectors and they cannot be distinguished from each other.

A commonly-used type of confusion reflector, known as "chaff", consists of strips of metallic-foil whose length (which is approximately one-half the wavelength of the radar against which it is to be used) may vary from about an inch or less, to a foot or more and whose width is small compared to the length.

A quantity of these strips is packaged in a suitable container and is dispensed from the aircraft in accordance with a predetermined plan. When the package opens, the contents are dispersed and fall in a more or less random manner.



A common form of electromagnetic wave reflector, used to create artificial radar echoes, is known as Chaff. It consists of metallic-foil strips whose length is approximately one-half wavelength for the radio frequency involved. Chaff, as packaged for operational use, is illustrated. The material is held by a single turn of cardboard which, in turn, is held in place by two turns of paper.



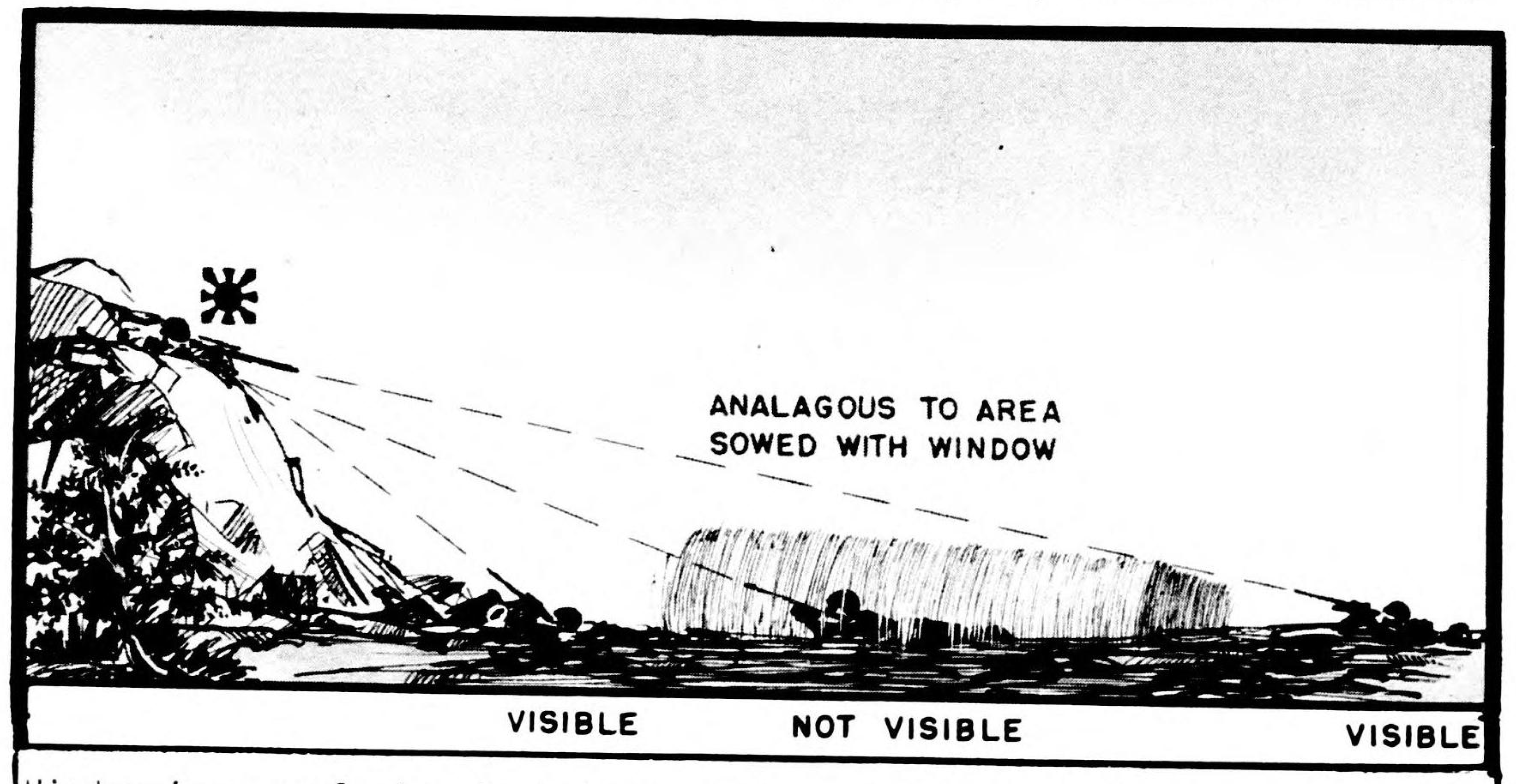
Since long strips of foil are not mechanically rigid, an untuned reflector called "Rope" is used for the lower frequencies. This reflector consists of an aluminum ribbon about one-half inch wide. It has been found that about four hundred feet is the greatest length that can be conveniently handled. Its effectiveness increases as the frequency decreases. Hence it is very effective against the enemy's low frequency radar.

One rope is a 400-length of aluminum ribbon attached and rolled onto a small cardboard spool. The free end is connected to a fifteen foot cloth leader which is in turn attached either to a small paper parachute about one foot in diameter or to a square of cardboard about three inches on a side. The parachute type is for use against vertical polarization. The card type is for use against horizontal polarization. The card functions as a drag to unroll the rope which shoots out in a horizontal direction and tends to stay that way. The card having little orienting action during descent.

When wound up, the rope is enclosed in a small package designed to open easily when tossed out of a plane, after being tossed out, it unwinds and floats down slowly either hanging practically vertically from a parachute or in a position that is predominantly horizontal if attached to a square card.

OPERATIONAL APPLICATION OF WINDOW

Operationally, Window may be thought of as a radar "smoke-screen". If Window of proper dimensions is sown in sufficient quantity, targets passing through the area involved will not be detectable by radar, since the Window creates a large, fluctuating signal whose depth in range and width in azimuth corresponds to that of the infested area. In aircraft applications, an operation of this type is useful for confusing SLC, GL, GCI and AI radars.

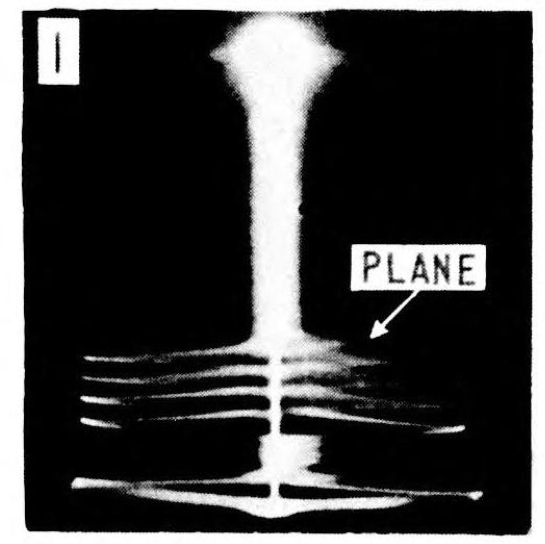


Window is a confusion technique which provides cover from radar scrutiny in much the same manner as a field of grain would cover a person crawling therein. The appearance of window on a radar "A" scope is even somewhat similar to a field of grain being swayed by a breeze. As a person moves through the grain it is seen to be disturbed but one cannot readily distinguish this disturbance from that caused by the wind, unless the course of the person is carefully followed (and never lost) as it moves across the field. Much the same effect is observed on a radar "A" scope and under some circumstances the course of a target may be followed (or occasionally glimpsed) through the echo signals created by the Window.

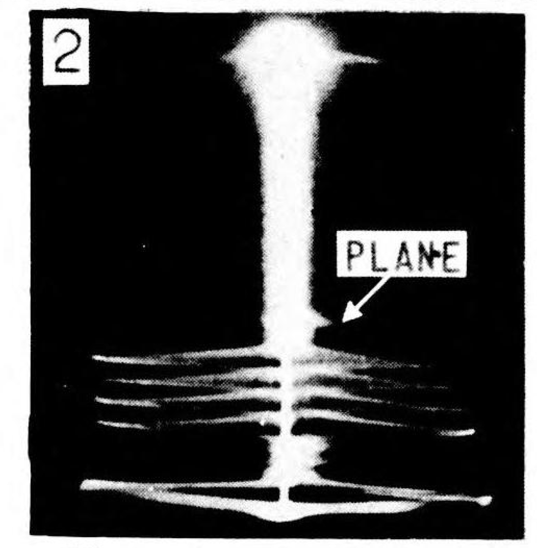
A region that has been infested with large quantities of Window provides relatively high security to an aircraft against gun-laying systems. A reasonably small quantity of the material is required for this purpose but the packages of material must be so dispersed that their separation in range from the radar does not exceed the resolving power of the system, that is, the separation between infestations must not exceed the minimum difference in range that can be distinguished by the radar.

Window may be used to conceal the size of an operation. It has been effectively used to create an area in which aircraft could mill around without being observable by SLC and GL radar and out of which they suddenly emerged to make the target run. Window may

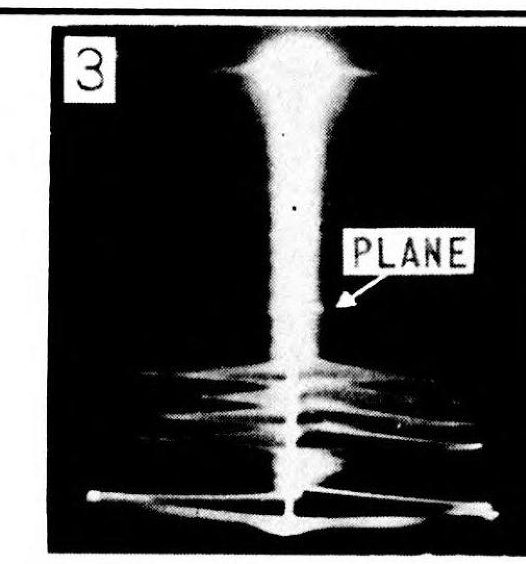
The five photographs below show the action of window on the scope of a special radar designed to indicate separately the echoes produced by horizontally and vertically polarized waves. A 515 Mc radar on the ground used one horizontal and one vertical antenna alternately, so that the left side of the scope shows vertical polarization, while the right side shows horizontal polarization. The scope covers approximately 7 miles from the main bang to the end of the sweep. Four discrete drops of Chaff were made by the airplane at a height of about 500 feet. Each photo of the A scope was made at a time interval of approximately one-half minute --all the pictures being taken in 2 minutes. In each of these photos the pip made by the airplane is visible. When an area is heavily infested with Chaff, an airplane or a flight of airplanes can be hidden in the Chaff -as illustrated in photo at bottom of this page.



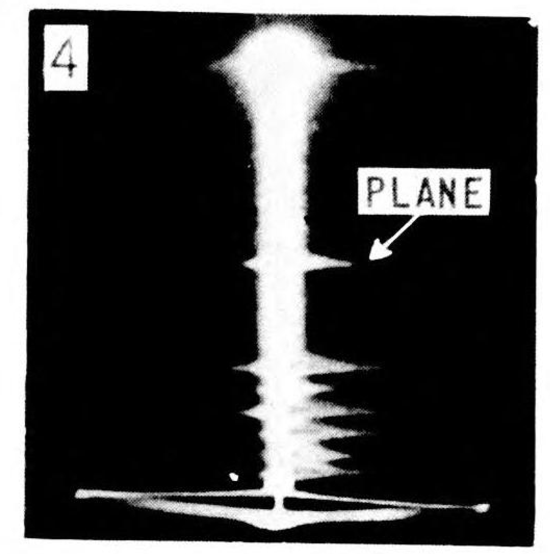
Plane has just dropped 4th batch of Chaff.



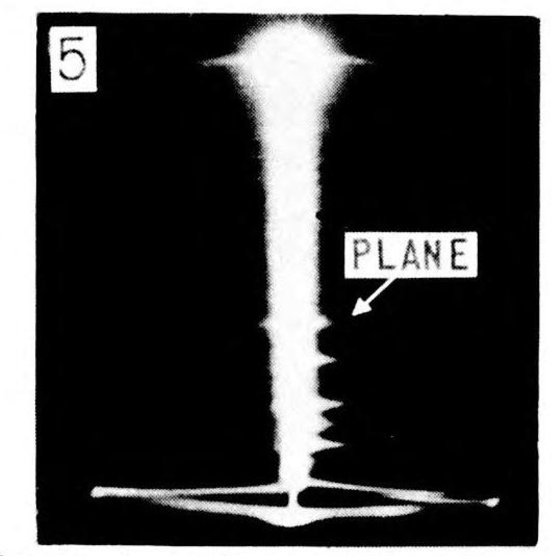
Plane has left Chaff-infested area.



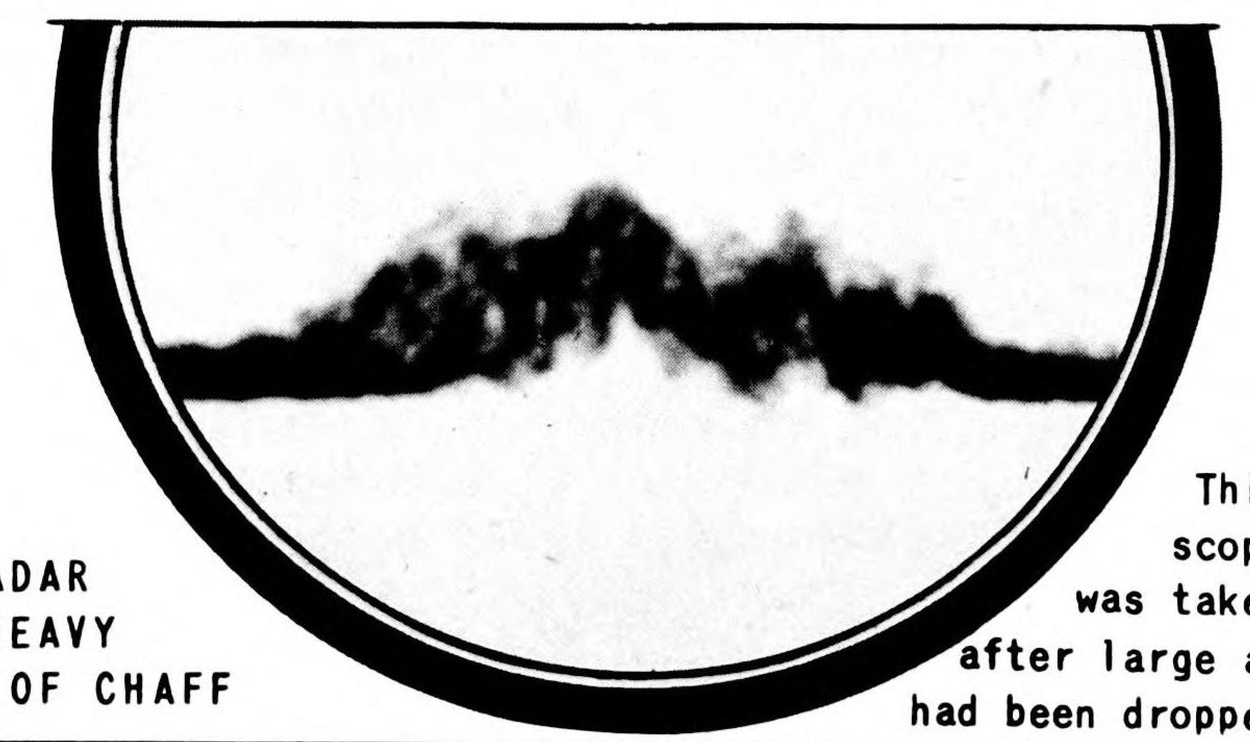
Because of more rapid fall of vertical strips of Chaff, many have left radar beam.



Echoes are now produced mainly by horizontal strips, most of the vertical strips having fallen out of the radar beam. The plane is banking; hence, its echo is strong.



Airplane has turned around and is returning to base. Echoes on scope are now caused only by the horizontal strips of Chaff still remaining within the radar beam.



EFFECT ON RADAR SCOPE OF HEAVY INFESTATION OF CHAFF

This photo of an A scope on an SCR-648 was taken about 25 min. after large amounts of Chaff had been dropped from a plane.

also be used advantageously to cover aircraft leaving the target area.

Window may sometimes be used to create diversionary false targets during convoy or landing barge operations. Both Chaff and Rope may be used for this. Since these applications are largely of naval character, they will not be discussed here. It may be noted in passing, however, that for seaborne applications Window may also be released from rockets.

In connection with the operational use of Window, it is of interest to note that it is unnecessary to take any precautions to reduce the optical reflectivity of Chaff. Even when made of shiny metal foil, it is not generally visible from the ground except possibly for a few seconds after its ejection from the aircraft and then only when sown at low altitudes. Since in general it would probably be released at altitudes of ten thousand feet or more, it is not likely to be detected visually from the ground.

FREQUENCY BANDWIDTH OF WINDOW

In all applications of Window it is important that tuned reflectors be of proper lengths to provide echoes on all the radar systems that are operating in the area involved. If this is not so, confusion may be created for certain radars whereas others, operating at different frequencies, may not be affected.

The length of the individual reflector strips of Chaff must be approximately one-half the wavelength of the radar signal involved. The total bandwidth over which Chaff of given length is useful is a function of the length-to-width ratio. It is about 15% for Chaff of practical dimensions. Thus, for example strips of a given size may be used over a band of frequencies from 515 to 585 Mc, while those of another length could be used for the band from say 350 to 400 Mc.

Rope, on the other hand, being an untuned reflector, is not sensitive to frequency in the same way as Chaff. The echo strength is a much more slowly varying function of frequency, steadily increasing with decrease in radar frequency and therefore may be said to have a much greater bandwidth than Chaff. The echo from a given number of rolls of rope has a varying value in terms of the echo from a heavy bomber, depending on the radar frequency. Three ropes are being packaged in one bundle. The curve shown later gives the frequency response in detail and must be consulted to determine the value of the bundle in units for a particular frequency.

DURATION OF WINDOW EFFECTIVENESS

The rate at which the various forms of Window descend depends upon the size, shape and weight of the material involved. Chaff

falls at a rate of 2 to 4 miles per hour. Thus, Chaff dropped from a height of 10,000 feet above the ground will require from one-half to one hour to reach the surface. Even though the material gradually falls below the level where the planes that are to be screened are located, because of the inability of much radar equipment to distinguish between targets at various altitudes, it remains effective during a large portion of the time required for its descent. With radars having high resolution in the vertical plane this advantage would not exist and the period during which a given sowing of Window is effective, would be reduced accordingly. Fortunately, equipment having high vertical resolution is not in wide use by the enemy at the present time.

When the radar pulse length is short, horizontal dispersal of a batch of Chaff will have the effect of decreasing its density and the corresponding intensity of its radar echo, even before the effect of decrease in altitude becomes important.

The rate of fall of Rope that is parachute supported is about 4 to 5 miles per hour. Card equipped Ropes descend slightly more rapidly, however. It is conceivable that balloons might be used to support ropes to increase the length of time that it is effective.

QUANTITIES OF WINDOW REQUIRED

The quantity (and consequently the bulk and weight) of Window required for a given airborne operation depends upon the type and number of planes involved, their disposition, the type of radar against which the operation is directed, the prevailing wind direction and velocity, and other factors.

Since these parameters may vary over wide limits, it is evident that no single yardstick can be used to determine the amount of Window required for a given application. Rather, the amount required must be estimated for each type of operation on the basis of known results and experience. The development of improved forms of Window and of automatic dispensing machines, and the knowledge gained in the use of Window may be expected to change the methods of use and the weight of material to be carried per plane. The following examples are typical as of the Spring of 1944.

In U. S. bomber daytime operations a Division is made up of 3 or 4 Combat Wings, each of which is composed of between 50 and 60 planes in relatively close formation. Against German gun-laying radar, Chaff is dispensed by all planes in the leading Wing. Beginning at a point about 12 miles before the target is reached, each plane drops Chaff (CHA-3) continuously at the rate of about one package every 3 or 4 seconds until a point is reached about 12 miles beyond the target. No attempt is made to time the dispensing operations accurately in a given plane or to coordinate operations between planes. It is assumed that the lack of coordination in the dropping operations of 50 or 60 planes will result in a distribution that is essentially random and free of gaps, and that the region will be completely blanketed. Each plane in the leading Wing carries three cartons each containing 60 packages of Chaff, or a total weight of about 60 pounds per plane. The dispensing is done by regular crew members, usually the radio operator or one of the gunners.

In British night operations, bombers fly in a lane about 20 miles wide and one mile deep in a very loose open formation. The plane density is about one plane for each four cubic miles of air space. The attempt is not made to saturate the entire region with Chaff,but, instead, packages are spaced at sufficiently great intervals to simulate individual planes. Each plane starts dropping Chaff at a point about 40 miles from the enemy coast at the rate of one package per minute and continues dropping at this rate until the target area is reached. The rate is then doubled. On the return flight each plane again drops Chaff at the rate of one package per minute until it is about 40 miles beyond the enemy coast. The bomber formations fly at altitudes between 15,000 and 25,000 feet. The time during which each package of Chaff is effective when released at these altitudes is determined by the rate of dispersion, rather than by the time of fall, and approximates 10 minutes.

ELECTRICAL RADAR DECEPTION DEVICES

Ordinary jammers may be used in conducting electrical deception operations. An amount of care in planning such a movement equal to that shown in planning the use of jammers to cover the real attack must be shown, otherwise the deception will not succeed.

If a bonafide raid is going to have certain radar countermeasures protection provided by window and jammers, then it is possible to create a diversionary raid by using a small number of airplanes employing the same Window and jammers in this small number of aircraft in such a way as to create an indication on the enemy's radar defense system that will duplicate that of the genuine raid.

The prime requirement in carrying out any deception is that no element of the system being deceived shall be able to see through the deception. Thus countermeasures must be successfully applied to all the elements of an enemy radar system and other methods of detection by the deception flight if it is to succeed.

DECOY RADAR TRANSMITTERS

A possible deception technique that should be borne in mind is the use of pulse transmitters operating in the radar frequency bands. To a search receiver these transmitters would appear to be radar systems. It would be impossible to determine with certainty which emissions are actually from radars and should be jammed. Hence, if this method were practiced on a large scale, either by us or by the enemy, and an effort were made to practice countermeasures against all the transmissions, a considerable amount of RCM equipment would be required.

A disadvantage that might result from the inauguration of this type of deception is the possibility that it will stimulate the acquisition and use by the enemy of jamming equipment for a large portion of the radar band of frequencies. Under such circumstances the frequencies that would be available for new radar equipment would be severely limited since the enemy would be prepared to jam over a good deal of the spectrum.

FRIENDLY AND ENEMY RADARS ON SAME FREQUENCY

A subterfuge that may be practiced and is almost certain to cause both confusion and deception until detected, is the operation of radar equipment on the same frequency as the enemy but with slightly different pulse repetition frequencies. This would be almost perfect insurance against jamming unless the enemy were also willing to forego the use of his equipment operating on the same frequency. By the same token, operation on enemy radar frequencies is feasible only if it is more important to use our own radar than to deny the enemy the use of his by jamming.

On the other hand, one should always be alert to the possibility that the enemy may set up a radar system in the same frequencies as our own equipment. In a theater where a number of radar sets are in use it is common to experience interference from the other units. Since these emissions are not generally synchronized with one another, any given radar can successfully concentrate on its own signals and ignore those of other radars as they pass across the screen. It is well to ascertain, periodically, that all such interfering signals originate from one's own radar equipment.

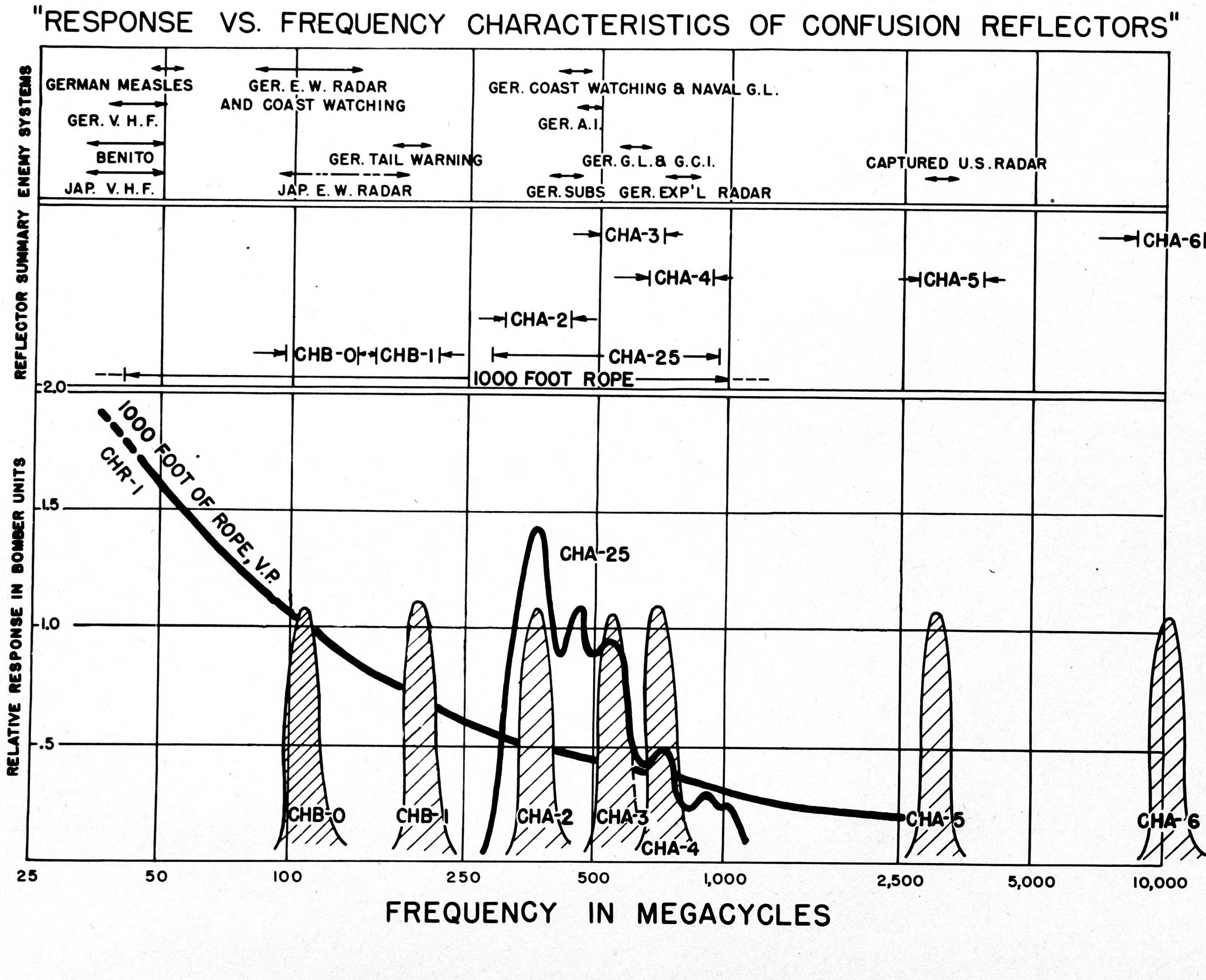
WINDOW SPECIFICATIONS

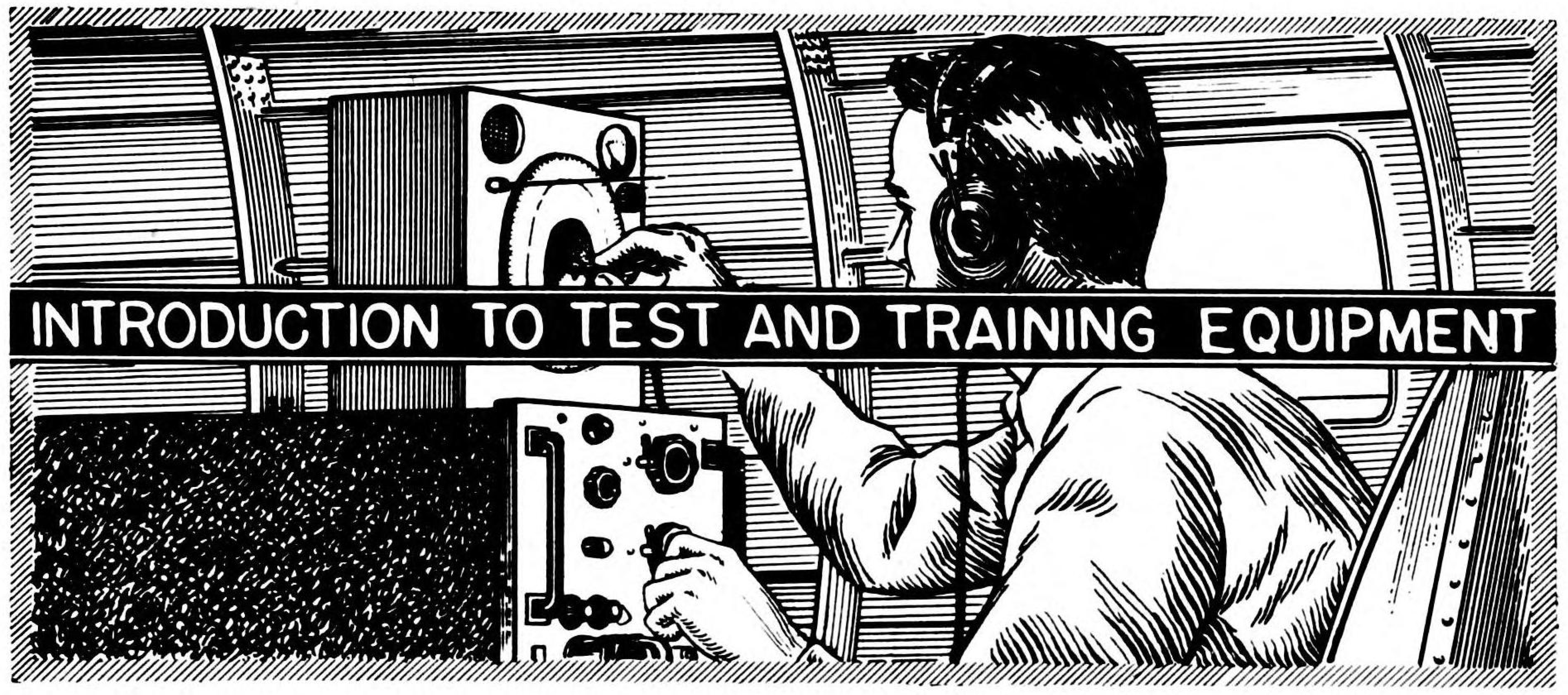
ECHO OF ONE UNIT IS EQUIVALENT TO THAT OF A HEAVY BOMBER

	CREASED CHAFF							FLAT CHAFF			
TYPE	CHA-2	CHA-28	CHA-3	CHA-4	CHA-5	CHA-6	CHA-25 (3)	CHB-0		CHB-1	
FREQUENCY, MC.	375	450-600	550	700	3,000	10,000	320-600	107		207	
NO. OF STRIPS PER BUNDLE	1,000	1200 EA. OF TWO LENGTHS	2,000	2,000	40,000	600,000	2,400 EA. OF 3 LENGTHS	50		250	
NET WT. - OZ.	2	2	1.7	2.9	6	16	7	3-1/2		5	
WEIGHT PACKED - OZ.	3.5	2.8	2.7	3.7	12	24	9	5		9	
LENGTH - INCHES	15	10-7/8 & 11-1/2	10-3/16	7-7/8	1-3/16	9/16	10, 12 & 15-1/2	53		60, 43, 38, 30	
WIDTH - INCHES	.09	.045 BOTH LENGTHS	.045	.045	.03	.035	.06	1/4		1/8	
BUNDLES PER CARTON	60	72	72	60	10	3	102	150		100	
VOLUME OF CARTON, CU. FT.	1	1.1	1.0	1.0	1	1	4.0	3		3	
APPROX. WT. OF FILLED CARTON LBS.	15	14	14	16	9	6	60	50		60	
NO. OF HEAVY BOMBERS TO WHICH BUNDLE IS EQUIVALENT	1	1	1	1	1	1	3	1		1	

CHR-1, Untuned Rope: One bundle consists of a 10½" x 3" x 3/4" "sleeve" container holding 3 packages of ribbon foil 400 feet long and ½" wide, attached to a paper parachute. The bundle weighs approximately 3/4 pounds and at 150 Mc gives an echo equivalent to that of one heavy bomber.

"RESPONSE VS. FREQUENCY CHARACTERISTICS OF CONFUSION REFLECTORS"





As for all radio equipment, it is essential to supply adequate test equipment for the adjustment and maintenance of RCM facilities. Aside from the test equipment commonly used for the maintenance of radio apparatus, probably the most important item in the RCM field is an accurate and stable frequency meter. As has already been pointed out in the introductions to the receiver and the transmitter sections, this instrument is essential for accurately determining the exact operating frequencies of enemy communications and radar channels and for setting jammers to these frequencies.

Next in importance for maintenance of transmitters are instruments for checking the power output of the transmitters and their modulation capabilities. In the maintenance of receivers, test oscillators or signal generators are useful for checking the performance in the various frequency bands.

On the following pages are catalogued those pieces of test equipment which are particularly pertinent to RCM facilities. Items such as volt-ohmmeters, oscilloscopes, and tube testers, which are more or less "standard" and are used with many types of radio equipment, are omitted since they are adequately covered elsewhere. The following short discussion treats some of the factors involved in the use of test equipment.

FREQUENCY MEASUREMENTS

Accurate means for measuring frequencies are essential in RCM receiving and transmitting activities. In receiving activities, it is important to keep a careful check on the frequencies that are in use by the enemy; in transmitting, means are required for ac-

curately adjusting the transmitters to those frequencies. As explained previously*, the pre-setting of transmitter frequencies with sufficient accuracy for spot-jamming is not generally feasible. For barrage jamming, however, not only is it feasible to do this but, from a practical standpoint, it is essential to do so.

If the same frequency-meter can be used both for measuring the enemy frequency and for adjusting the jammer, the absolute accuracy of the meter is not too consequential. Its stability, as a function of temperature, humidity and pressure (altitude) is very important, however.

SPOT-JAMMER FREQUENCY-SETTING

A simple, but effective, method of accurately setting spot-jammers is to make use of an insensitive, narrow-band receiver which is tuned to the victim frequency and subsequently used to monitor, not only the frequency of the jamming transmitter, but also the victim signal. Almost any well-shielded receiver with an r-f or i-f volume control (in order that it may be made insensitive) can be used for this purpose. Some of the communications receivers fulfilling these requirements are described elsewhere (*Signal Communication Equipment Directory*) while receivers for radar band, and certain airborne communications receivers, are described in the *Search Receiver* section of this book.

Of the receivers described herein, the AN/ARR-5, covering communications channels, is excellent for the purpose of setting spot-jammers within its frequency range of 28 to 143 Mc. The AN/APR-4, because it has a narrow i-f band, is also an excellent equipment, particularly when used with the single-dial tuning units (TU-56A, TU-57B, TU-58B, etc.), which cover the frequency range from 40 to 1000 Mc. The older SCR-587 receiver is satisfactory when used with the single-dial tuning units, provided that it is modified to incorporate an i-f amplifier volume control in place of the original audio volume-control. The modified SCR-587 receiver can also be used with the older style, two-control (TU-57A, TU-58A) tuning units although, in the setting of carrier-suppressed jammers (for example, AN/APT-1), considerable skill and training is required.

OUTPUT POWER MEASUREMENTS

The need for equipment to measure the power output of transmitters on the test bench is self-evident and equipment suitable for this purpose is described on the following pages. In addition, however, it is prudent to check the performance of such transmitters after they are installed and connected to their regular an-

*A more detailed discussion of the jammer frequency-setting problem is given in the INTRODUCTION TO JAMMING TRANSMITTERS.

tennas. Equipment suitable for such field checks has therefore been developed and is also described herein. Although checks of this kind are qualitative, they are very useful since, being made under actual operating conditions, they are comprehensive and will therefore expose any shortcomings of the antenna, the transmission line, the primary power source, or the set itself.

SPECTRUM ANALYSIS

The distribution of the energy in the side-bands of a barrage jammer is often a function of the particular tuning adjustments that are used. Some transmitters are more critical than others in this respect. With such transmitters, the use of some simple means for determining the shape of the side-band energy distribution curve is desirable. Spectrum analyzers and other devices that are suitable for this purpose have therefore been developed and are described in detail in this section.

SIGNAL GENERATORS

Sometimes the complete absence of signals in a certain band of frequencies (generally the very high ones) makes it impossible to ascertain whether a receiver operating in this region is in good working condition. As may well be appreciated, after many hours of fruitless search over a band of frequencies wherein no signals are present, doubts may exist concerning the functioning of the receiver. Test oscillators, capable of supplying a signal at the frequencies in question, are very useful for checking the performance of receivers under these circumstances.

For more careful measurements on the test bench, and for aligning the various tuned circuits in the receiver, use can be made of standard signal generators. Standard signal generators differ from test oscillators in that known and adjustable output voltages are available, either unmodulated or modulated to a known degree by waves of various forms.

Signal generators and test oscillators for the communications frequencies fall into the category of "standard" test equipment and consequently are not catalogued here. Equipment of this type for the radar frequencies, however, is described in this section.

TRAINING EQUIPMENT

The need for thorough training of communications and radar personnel in the art of recognizing and coping with jamming has been stressed in preceding sections of this book. Among the devices that have been developed especially for this purpose are practice

jamming transmitters and plug-in units to convert regular jamming transmitters into units suitable for training purposes. The transmitters involved are normally amplitude-modulated with noise and the modifications make it possible to obtain (for training purposes) other types of modulation, similar to those that have been employed by the enemy.

Jamming signal generators in the radar frequency range have also been developed. These units are useful for training purposes and for studying the vulnerability of radar sets to jamming. These sources of jamming signals may be effectively used by the operating personnel for ascertaining the best settings of the various controls on the radar (and any associated anti-jamming attachments) in order to minimize the effect of various types of jamming signals. Frequent exercises of this kind will pay dividends when actual jamming is encountered during operations.

In addition to these modulated r-f signal generators, a source of audio-frequency signals, simulating the types of jamming signals used on communications channels, has been developed. This device is of particular value for training communications operators to recognize jamming signals and to give them experience in working through such interference.

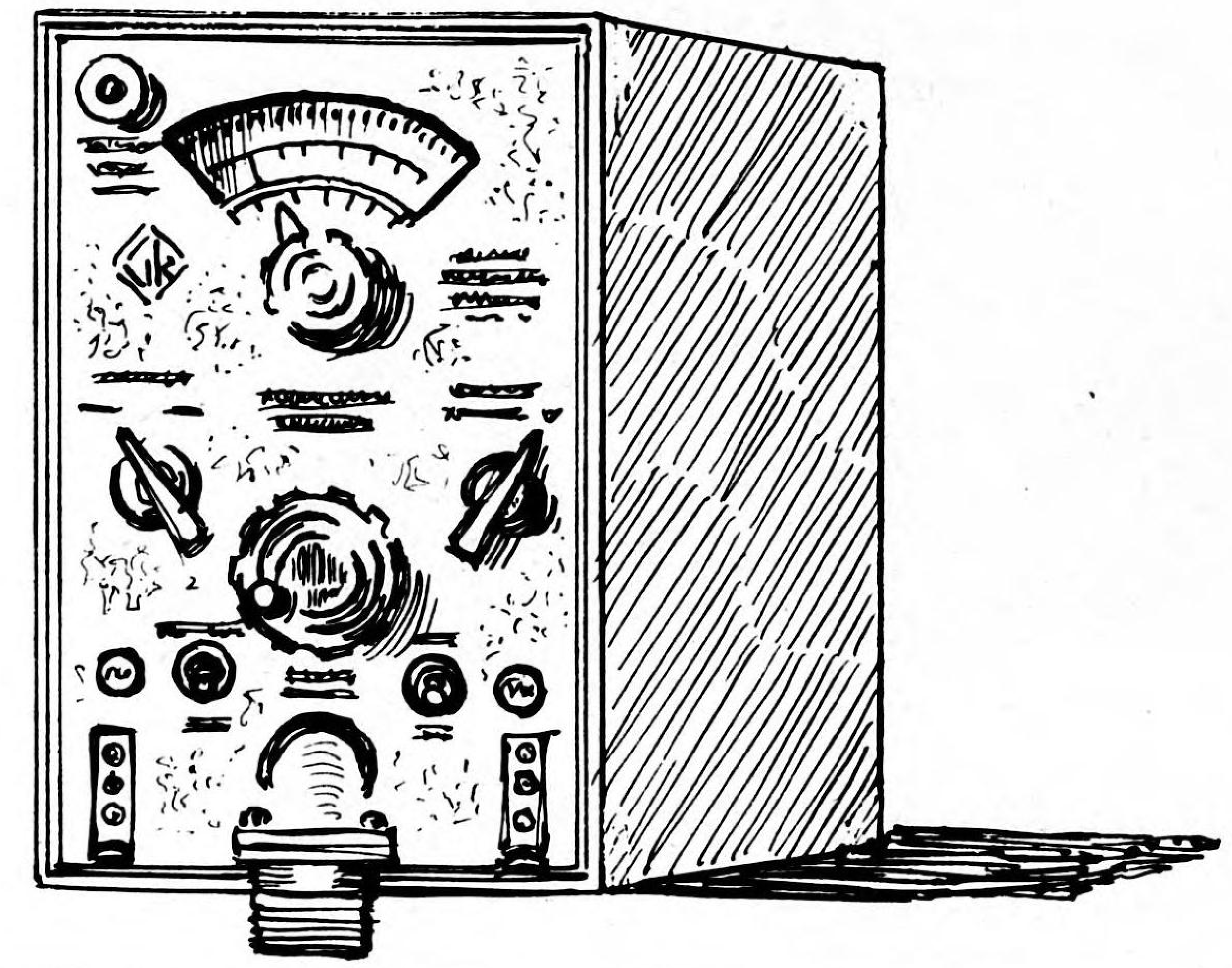
IMPORTANCE OF TEST EQUIPMENT

The importance of having adequate test equipment available for the maintenance and repair of RCM facilities cannot be over-emphasized. As already noted, the units described on the following pages are only those which have been especially developed (or are particularly applicable) to the RCM field. In planning complete servicing facilities, therefore, it is essential to make provision for the various standard types of radio test and servicing equipment.

SUMMARY OF TEST AND TRAINING EQUIPMENT

AN NUMBER	TYPE OF INSTRUMENT	FREQUENCY RANGE (MC)	COMMENTS	PAGE
TS-47/APR	TEST OSCILLATOR	40-500 (HARMONICS TO 3000)	STANDARD	157
TS-131/AP	PICKUP ASSEMBLY	UNTUNED	STANDARD FOR USE WITH ALL JAMMERS	158
TS-70/AP	WATTMETER	200-750	BEING REPLACED BY TS-118/AP	159
TS-87/AP	WATTMETER	85-220	BEING REPLACED BY TS-118/AP	159
BC-1255A	FREQUENCY METER	70-140	BEING REPLACED BY TS-174/U	160
TS-53/AP	TRANSMITTER MONITOR	200-700	WAVEMETER, POWER IND-ICATOR AND MOD-ULATION MONITOR STANDARD	161
TS-69/AP	FREQUENCY METER	350-1000	BEING REPLACED BY TS-175/U	162
TS-92/AP	ALIGNMENT INDICATOR	15-250	STANDARD	163
	FREQUENCY METER	10-3000	GENERAL RADIO NO. GR-720B	164
TS-118/AP	WATTMETER	20-750	STANDARD	165
TS-174/U	FREQUENCY METER	20-280	STANDARD	166
TS-175/U	FREQUENCY METER	85-1000	STANDARD	166
TS-15A/AP	FLUXMETER		RANGE TO 1200 9600 GAUSS	167
GR-804 CSI	SIGNAL GENERATOR	7.5-330 (400 CPS)	GENERAL RADIO NO. GR-804 CSI	172
NAVY LAF	SIGNAL GENERATOR	90-600	WILL BE STANDARD	168
NAVY LAE	SIGNAL GENERATOR	500-1300	WILL BE STANDARD	169
NAVY LAG	SIGNAL GENERATOR	1200-4000	WILL BE STANDARD	169
URA-TI	AUDIO SIGNAL SOURCE		TRAINER FOR AJ	171
TPQ-T2	PRACTICE JAMMER	90-270		173
TPQ-TI	PRACTICE JAMMER	100-230		174
UPT-TI	PRACTICE JAMMER	450-720		175

TEST OSCILLATOR TS-47/APR



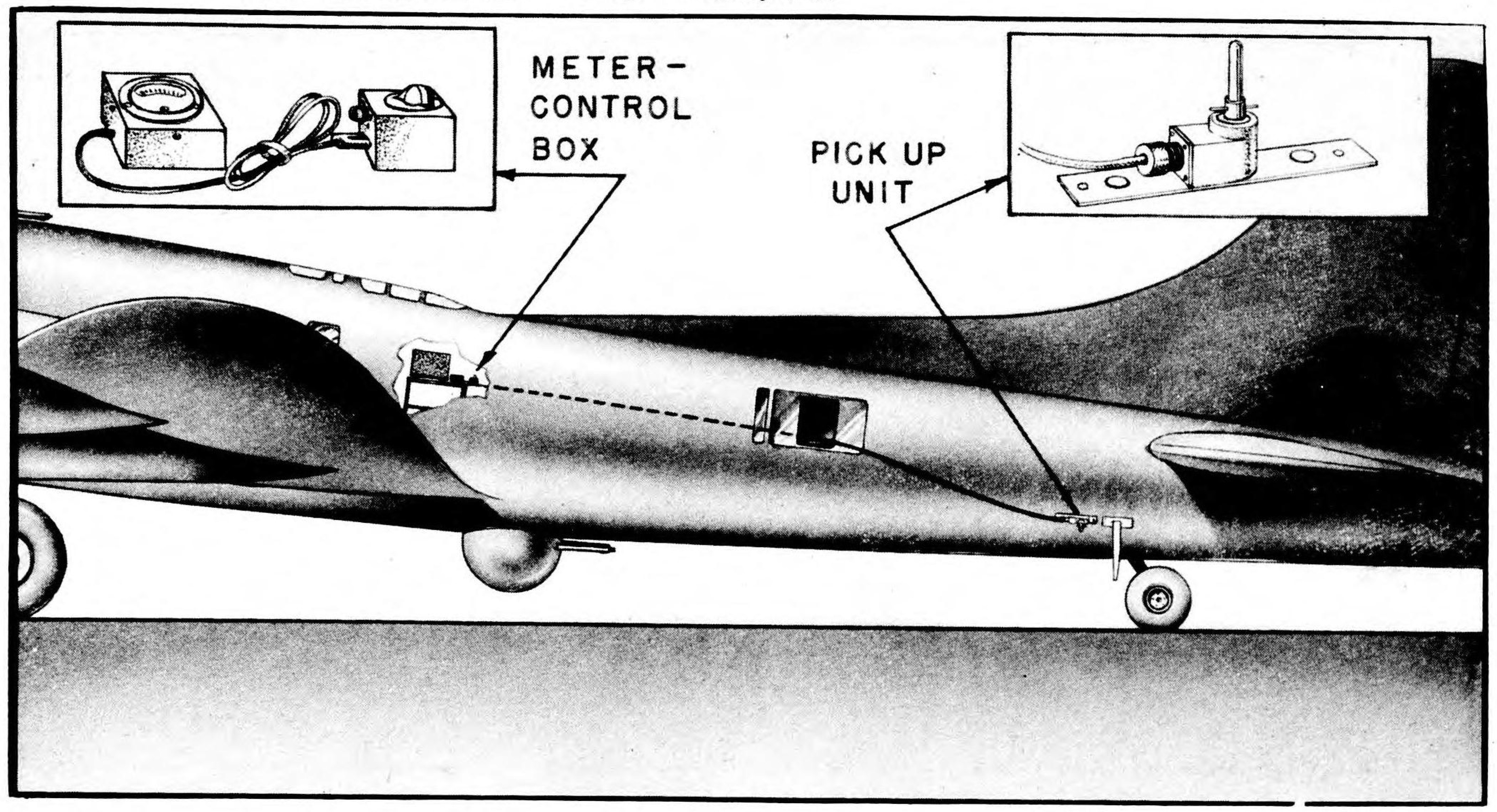
PURPOSE TS-47/APR is a compact instrument used for field testing of receivers operating in the frequency range from 40 to 3000 Mc. It is designed primarily for testing AN/APR-2, AN/APR-4, and AN/APR-5 search receivers. It generates several types of low-power signals simulating those produced by various kinds of enemy radar and communication systems. The performance characteristics of a receiver can be quickly determined by the use of TS-47/APR. The tracking accuracy of the tuned circuits in the AN/APR-4 may be adjusted with its aid.

DESCRIPTION & PERFORMANCE TS-47/APR is housed in an airplane luggage case. It can be used either as a portable instrument or can be secured in a shock mount. The instrument is calibrated for the oscillator fundamental frequency range of 50 to 500 Mc. Harmonic output is usable to 3000 Mc. The signals can optionally be unmodulated, or modulated with either pulses or an audio frequency. The instrument can be operated either from an a-c source or from dry batteries.

SPECIFICATIONS **FREQUENCY RANGE:** Two ranges are provided: 40 to 120 Mc and 120 to 500 Mc, harmonics usable to 3000 Mc.
INPUT POWER: 15 watts, 80/115/230 volts, 50 to 2600 cps, a.c. or 6.3 volt and 202.5 volt d.c. from batteries.
OUTPUT POWER: About .005 watt (max.) up to 400 Mc adjustable over 30 db. range.
ACCURACY OF FREQUENCY DIAL: Within ± 1% at 40 Mc and ± 2% at 500 Mc.
SIZE AND WEIGHT: 6' x 8' x 8', 12 pounds.
MODULATION: Either none, 1000 cps sine wave, or 70 microsecond pulses at prf of 500 cps.
TECHNICAL FEATURES: TS-47/APR consists of a variable frequency oscillator and a modulator, with a transformer-rectifier-filter system for power supply from an a.c. source and provision for optional use of external batteries. Modulation is provided by an audio oscillator with or without transformer connection to produce pulses.

STATUS Moderate production under way. Equipment Restricted.

PICKUP ASSEMBLY TS-131/AP



PURPOSE TS-131/AP is a simple device for adjusting an airborne jamming transmitter. It is used with a test milliammeter (TS-60/U) to obtain an indication of antenna current strength. By picking up and rectifying a small part of the radiation from the antenna and measuring the resulting direct current, the equipment makes it possible to adjust a transmitter to give maximum output.

DESCRIPTION TS-131/AP consists of two units, one of which is mounted outside the aircraft near the antenna, and the other inside near the transmitter. These units are connected by an intervening length of cable. The entire equipment is intended for use in ground line-up of jamming transmitters before operation. Convenient mounting fixtures are provided so that the units may be mounted quite quickly before each use. One unit consists of a short antenna to pick up the radiated signals and the other is a small control box containing a variable resistor and fitted with a meter jack.

OPERATION With the meter plugged into the jack, the variable resistor is adjusted to give a readable indication on the meter while the transmitter is operating. The transmitter is then adjusted until the meter reading is a maximum. Mounting of the equipment before each measurement and operation of the device are quite simple and requires no particular training.

SPECIFICATIONS FREQUENCY RANGE: Untuned.
MOUNTING: Pickup unit by snap-on fasteners near antenna. Control unit on flat surface near transmitter.
SIZE AND WEIGHT: Each unit about 2"x2"x3", about 1 pound total without cable.

STATUS Heavy production under way. Equipment Unclassified.

RADIO FREQUENCY WATTMETER TS-70/AP

PURPOSE TS-70/AP is a power meter to measure the output of relatively low-power transmitters (below about 25 watts) in the frequency range from 200 to 750 Mc. Use of this equipment will provide a quantitative measure of the operating condition of such transmitters as AN/APQ-2, AN/APQ-9, and AN/APT-2.

DESCRIPTION TS-70/AP consists of a single self-contained unit, 4"x 5"x 23". The equipment is hand-transportable in a wooden case and can be brought to the transmitter which is to be tested. The operation consists of connecting the transmitter to the meter and tuning the meter for maximum reading. TS-70/AP may be calibrated by use of ordinary line power in conjunction with a wattmeter or an ammeter and voltmeter.

SPECIFICATIONS FREQUENCY RANGE: 200 to 750 Mc.
POWER MEASUREMENT RANGE: 2 to 25 watts.
ACCEPTANCE BAND: About 10 Mc.
ACCURACY: within ± 10%.
SIZE AND WEIGHT: 5"x 4"x 23", 20 pounds.
TECHNICAL FEATURES: TS-70/AP consists of a small electric light, which serves as a load, and two co-axial tuning stubs for matching it to a transmitter. The illumination from the light is measured by means of a photronic cell and a meter, which is calibrated to indicate the power.

STATUS Light production under way. Equipment Restricted.

RADIO FREQUENCY WATTMETER TS-87/AP

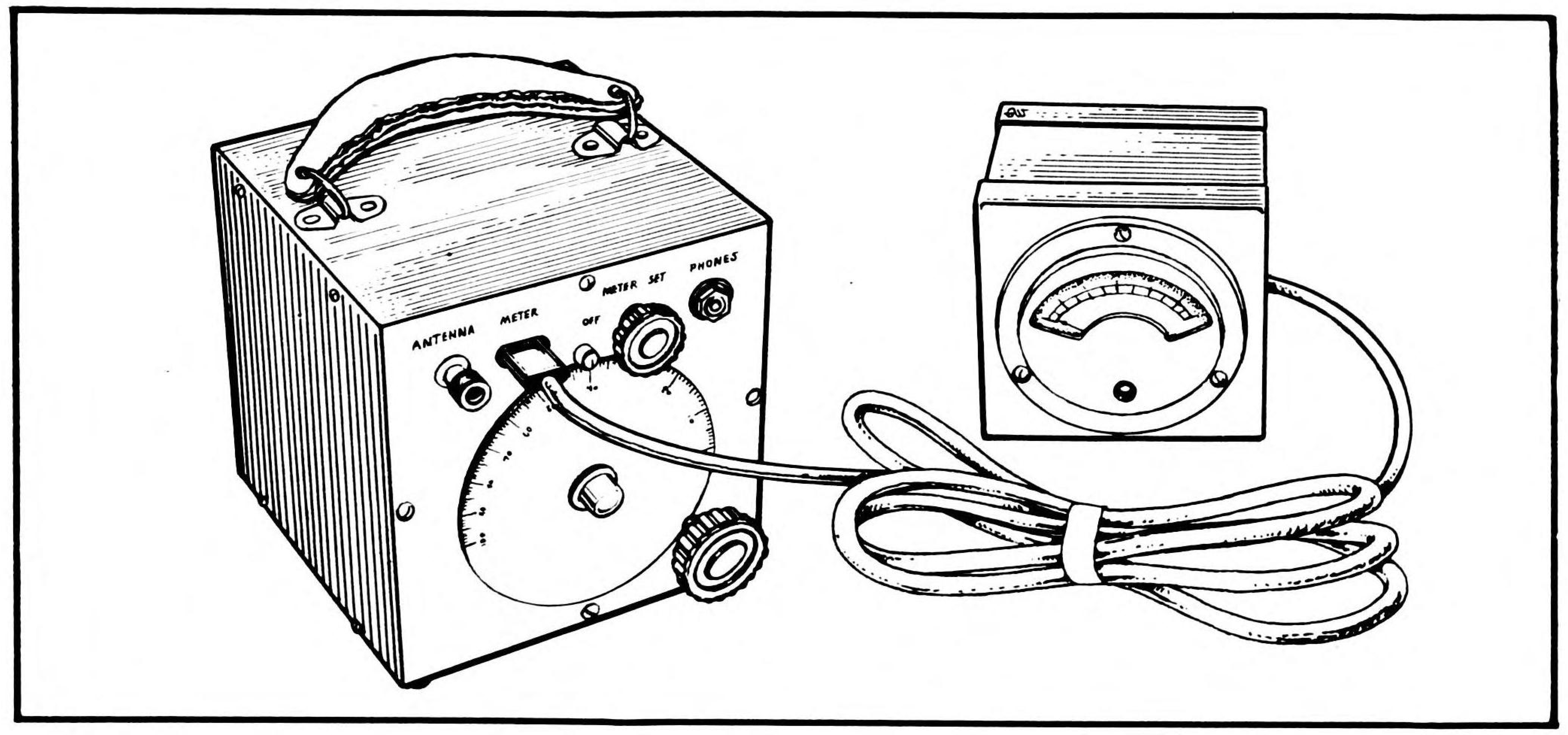
PURPOSE TS-87/AP is a power meter to measure the output of relatively low-power transmitters (below about 25 watts) in the frequency range from 85 to 220 Mc. Use of this equipment will provide a quantitative measure of the operating condition of such transmitters as the AN/APT-1 and AN/APT-3.

DESCRIPTION TS-87/AP consists of a single self-contained unit 6"x 7½"x 7½". The equipment is hand-transportable in a wooden case and can be brought to the transmitter which is to be tested. The operation consists merely of connecting the transmitter to the meter and tuning it for maximum reading. TS-87/AP may be calibrated by use of ordinary line power in conjunction with a wattmeter or an ammeter and voltmeter.

SPECIFICATIONS FREQUENCY RANGE: 85 to 220 Mc.
POWER MEASUREMENT RANGE: 2 to 25 watts.
ACCEPTANCE BAND: About 10 Mc.
ACCURACY: within ± 10%.
SIZE AND WEIGHT: 6"x 7½"x 7½"; 14 pounds.
TECHNICAL FEATURES: TS-87/AP consists of a small electric light, which serves as a load, and a lumped-parameter tuning mechanism for matching it to a transmitter. The illumination from the light is measured by means of a photronic cell and a meter, which is calibrated to indicate the power.

STATUS Light production under way. Equipment Restricted.

MONITOR BC-1255-A



PURPOSE BC-1255-A is a self-contained, battery-operated frequency meter covering the range from 70 to 140 Mc. It is designed primarily for use in adjusting AN/APT-3.

DESCRIPTION The instrument with its batteries is contained in a portable carrying case and weighs 5.5 pounds. The input system consists of a binding post to which a short wire can be connected to pick up signals. Jacks are provided for either headphones or a meter (TS-60/U.) Frequency is read on a calibrated dial.

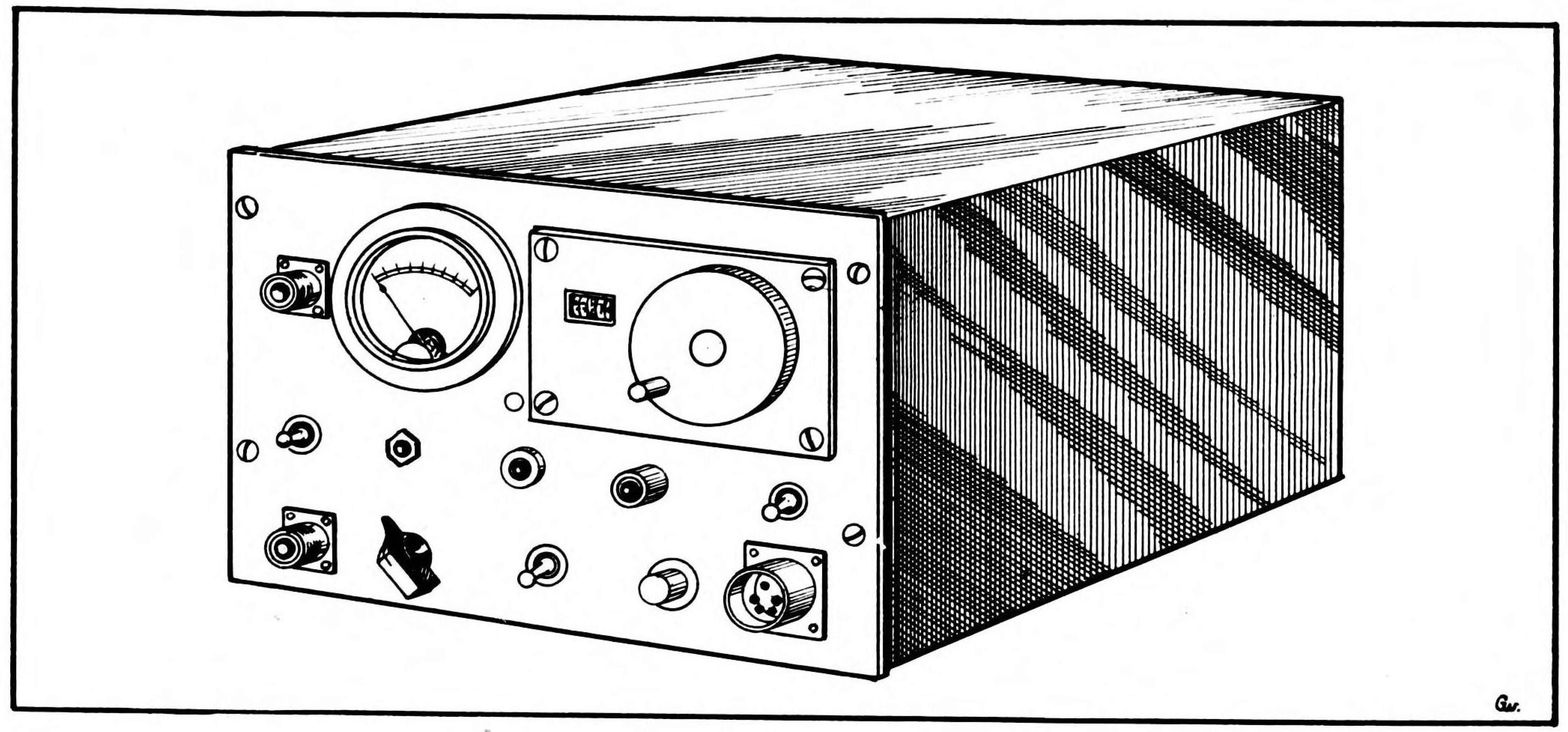
PERFORMANCE BC-1255A has an accuracy of ± 0.3 Mc or better. It distinguishes between two signals separated by 0.25 Mc. The meter dips from 0.5 to 0.4 full scale reading for a signal strength of 20 mv or less.

OPERATION The frequency of a received signal is given by the dial reading which corresponds to zero beat in the headphones or (more accurately) to a dip of the needle of TS-60/U. No special training is required for operation.

SPECIFICATIONS FREQUENCY RANGE: 70 to 140 Mc.
INPUT POWER: Dry batteries (one BA-15 and two BA-56).
ACCURACY OF CALIBRATION: ± 0.3 Mc.
SIZE AND WEIGHT: 6" x 6" x 6", 5.5 pounds.
TECHNICAL FEATURES: BC-1255-A consists of an oscillator-mixer tube followed by a two-stage amplifier. The oscillator is tuned to generate an output at a frequency in the 70 to 140 Mc range. This local frequency is mixed with an incoming signal to produce a beat frequency. This is amplified and applied to the test meter which indicates its presence. When the local frequency is identical with that of the signal, the beat frequency is zero and the meter dips (or the phones indicate no signal).

STATUS Moderate production completed. Equipment Restricted.

TEST SET TS-53/AP



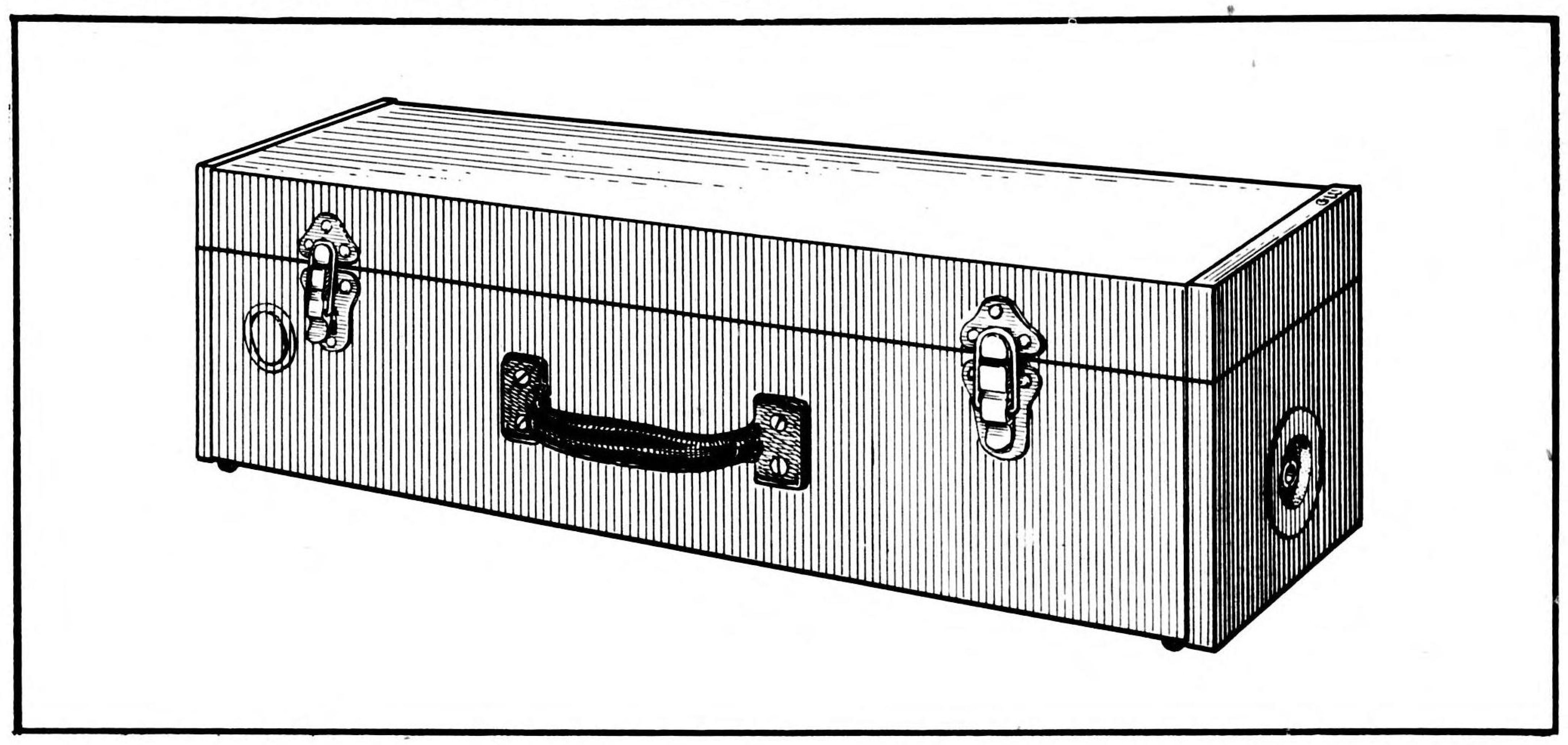
PURPOSE & DESCRIPTION TS-53/AP is a portable instrument used in adjusting and monitoring a jamming transmitter. It consists of a combined wavemeter, power output indicator, and modulation monitor. The frequency range is either 200 to 450 or 400 to 700 Mc, depending upon which of two associated wavemeters is employed. The equipment is designed primarily for testing and aligning transmitters such as AN/APT-2, AN/APQ-2, or AN/APQ-9. TS-53/AP is intended for temporary installation in the field near the aircraft carrying the transmitter. It consists of a single unit (SARC B1-D) weighing 23 pounds.

PERFORMANCE & OPERATION TS-53/AP allows frequency determination with a reading error of less than 0.6 Mc per division and an absolute error of less than 0.25%. For power output indication and modulation monitoring, the equipment may be used as a receiver without the frequency meter; when so used the sensitivity is 25 millivolts for usable output. Operation is quite simple and regular radar maintenance personnel with a little training can use TS-53/AP.

SPECIFICATIONS FREQUENCY RANGE: 200 to 450 Mc, and 400 to 700 Mc with interchangeable units.
INPUT POWER: 50 watts, 80 or 115 volts, 400 to 2600 cps, a.c.
READING ERROR: Less than 0.6 Mc per division.
ABSOLUTE ERROR: Less than 0.25%.
SENSITIVITY: (Used as receiver without frequency meter) 25 millivolts.
SIZE AND WEIGHT: SARC B1-B, 23 pounds.

STATUS Moderate production under way. Equipment Restricted.

FREQUENCY METER TS-69/AP



PURPOSE: TS-69/AP is a wavemeter intended chiefly for setting jamming transmitters, such as AN/APQ-9, AN/APT-2, and AN/APT-4, in the frequency range from 350 to 1000 Mc.

DESCRIPTION The equipment is hand-transportable in a 10" x 10" x 26" wood carrying case.

OPERATION The principal application for this equipment is in the ground line-up of transmitters for barrage jamming operations. It is intended mainly for squadron use. The frequency of any desired signal being examined is indicated on a calibrated chart. No particular training in its use is required.

SPECIFICATIONS FREQUENCY RANGE: Calibrated from 350 to 1000 Mc.

INPUT REQUIRED FOR OPERATION: 0.3 volt r-f through small detachable antenna or through input socket provided.

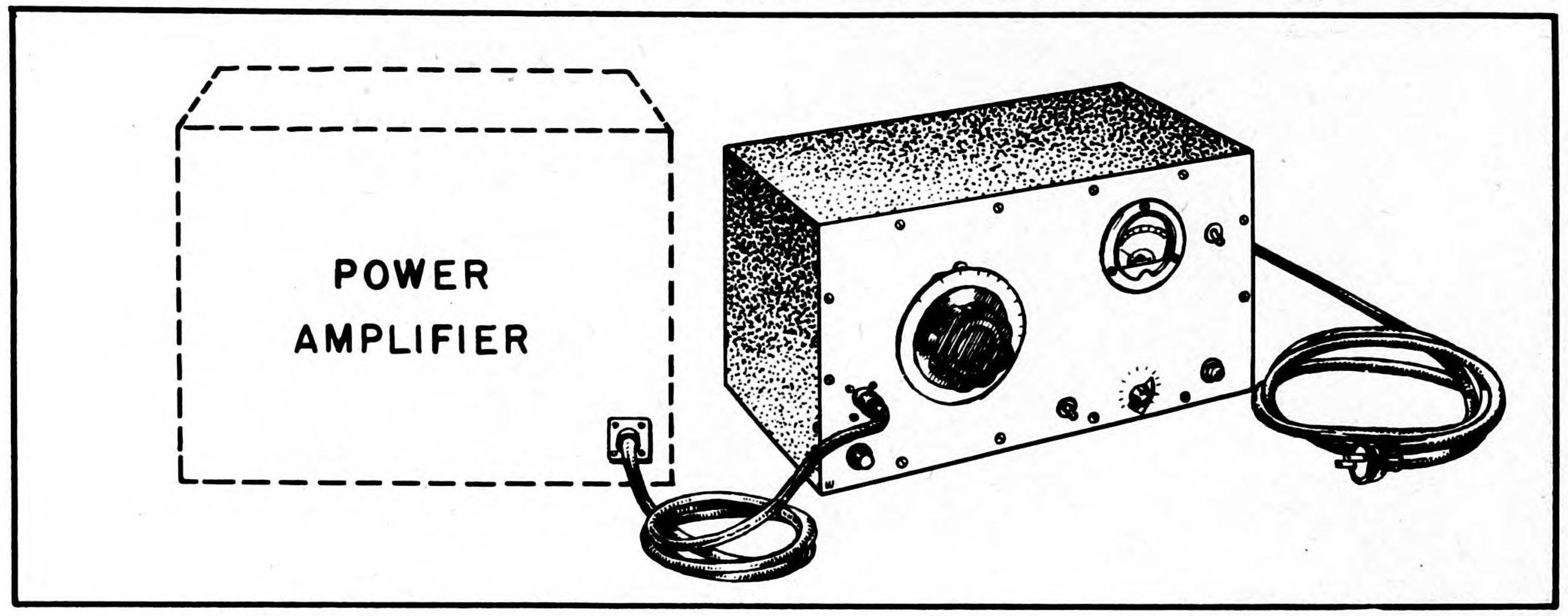
ACCURACY OF CALIBRATION: within ± 0.2% to 550 Mc, ± 0.3% to 1000 Mc.

SIZE AND WEIGHT: 6" x 8" x 22", 15 pounds.

TECHNICAL FEATURES: TS-69/AP consists of a coaxial wavemeter of the conventional type containing its own meter, crystal detector and filter circuit. A phone jack is provided for examining modulated signals with the aid of the plane's interphone system (the plane motors must be off).

STATUS Heavy production under way. Equipment Restricted.

AMPLIFIER ALIGNMENT UNIT TS-92/AP



PURPOSE TS-92/AP is a device used in aligning a wideband power amplifier with an associated jamming transmitter. It is designed for aligning AM-14/APT and AM-18/APT when these amplifiers are used with AN/APT-1 or AN/APT-3. It may also be used to align the final amplifier in the AN/APT-1 transmitter. With its aid the amplifier may be adjusted to give optimum performance at a specified bandwidth for any carrier frequency in the range from 15 to 250 Mc. This simple portable device is intended for use in the field where more elaborate equipment, such as an oscilloscope and sweep oscillator, is not available.

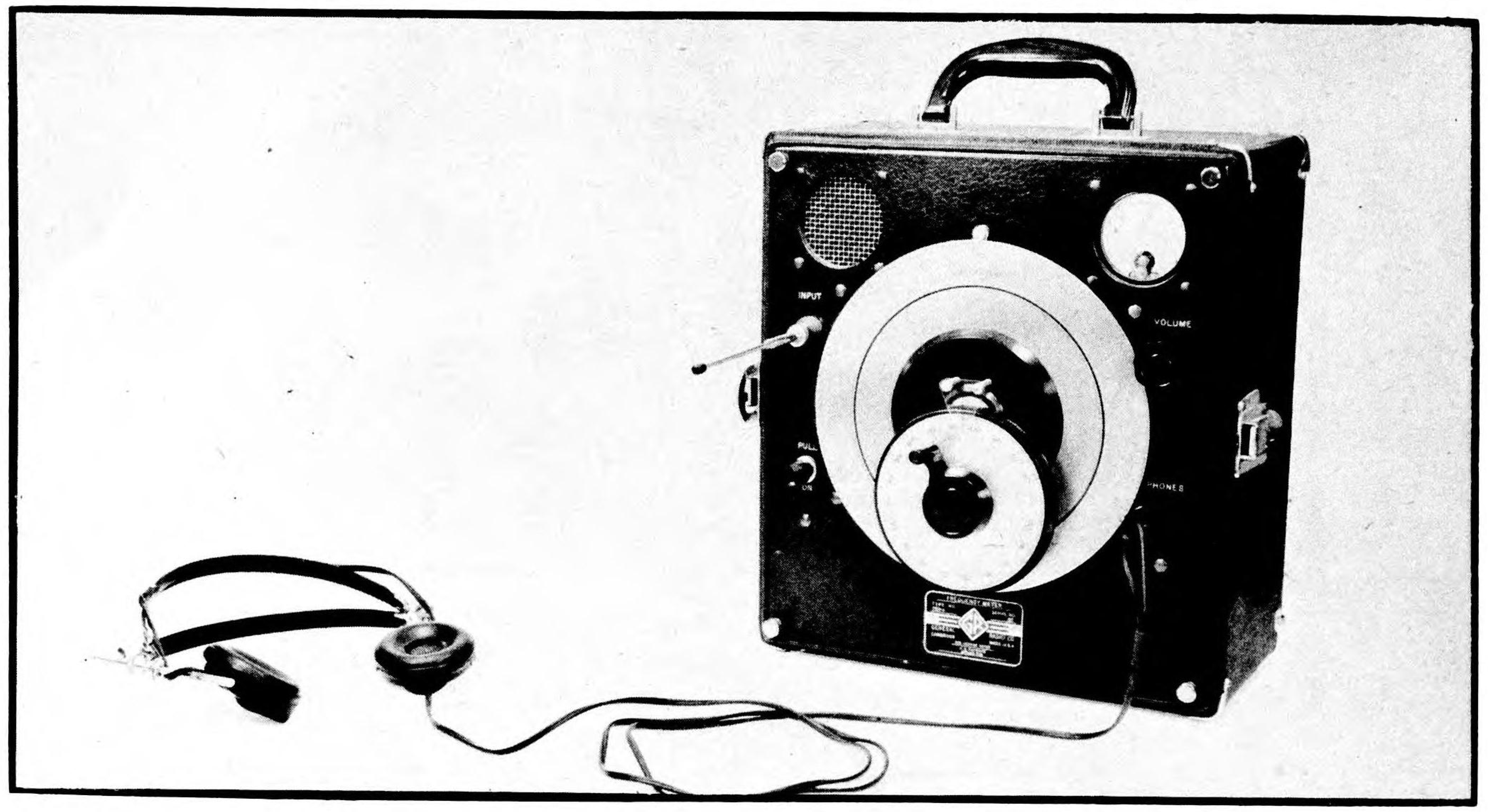
DESCRIPTION TS-92/AP comprises a means for adjusting the response of double-tuned (double-peaked response curve) amplifiers for optimum performance. It consists essentially of a simplified radio receiver which is used in such a way that the two peaks in the amplifier response curve may be maximized, thus giving optimum adjustment of the amplifier. The equipment is contained in a single unit (8" x 7½" x 14").

OPERATION The power amplifier to be adjusted is connected to a source of noise frequencies. TS-92/AP is then loosely coupled to the power amplifier output, and adjusted for the bandwidth desired. The amplifier is then adjusted stage by stage to show maximum reading on the panel meter of TS-92/AP. This insures exact alignment of the unit.

SPECIFICATIONS FREQUENCY RANGE: 15-250 Mc.
INPUT POWER: 50 watts, 80 or 115 volts, 60 to 2600 cps, a.c.
BANDWIDTH ADJUSTMENT RANGE: 1 to 14 Mc.
SENSITIVITY: 1 millivolt input gives usable indication.
SELECTIVITY: 50 kc.
ACCURACY OF FREQUENCY CALIBRATION: Within ± 5%.
SIZE AND WEIGHT: 14" x 8" x 7½", 20 pounds.
TECHNICAL FEATURES: TS-92/AP consists of a crystal detector followed by a narrowband amplifier tunable between .5 and 7 Mc, feeding into a diode detector and output meter. The noise components present in the amplifier beat in the detector; those whose frequency separation equals the frequency to which the amplifier is tuned actuate the output meter. The amplifier being adjusted is aligned by setting the indicator's frequency to the desired spacing between peaks and then adjusting the amplifier stage by stage to give maximum indication on the output meter.

STATUS Light production under way. Equipment Restricted.

HETERODYNE FREQUENCY METER GR-720B



PURPOSE & DESCRIPTION

General Radio type 720-B heterodyne frequency meter is designed for measuring frequencies between 10 Mc and 3000 Mc. It is useful in RCM activities in setting jamming transmitters on frequency and in performing other operations which require precise knowledge of frequency. The equipment is self-contained in a single hand-transportable unit which includes the antenna and the operating batteries.

PERFORMANCE

The equipment indicates the frequency of a signal in the frequency range from 10 Mc to 3000 Mc. The sensitivity varies with the frequency measured and depends to some extent on the wave form of the signal. In general, the meter is not as sensitive as a receiver in this frequency band, but is sufficiently sensitive to determine the frequency of any transmitter when the meter is fairly close to the transmitter.

OPERATION & PERSONNEL

GR-720B is easy to operate, but requires some interpretation of the readings to ascertain the exact frequency. An operator can be trained for this purpose in a short time.

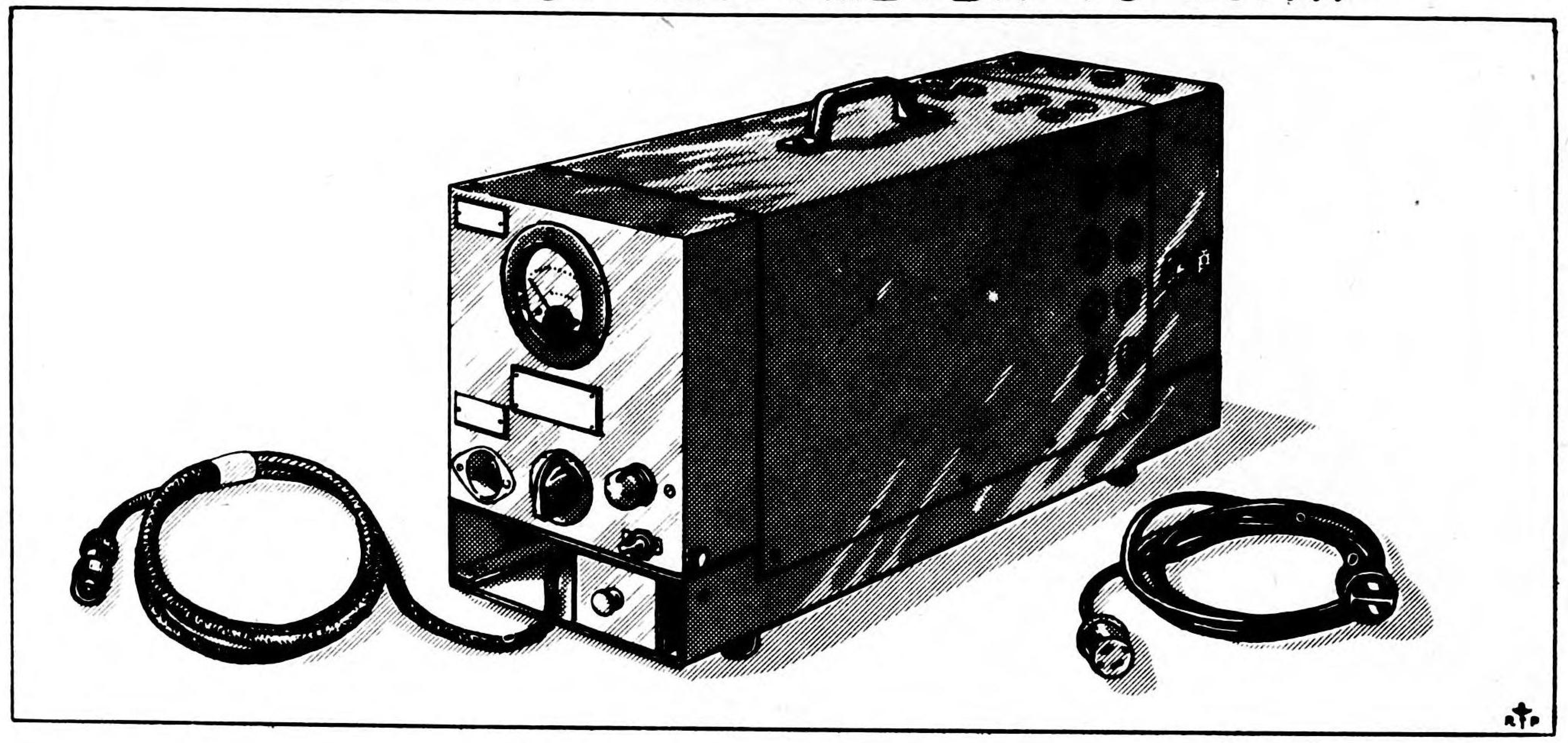
SPECIFICATIONS

FREQUENCY RANGE: 10 Mc to 3000 Mc. (The oscillator in the frequency meter tunes from 100 Mc to 200 Mc; frequencies outside this range are are determined by harmonic responses).
POWER SUPPLY: Self-contained batteries.
SIZE AND WEIGHT: 9½" x 11½" x 12½", 31 pounds.
TECHNICAL FEATURES: The frequency meter consists of a 100 to 200 Mc oscillator which is controlled by an accurate mechanical drive, followed by a crystal mixer and audio amplifier. The built-in antenna input circuit is also connected to the crystal mixer and provision is made for listening to the beat note produced between the oscillater (or one of its harmonics) and the incoming signal (or one of its harmonics) through headphones or a self-contained dynamic speakier. A panel meter is provided for checking the operation of the equipment and for indicating the approximate relative strength of very strong signals.

STATUS

Unclassified commercial item.

RADIO FREQUENCY WATTMETER TS-118/AP



PURPOSE

TS-118/AP is an r-f power meter designed to measure the output of most RCM transmitters in the frequency range of 20 to 750 Mc. The meter is intended primarily for field use and will give an immediate and approximate indication of the power output of CW and modulated CW transmitters.

DESCRIPTION AND PERFORMANCE

TS-118/AP consists of a single self-contained unit, 24" x 11" x 8". The equipment weighs approximately 50 lb. and can be carried to the transmitter which is to be tested. R-F power is indicated by deflections on a panel meter, and these readings are checked against a calibrated chart for r-f power determination. The average power output of modulated transmitters is indicated. It is essential that the transmitter under test provide a d-c path through its output coupling circuit, such as is usually provided by inductive-coupled transmitters. Extra equipment is needed if the transmitter does not provide a d-c path.

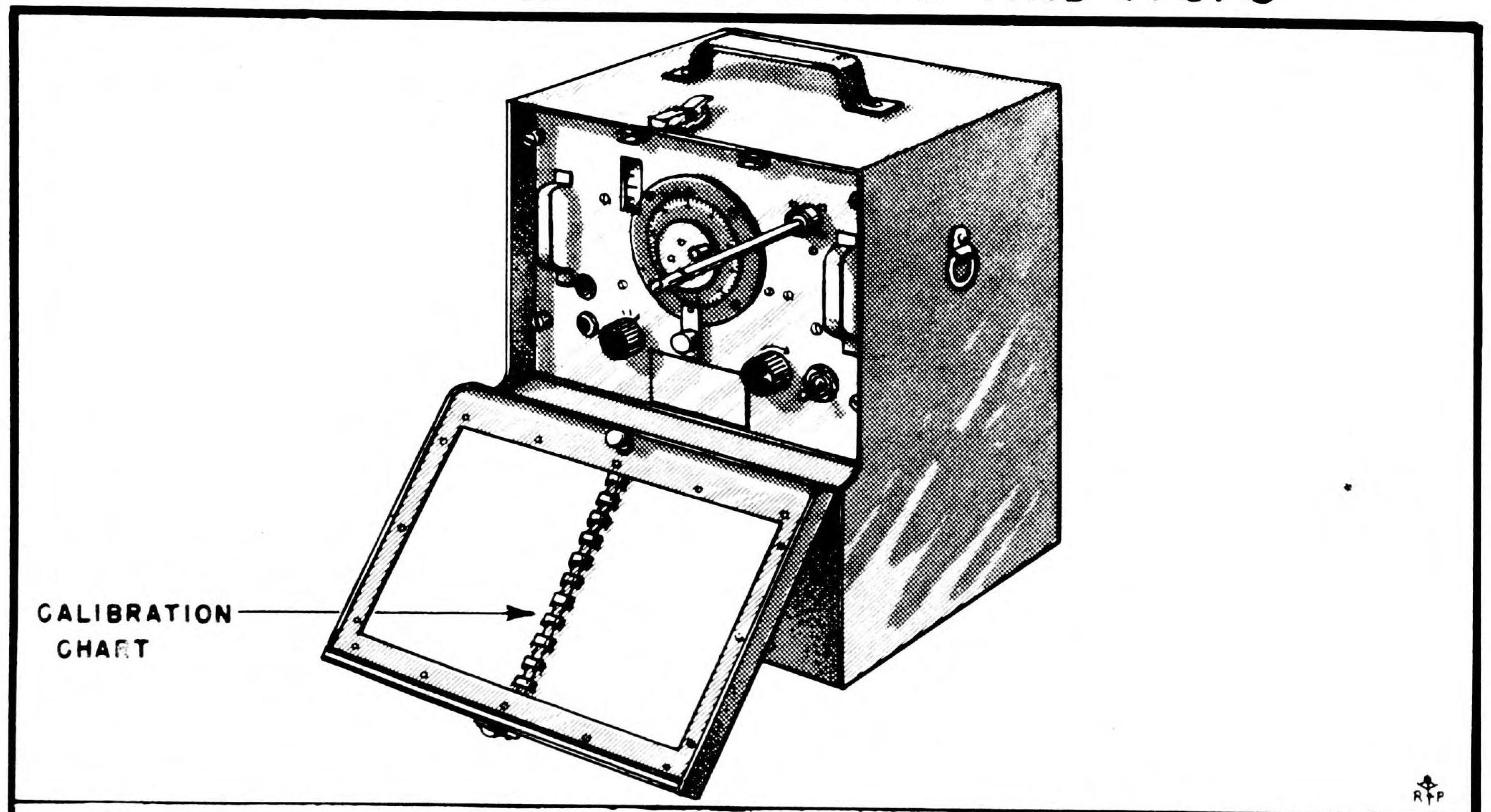
SPECIFICATIONS

FREQUENCY RANGE: 20 to 750 Mc.
POWER MEASUREMENT RANGE: 2 to 300 watts (20 to 100 Mc); 2 to 500 watts (100 to 300 Mc); 2 to 100 watts (300 to 750 Mc).
ACCURACY: Approximately ± 10%.
POWER REQUIREMENTS: 50 watts, 110 volts, 60 cycles.
SIZE AND WEIGHT: 24' x 11' x 8"; 50 lb.
TECHNICAL FEATURES: This equipment uses a 100' 'lossy' coaxial cable. A thermocouple is connected in series with the inner conductor at the input end of the cable. A d-c voltage is generated across the thermocouple-- this d-c voltage being a function of the r-f current flowing in the cable. The cable is terminated in a 50-ohm, 35 watt resistor to which is connected a meter that indicates the current flowing through the cable as a result of the voltage generated in the thermocouple. An r-f filter prevents the flow of r-f through the meter.Curves are supplied to permit conversion of meter readings to watts.

STATUS

Light production under way. Equipment restricted.

FREQUENCY METERS TS-174/U AND 175/U



Shown above is TS-175/U. TS-174/U is similar in appearance except that the antenna extends from the top.

PURPOSE TS-174/U and TS-175/U are portable heterodyne frequency meters: TS-174/U covering the frequency range of 20 to 280 Mc. and TS-175/U covering the range of 85 to 1000 Mc.* Both are particularly useful in RCM activities for setting jamming transmitters to frequency. TS-174/U is used with such equipments as AN/APT-3; TS-175/U is used with such equipments as AN/APT-2.

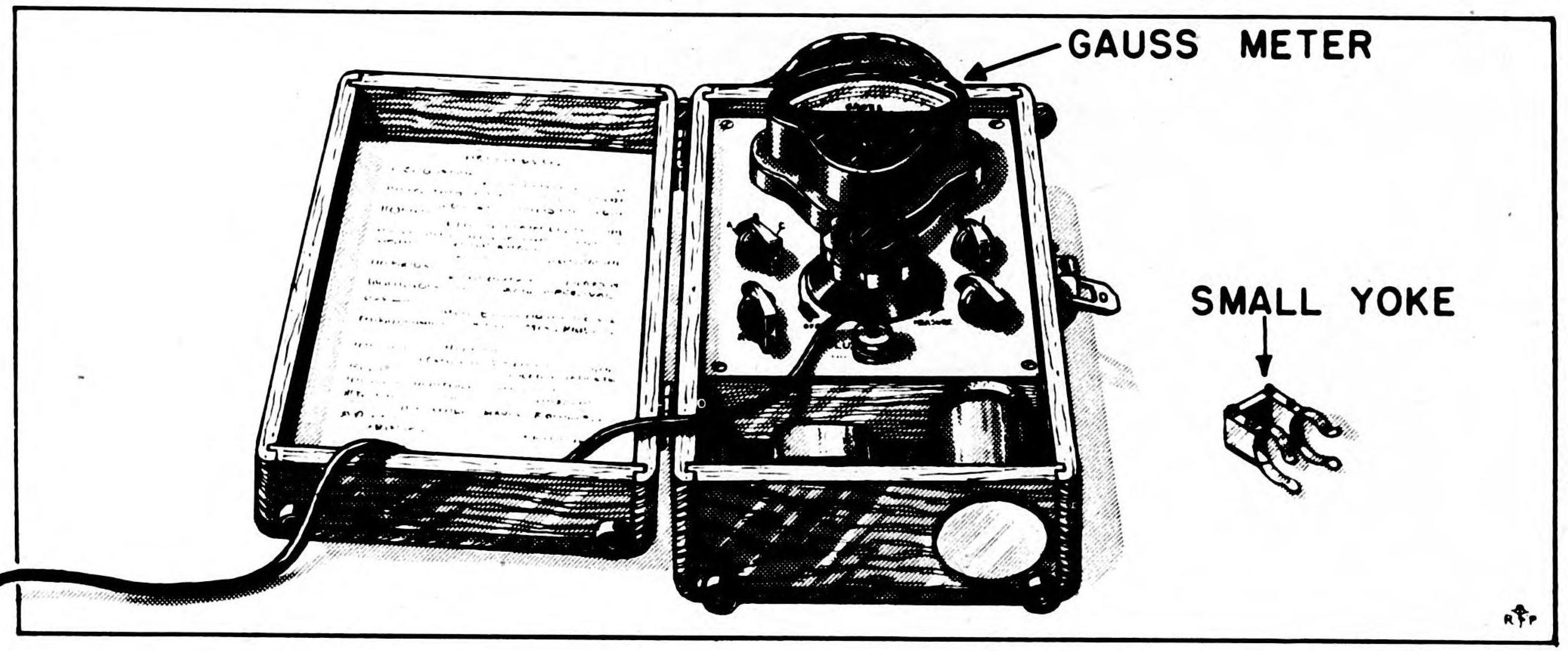
DESCRIPTION AND PERFORMANCE Each meter is housed in 9-1/4" x 12½" x 10" box and weighs approximately 42 lb. TS-174/U's fundamental range is 20 to 50 Mc; but it is usable on harmonics up to about 280 Mc. TS-175/U's fundamental range is 85 to 200 Mc; but it is usable up to the fifth harmonic or 1000 Mc. Numerous crystal check points are provided on both meters at various intervals along the oscillator frequency range. A vernier dial and an associated calibrated chart are used in making frequency measurements with both meters. A small, adjustable antenna is provided with each meter for r-f output; and beat signals for determining frequency are detected on headphones. Both meters have accuracy of 0.05% and will measure the frequency of unmodulated, modulated or pulsed r-f generators.

SPECIFICATIONS FREQUENCY RANGE: TS-174/U: 20-250 Mc; TS-175/U: 85 to 1000 Mc.
POWER SUPPLY: TS-174/U and TS-175/U 1½-volt BA 23 batteries connected in series to give a plate voltage of 135 volts.
SENSITIVITY: 20 millivolts to 2 volts for both meters.
OUTPUT POWER: 50 microvolts to 20 millivolts (1000 cycle modulation) for TS-174/U and TS-175/U is expected to have a slightly higher output power; tests being under way at present.
ACCURACY OF CALIBRATION: ± 0.05% for both meters.

STATUS Light production under way for TS-174/U; production starting on TS-175/U. Both equipments are classified as Restricted.

*A third frequency meter is under development in this series. This will be known as TS-213/U (500 to 5000 Mc).

FLUX METER TS-15A/AP

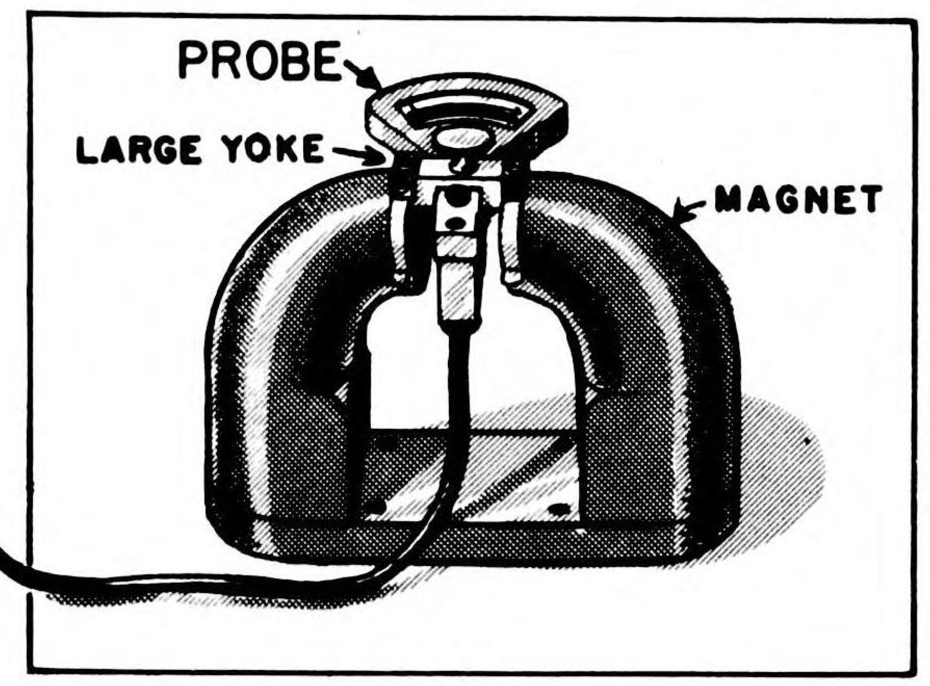


PURPOSE TS-15A/AP* is a fluxmeter designed to check magnets in radars or RCM equipment (such as AN/APT-4) using the magnetron transmitter. It is a portable direct reading equipment for measuring the magnetic field strength or flux density between the pole faces of magnets.

DESCRIPTION AND PERFORMANCE The instruments consist of a calibrated magnet with a milliameter (gauss-meter) between its pole faces. This milliameter is connected in series with a second milliameter (probe) which can be inserted between the pole faces of a magnet of unknown field strength to compare the field strength against that of the calibrated magnet. The actual field strength of the unknown magnet is given on a direct-reading dial of the gauss-meter after simple adjustments are made. The gauss meter reading is accurate to within 1%.

OPERATION Two interchangeable yokes are supplied for holding the probe between the pole faces of the unknown magnet: the small yoke fits magnets having gaps of .6" to .7", and 3/4" face diameters; the large yoke fits magnets having gaps of 1.3" to 1.5", and 1-5/8" face diameters. In measuring the magnetic field strength, the probe is placed between the pole faces of the unknown magnet--and it is important that the magnet and gauss-meter be sufficiently separated to prevent interference between the magnetic fields of the known magnet in the box and the unknown magnet.

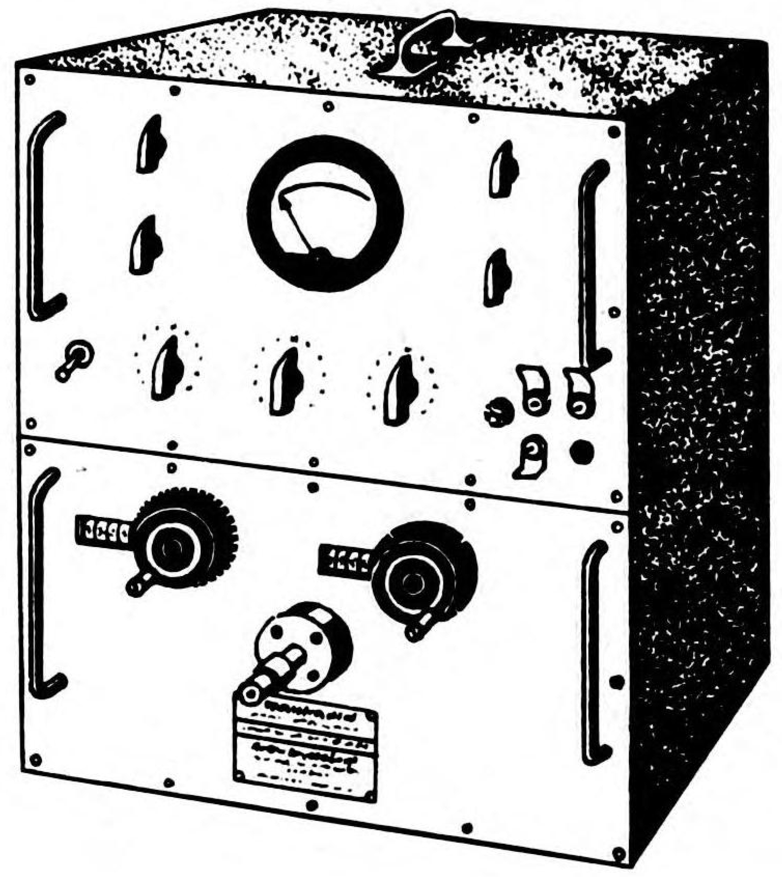
SPECIFICATIONS RANGE: 1200 to 9600 gauss. ACCURACY: ±1%. For maximum accuracy the gauss-meter zero set should be made with the instrument at a temperature of 15° C to 30° C.
POWER SUPPLY: 1½ volt flashlight cell (type D Burgess #2 or BA-30, or equal).
CURRENT DRAIN: One to eight milliamperes.
SIZE AND WEIGHT: 4½" x 6" x 10"; approximately 7 lb.



STATUS Equipment is in production. Classification is confidential.

*TS-15A/AP is replacing TS-15/AP, which covers 1200 to 4500 gauss for magnets of 1.3" to 1.5" gaps only.

SIGNAL GENERATOR LAF



PURPOSE

LAF is a radio-frequency signal generator designed for measurement work (such as alignment of receivers) where an adjustable and approximately known r-f voltage is required in the frequency range of 90 to 600 Mc. It is also designed to provide pulses that may be used to simulate radar signals in this frequency range.

DESCRIPTION AND PERFORMANCE

LAF is housed in a single cabinet and can be carried by hand. The generator supplies unmodulated signals, or pulse signals adjustable from 60 to 2000 pulses per second. Provision is also made for external modulation of any form and for synchronizing the built-in pulser with an external signal of either polarity. A pulse delay circuit is provided. A positive synchronizing pulse is available for the control of associated equipment. The output voltage is variable up to 100 millivolts. The attenuation and frequency controls are both geared to counters on the panel. A frequency calibration curve supplied gives the frequency as a function of the counter reading, and this curve is accurate to 1/10 of one per cent of the indicated value. The attenuator counter reading may be converted to output voltages by means of the supplied attenuator curve.

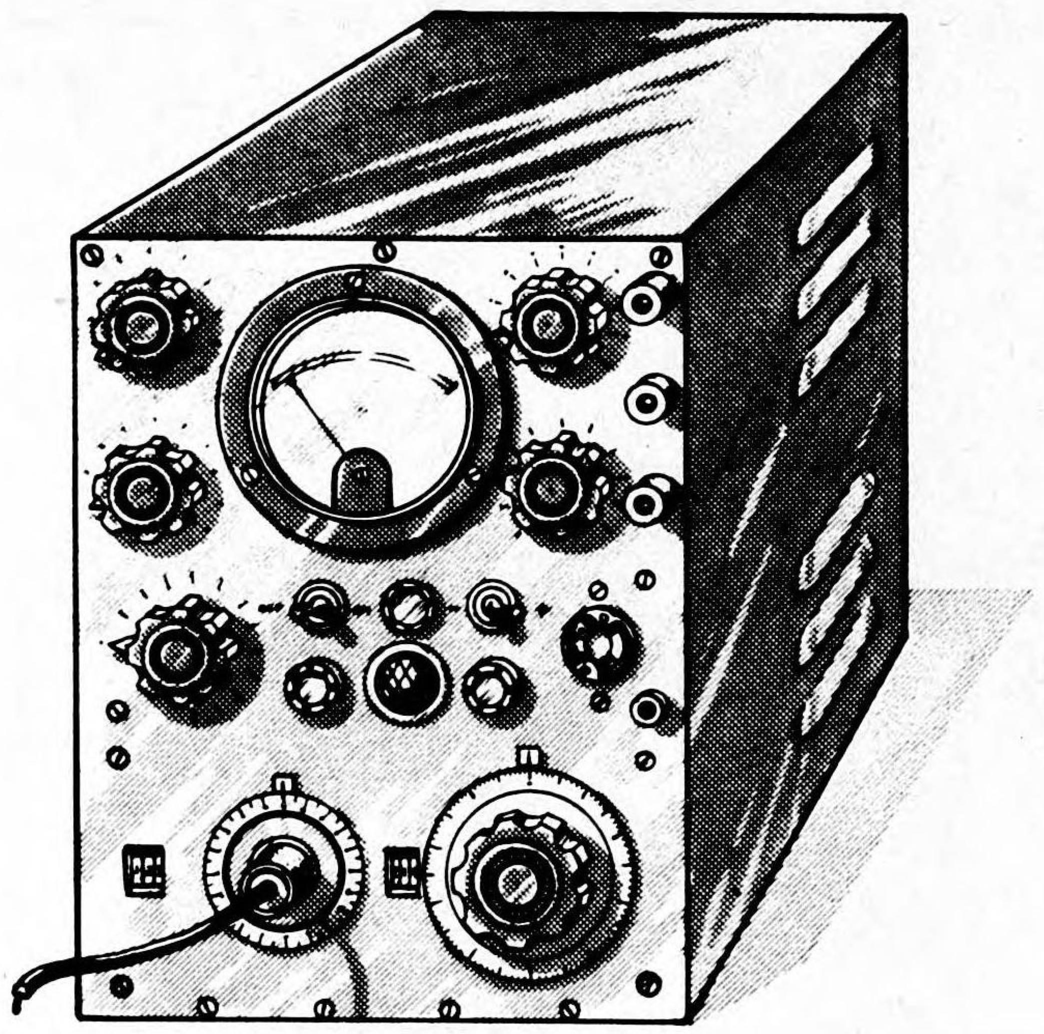
SPECIFICATIONS

FREQUENCY RANGE: 90 to 600 Mc.
OUTPUT SYSTEM: Output is from a calibrated attenuator having a characteristic impedance of 50 ohms. The output is brought out to a coaxial connector. 4' coaxial cable is supplied.
OUTPUT VOLTAGE: Calibrated output is from 1 microvolt to 100 microvolts.
MODULATION: The pulse repetition rate is variable from 60 to 2000 cycles per second. Pulse length is variable between 2 and 30 microseconds. A pulse delay circuit is provided which allows delaying the output pulse relative to the synchronizing pulse by an interval adjustable from 3 to 200 microseconds.
POWER SUPPLY: 115 volt, 50-60 cycle, A. C.
SIZE AND WEIGHT: 14 5/8" x 12 5/8" x 15"; approximately 60 lb.

STATUS

Production under way. Equipment is restricted.

SIGNAL GENERATORS LAE AND LAG *



PURPOSE

LAE is a radio-frequency signal generator designed for measurement work (such as alignment of receivers) where an adjustable and approximately known r-f voltage is required in the frequency range of 510 to 1300 Mc. It is also designed to provide pulses that may be used to simulate radar signals in this frequency range.

DESCRIPTION AND PERFORMANCE

LAE is housed in a single cabinet and can be carried by hand. The generator supplies unmodulated signals, or pulse signals adjustable from 60 to 2500 pulses per second. Provision is also made for external modulation of any form, and for synchronizing the built-in pulser with an external signal of either polarity. A pulse delay circuit is provided. A positive synchronizing pulse is available for the control of associated equipment. The output voltage is variable up to 100 millivolts. The attenuation and frequency controls are both geared to counters on the panel. A frequency calibration curve supplied gives the frequency as a function of the counter reading. The attenuator counter reading may be converted to output voltages by means of the supplied attenuator curves.

SPECIFICATIONS

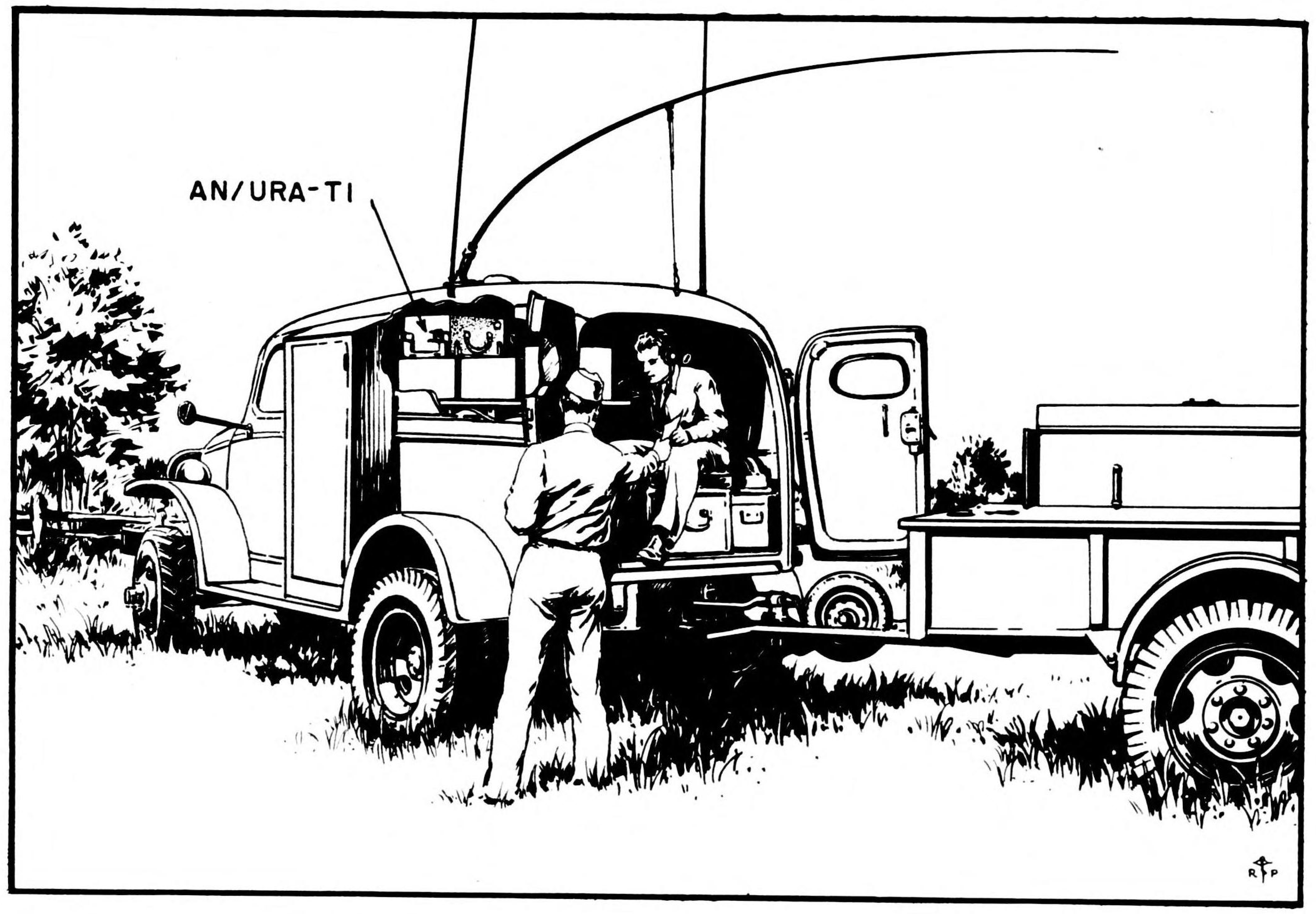
FREQUENCY RANGE: 510 to 1300 Mc.
OUTPUT SYSTEM: Output is taken across a 50 ohm concentric line which is attached to the attenuator.
OUTPUT VOLTAGE: Calibrated output is from 1 microvolt to 100 millivolts.
MODULATION: The pulse repetition rate is variable from 60 to 2500 cycles per second. Pulse length is variable between 1 and 30 microseconds. A pulse delay circuit is provided which allows delaying the output pulse relative to the synchronizing pulse by an interval adjustable from 3 to 300 microseconds.
POWER SUPPLY: 105/125 volts, 50-60 cycles single phase A.C.
SIZE AND WEIGHT: 11-5/16' x 7½' x 20-3/4'; 55 lb.

STATUS

Production under way. Equipment is restricted.

*LAG is a recently developed radio-frequency signal generator that covers the frequency range of 1200 to 4000 Mc.

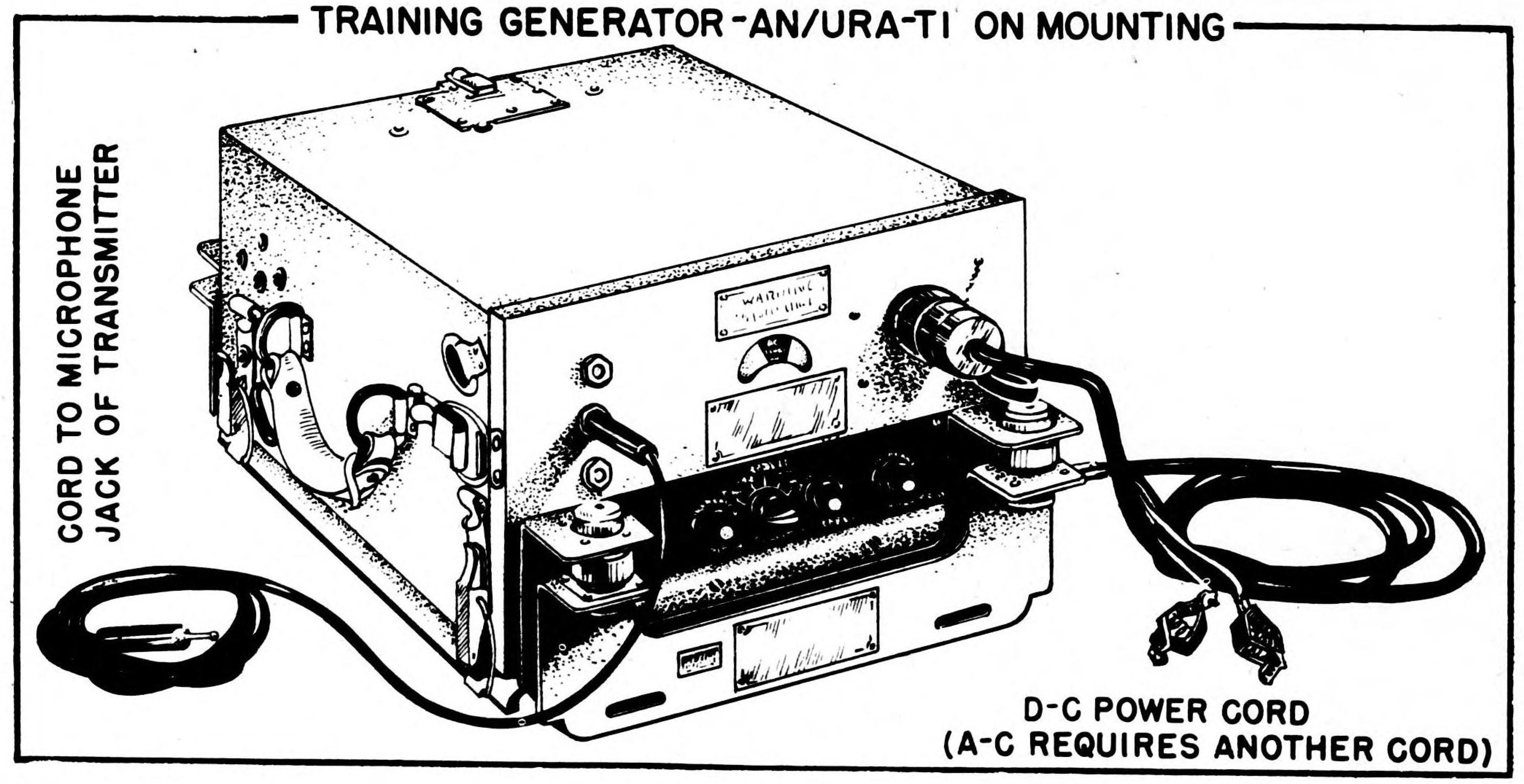
TRAINING GENERATOR AN/URA-T1



PURPOSE AN/URA-T1 is designed to generate audio frequency interference signals. These signals may be used to modulate regular communications transmitters for training radio operators to maintain communications under adverse conditions, and also to modulate radio transmitters used for jamming enemy radio communications. For operator-training purposes AN/URA-T1 may be used on code tables as well as with actual communications equipment.

DESCRIPTION The equipment consists of a single unit that provides output which may be used directly with a standard communications transmitter. The single unit includes generators of all the types of modulation signals provided.

PERFORMANCE It is possible to obtain audio output of the following types for use in training or jamming operations: stepped tones, random noise, or random keyed tones. In addition, random-keying for a



CW transmitter is provided. AN/URA-T1 delivers sufficient output to be fed into the microphone connection for any ordinary communications transmitter.

INSTALLATION & OPERATION The training generator is mounted in a portable case and provided with a shock mount. No particular installation problem should arise, as this unit is entirely self-contained and may be plugged into a communications transmitter without modification of the set, using cords provided with the unit.

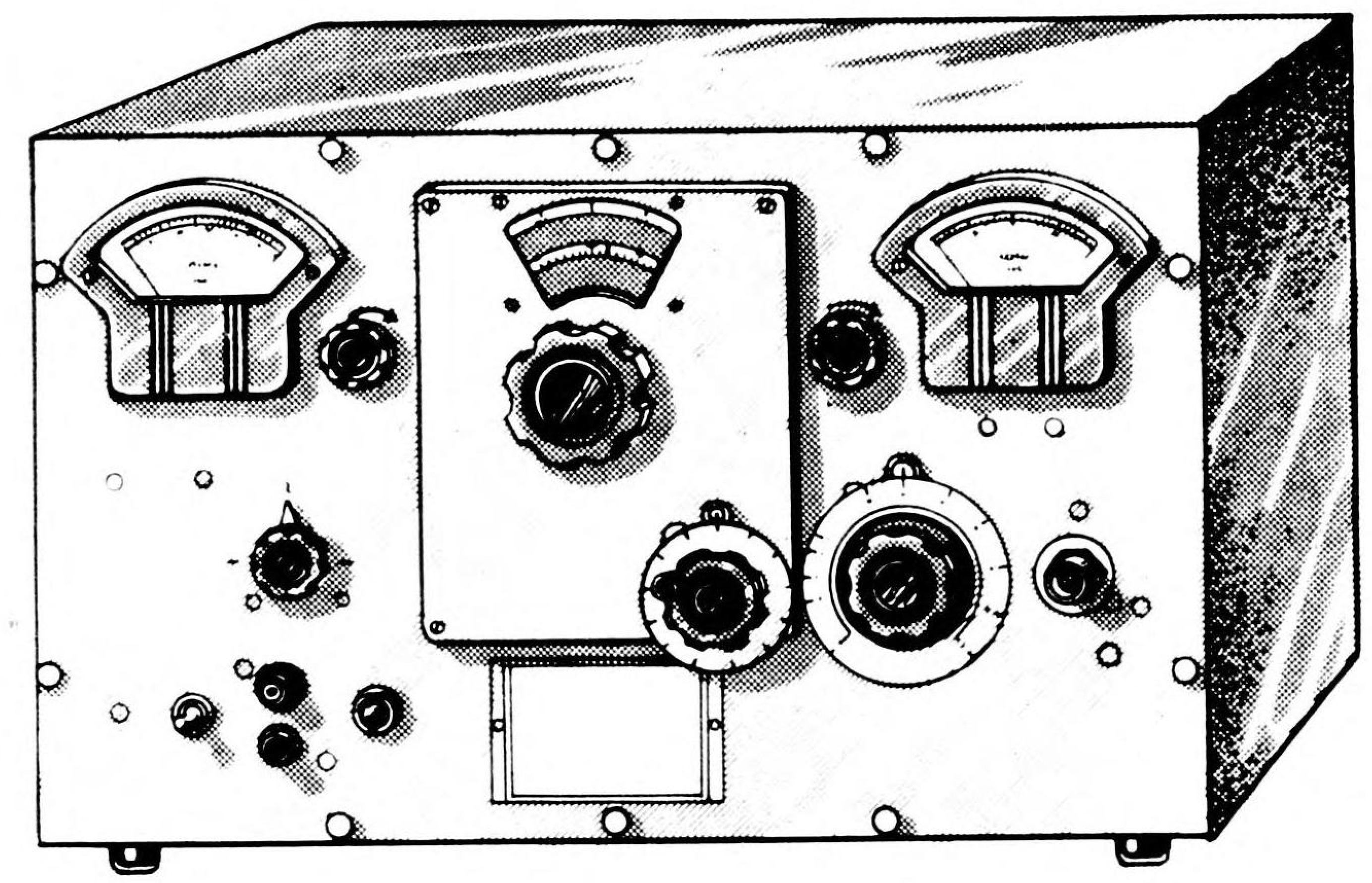
PERSONNEL No personnel in addition to the regular transmitter crew is required during operations. The only attention required is in the setting of the controls to the desired type of interference.

SPECIFICATIONS INPUT POWER: 35 watts, 110 volts, 60 cps. a.c. or approximately 35 watts, 6 or 12 volts d.c.
OUTPUT POWER: 5 milliwatts or 1½ watts on 110 volts a.c.
5 milliwatts on 6 or 12 volts d.c.
SIZE AND WEIGHT: 10-3/4" x 14-3/4" x 8"; about 46 pounds (with shock mount).

TECHNICAL FEATURES: The stepped tones available on the generator are produced by periodic switching of five resistances in the grid circuit of an audio oscillator. Random noise is produced by gas discharge tubes. Random keying is produced by the non-synchronous firing of 3 neon tubes operated in RC networks actuating a relay through a thyratron tube. All audio signals pass through an amplifier and are automatically limited to a maximum of one volt output across 200 ohms, unless the entire 1½ watts obtainable from a-c operation is desired.

STATUS Moderate production under way. Equipment Restricted.

SIGNAL GENERATOR GR-804 CSI



PURPOSE

GR-804-CS1* is a radio-frequency signal generator designed for measurement work (such as alignment of receivers) where an adjustable and approximately known r-f voltage is required in the frequency range of 7.5 to 330 Mc.

DESCRIPTION AND PERFORMANCE

GR-804-CSI is housed in a single cabinet and can be carried by hand. The generator supplies unmodulated or modulated signals. Modulation is adjustable up to 60%. An internal source for modulation at 1000 cycles is provided, and provision is made for use of external amplitude modulation. In addition, there is provision for use of external pulse modulation; however, the circuits are such that sharp wave fronts can not be obtained. The output is continuously variable from one microvolt to 20 millivolts. The output is determined by the reading of an output meter on the panel and by the setting of the calibrated attenuator dial. The 7.5 to 330 MC range is covered in five bands. Each band is direct reading in frequency to an accuracy of ± 2%, and any one can be selected by means of a band-change switch on the panel. A sixth position of the range switch is available, and a blank plug-in coil may be wound to cover some specific frequency band or to provide a low-frequency output band.

SPECIFICATIONS

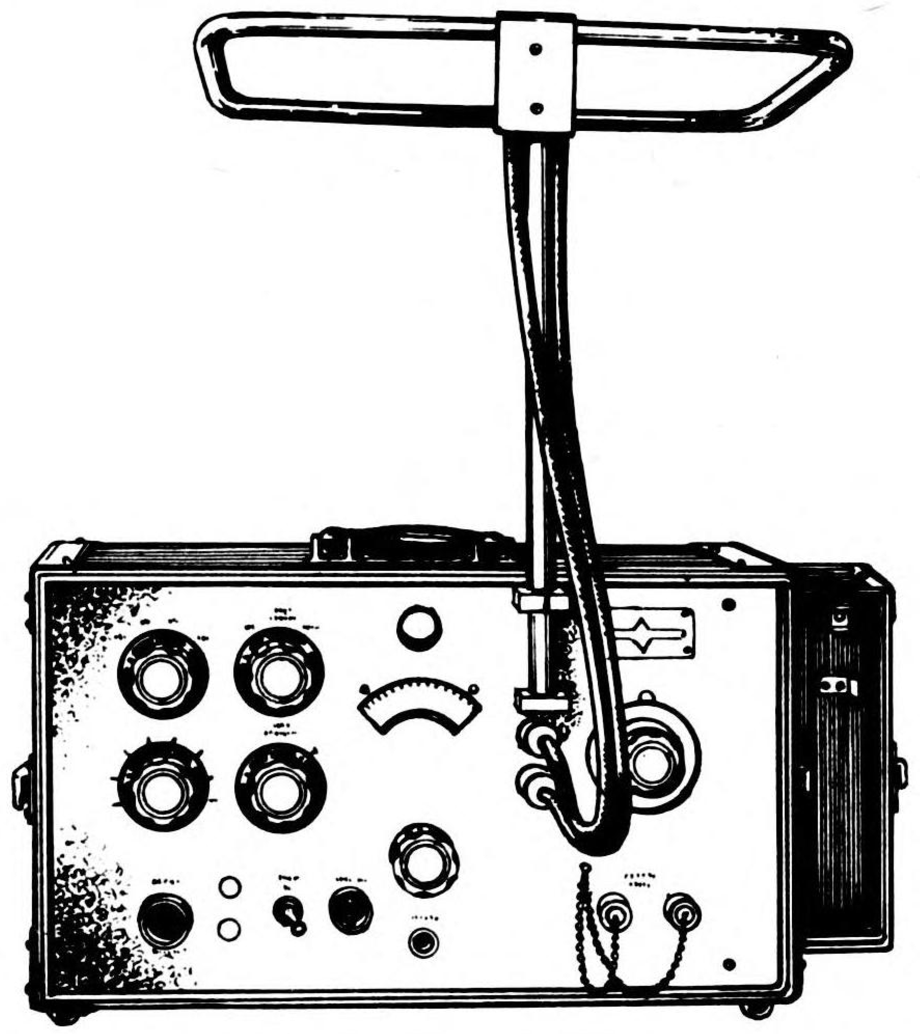
CARRIER FREQUENCY RANGE: 7.5 to 330 Mc.
OUTPUT SYSTEM: The output is obtained from a 75 ohm coaxial cable. A 3' coaxial cable is supplied.
OUTPUT VOLTAGE: One microvolt to 20 millivolts.
MODULATION: Amplitude modulation continuously adjustable up to 60%. Internal: 1000 cycles ± 5%. External: Flat within ± 1 db from 200 to 10,000 cycles, within - 3 db from 100 to 20,000 cycles. FM is present, particularly at the higher frequencies; testing of selective receivers, hence, should be done with unmodulated carrier. Pulse rise time is approximately ½ microseconds.
POWER SUPPLY: 115 or 230 volt power lines of 42- to 60 cps. Power consumption is about 25 watts.
SIZE AND WEIGHT: 19½' x 11 5/8' x 9'; 35 lb.

STATUS

Unclassified commercial item.

*GR-804-CS1 is similar to GR-804-CS2--the only differences being in the way video signals are applied and in the way the amplitude of the video output can be determined.

TRAINING SET AN/TPQ-T2



PURPOSE

AN/TPQ-T2 is a training signal generator to be used for jamming of our own radar systems in the frequency range from 90 to 270 Mc. It typifies the action of several types of jammers and is used to train radar personnel in anti-jamming techniques.

DESCRIPTION

AN/TPQ-T2 is a single unit (size 21" x 12" x 9") which provides for the generation of signals with various types of simple or combined modulation. The antenna may be any convenient type designed to operate in the required frequency range. The equipment provides several types of modulated signals: CW, sinewave AM at high and low frequencies, pulses at several repetition frequencies, and low frequency FM. A noise modulator with 2½ Mc bandwidth is also included. The output power is about 0.5 watts. The sideband energy and bandwidth depends upon the type and degree of modulation and clipping.

PERSONNEL

No extra personnel is needed. The regular training instructors can with a little training demonstrate and apply the equipment to its several purposes.

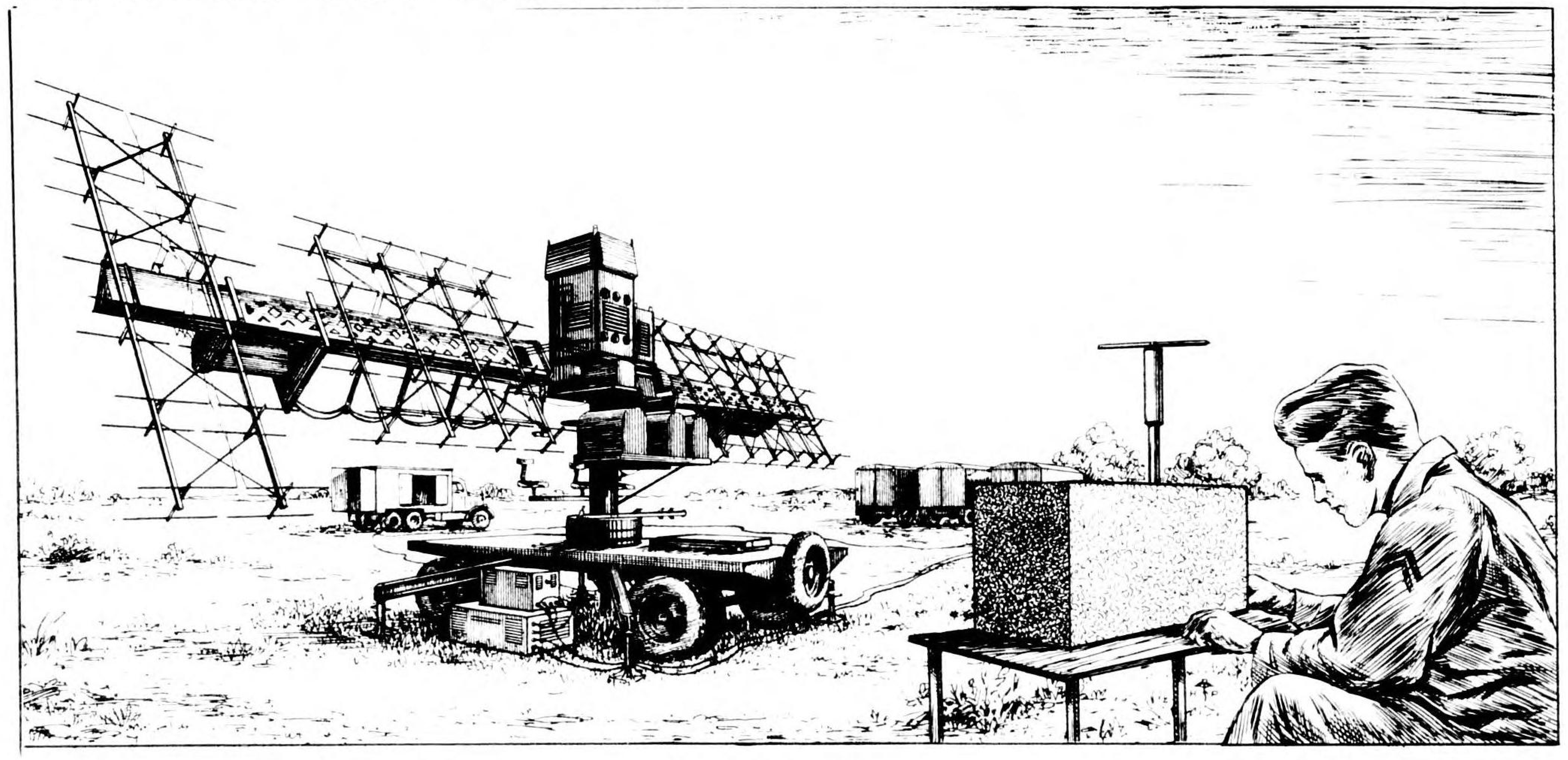
SPECIFICATIONS

FREQUENCY RANGE: 90 to 270 Mc.
INPUT POWER: 80 watts, 80 or 115 or 230 volts, 60 cps, a.c.
OUTPUT POWER: 0.5 watts, unmodulated.
MODULATION: Amplitude with noise (2½ Mc bandwidth), amplitude with sinewave (approximately 80% at 0.1, 0.3, 1, 3, 10, 30, 100, and 500 kc), amplitude with pulses (pulse lengths of 6, 4, or 1 microsecond and prf of 30, 100, or 500 kc), and frequency modulation (deviation 5 Mc or ½ Mc at rate of 40 to 100 cps). External modulation jack provided.
SIZE AND WEIGHT: 21" x 12" x 9", 35 pounds.

STATUS

Light production contemplated. Equipment Confidential.

TRAINING SET AN/TPQ-TI (OSCAR)



PURPOSE AN/TPQ-T1 is a transmitter for operator training in the use of AJ devices and in proper operating techniques in the presence of jamming. It will operate against radars in the frequency range from 100 to 230 Mc. It could also be used as an actual jamming transmitter if nothing better were available.

DESCRIPTION AN/TPQ-T1 consists of a single unit (SARC A1-D) which incorporates a jamming transmitter and a relatively insensitive receiver for use in setting the device on the radar frequency. Some of the circuits of the equipment are common to the receiver and transmitter sections, thus assuring accurate frequency setting.

PERFORMANCE AN/TPQ-T1 will provide sine wave amplitude-modulated and frequency-modulated signals for radar-operator training against jamming. The total power output of 3 watts is quite sufficient for this use, since in general the transmitter will be located close to the set to be jammed.

OPERATION & INSTALLATION An operator is required to tune to the radar signal to be jammed and to select the type of jamming to be used.

The equipment is transportable and may be set up in the vicinity of the radar against which it is to be used. Any convenient simple antenna (stub, etc) may be used with it. A source of a-c power must be provided.

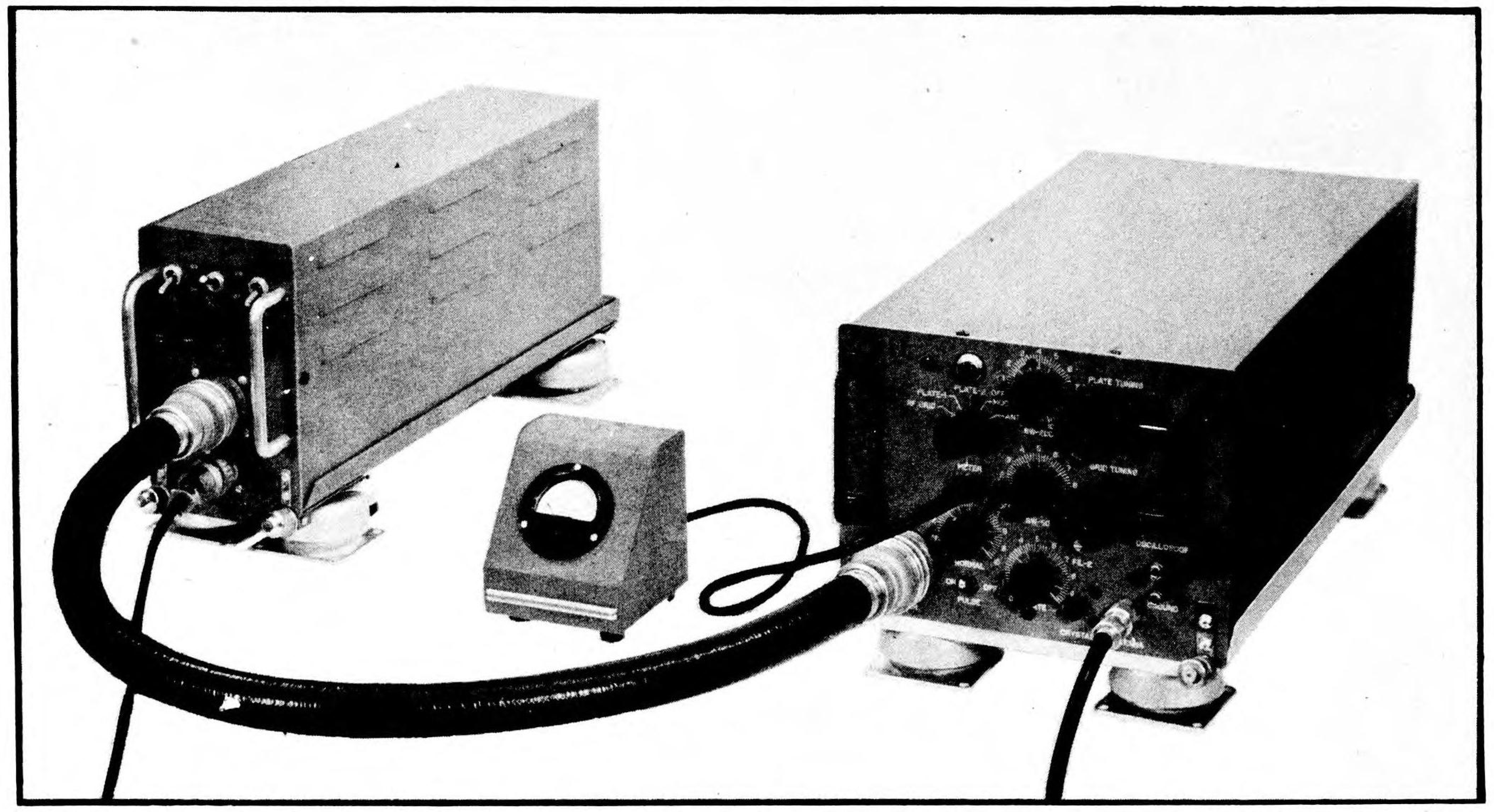
PERSONNEL An operator is required with the equipment to select the type of modulation to be used and to tune the equipment. A trained instructor should be provided for observing and correcting the reactions of the radar personnel against which the equipment is used, and for outlining the proper procedures to be followed for best results in the presence of jamming.

SPECIFICATIONS FREQUENCY RANGE: 100 to 230 Mc.
INPUT POWER: 50 watts, 115 volts, 60 to 400 cps a.c.
OUTPUT POWER: 3 watts.
MODULATION: 25 kc to 1 Mc sinusoidal amplitude modulation and ± 1 Mc frequency modulation at a rate which is variable from 1000 cps down.

SIZE AND WEIGHT: SARC B1-D, 23 pounds.

STATUS Light production due soon. Equipment Confidential.

RADAR TRAINING SET AN/UPT-TI



PURPOSE AN/UPT-T1 is a ground-based transmitter for practice jamming of our own radar systems in the frequency range from 450 to 720 Mc. It typifies the action of several types of jammers and is used to train radar personnel in anti-jamming techniques.

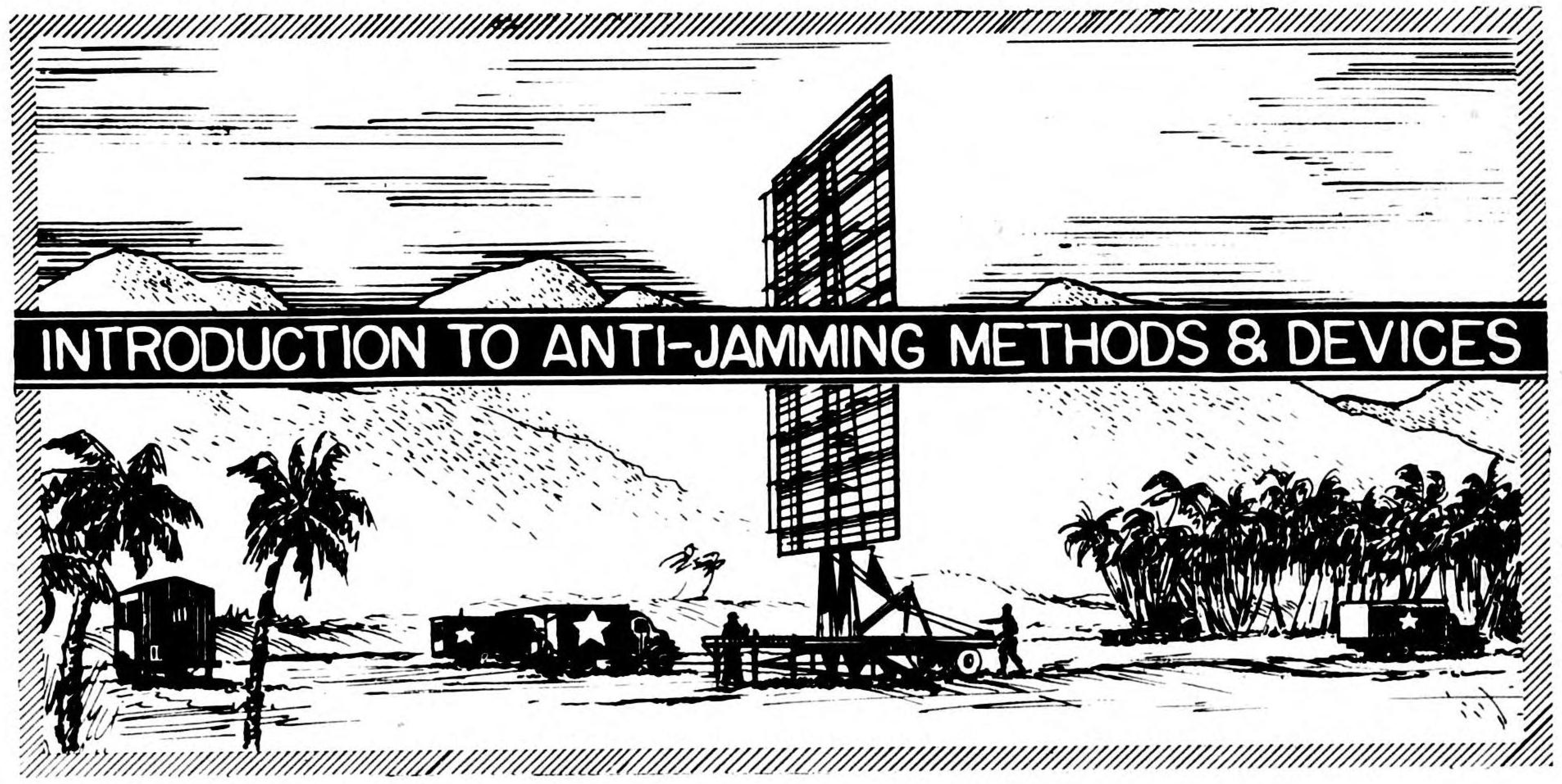
DESCRIPTION AN/UPT-T1 is essentially AN/APT-2 (described elsewhere) modified to permit various kinds of modulation, separately and in combination. The transmitter and its power unit are contained in two boxes (SARC B1-D and A1-D). The antenna may be any type designed to operate from a 50-ohm concentric cable and at the required frequency, such as AS-37/SPT-4.

PERFORMANCE The equipment provides four types of amplitude modulation: noise, high frequency sine wave, low frequency sine wave, and pulse. All types may be used separately or in any combination with the others, except that the pulses can be combined only with the low frequency sine wave. The unmodulated carrier power varies from 8 watts at 450 Mc to 3 watts at 720 Mc. The sideband energy and band width depends upon the type and degree of modulation and clipping.

PERSONNEL No extra personnel is needed. The regular training instructors can, with a little training, demonstrate and apply the equipment to its several purposes.

SPECIFICATIONS FREQUENCY RANGE: 450 to 720 Mc.
INPUT POWER: 350 watts, 110-125 volts, 60 cps.
OUTPUT POWER: 3-8 watts, unmodulated.
MODULATION: Amplitude with noise (40 kc to 3.5 Mc), amplitude with sine waves (50 and 200 kc with modulation variable between zero and 80%, and 120 cps at 100%), and amplitude with pulses (1.5 microsecond, 10-200 kc prf).
SIDEBAND POWER: 0.6-1.6 watts.
ANTENNA: AS-37/SPT-4
TEST EQUIPMENT: Not determined yet.
SIZE: SARC B1-D and A1-D.

STATUS Light production under way. Equipment Confidential.



The development and use of anti-jamming (AJ) techniques and equipment is related to radio countermeasures since AJ is, in effect, a counter-countermeasure. Studies of the vulnerability of our communications and radar equipment to jamming techniques developed by ourselves and by the enemy have resulted in the development of certain anti-jamming practices and techniques. A comprehensive discussion of communications and radar AJ techniques and methods would require a volume in itself. Various organizations responsible for AJ training and the incorporation of AJ features in communications and radar equipment have (or are) preparing such material. Consequently, the present discussion is limited to suggested means of coping with certain broad problems that are involved.

BASIC CONSIDERATIONS

It is important to recognize the fact that it is generally impossible to protect a specific communications or radar channel against a concerted and properly directed jamming attack. Anti-jamming precautions should therefore be considered from the viewpoint of the whole communication or radar system for a given area.

Communication and radar coverage should be planned with the idea in view of providing the required type of service in the area involved, in spite of the anticipated amount of enemy jamming. In other words, consideration of the AJ problem should not be limited to studies involving one particular piece of equipment at one particular site since, if this equipment is within range of the enemy, it can probably be put completely out of action under any circumstances.

The important consideration in planning service for a given

area is to provide both flexibility and diversity of frequency. Diversity of frequency may be achieved by using, for each type of service that must be provided, equipment that operates in widely separated frequency bands. Frequency flexibility involves means for selecting a number of operating frequencies in a given band of frequencies.

Probably the most important basic consideration in AJ techniques is adequate operator training and experience. There is no substitute for the ability and the will to overcome jamming. For several forms of interference (such as noise and Window), this is the most effective AJ measure yet developed.

FREQUENCY ALLOCATION

Whenever possible, the equipment used in a particular area for a given service should be of various types, operating in widely different portions of the frequency spectrum. A ground-controlled-interception (GCI) radar network, for example, might consist of equipment operating in the UHF (30 to 300 Mc). the VHF (300 to 3000 Mc) and the SHF (3000 to 30,000 Mc) regions. This procedure will avoid the necessity of relying completely upon equipment in any single radio-frequency band, which at any moment may be the object of enemy jamming operations.

Similarly, Early Warning (EW), Search Light Control (SLC) and even Aircraft Interception (AI) equipment operating in widely separated bands should be used. For example, if all planes are equipped with the same type of AI set, the enemy need only concentrate his jamming activities on the one particular band of frequencies that is involved.

Frequency diversification is also desirable in each type of communications service. Although diversification cannot always be achieved in either communications or radar equipment, its desirability should be kept in mind in any planning that affects entire theaters of operation.

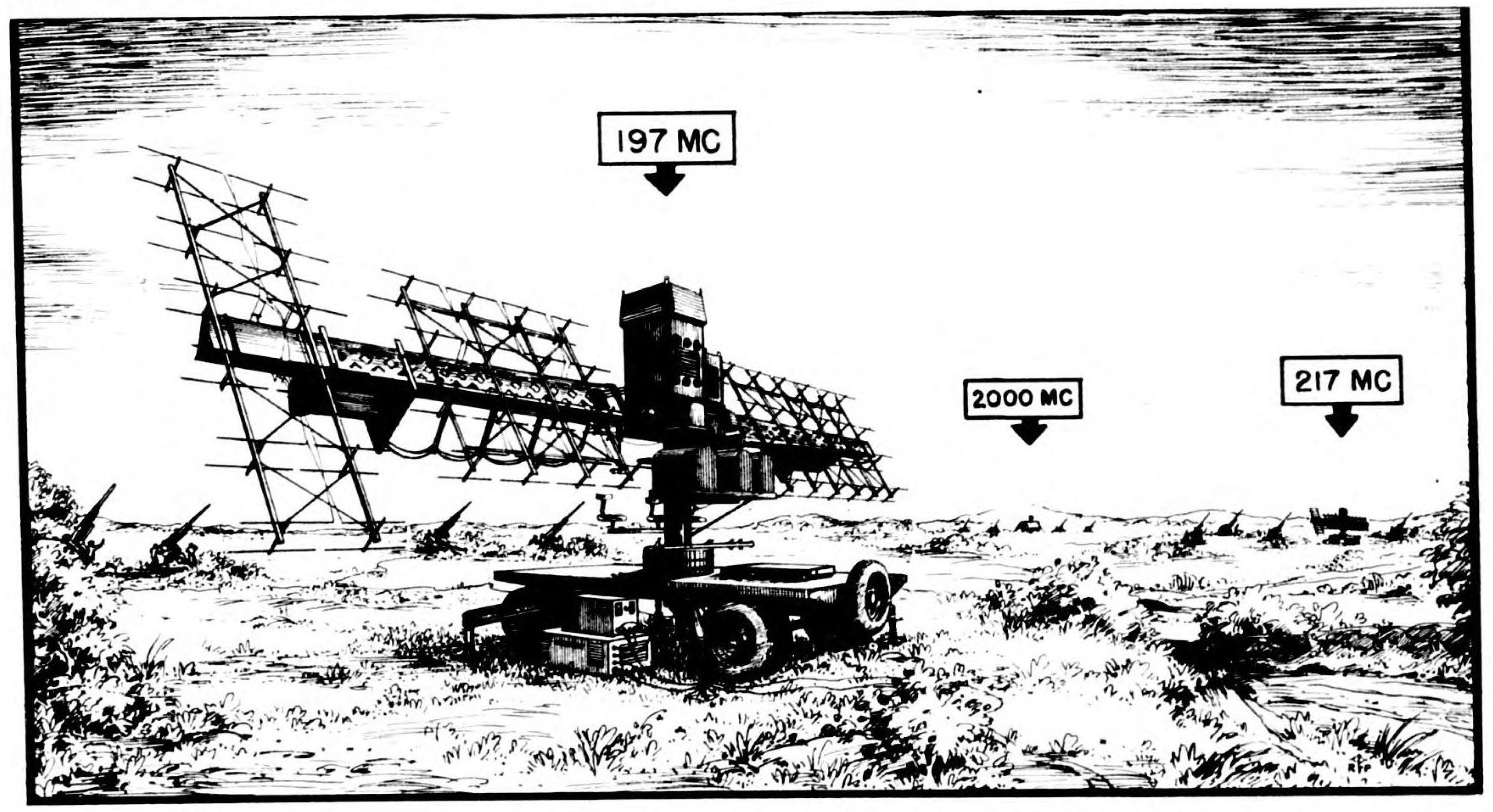
Where equipments operating in a new portion of the frequency spectrum are added to networks already in operation, the older equipment should not be removed from service when the new sets become available. Otherwise, the enemy is advised of the success of his jamming activities (if this is the reason for making the change) and is also warned to search for new operating frequencies.

It is also to be noted that, if suitable equipment is available, it is possible to use enemy communications channels for one's own radar. If this is done, the radar will probably jam the communications channels but, on the other hand, simple AJ devices should be capable of preventing the enemy communications from jamming the radar. A shortcoming of this procedure is the possibility of the enemy converting his communications transmitters to jammers. This is not a major consideration, however, since in all probability the communication set will not be capable of the wide-band modulation that is essential for effective radar jamming.

When planning the diversification of radar frequencies, sight must not be lost of the need for similar deployment of IFF (Identification) equipments. In GCI operations, for example, particularly when the friendly and enemy planes are close together, it is important to distinguish one from the other at all times. If, under these circumstances the enemy succeeds in jamming the IFF system, it will not generally be possible to distinguish the friendly plane from the foe even though the radar may not be affected. The only alternative then left to the GCI operator is to give his plane a vector and wait until his radar indicates which plane takes the prescribed course. Even after having determined one plane from another, quick evasive action on the part of the enemy may again confuse the GCI operator. In any event, such roundabout practices are not conducive to successful interception.

FREQUENCY FLEXIBILITY

In both communications and radar systems it is desirable to use the entire band of frequencies over which a given type of equipment is capable of being operated. This practice will make it necessary for the enemy to spread his jamming effort over the entire band and thus dilute the strength of such emissions in any given portion of the spectrum.



Shown above is a possible installation of two SCR-268 radars (one at 197 Mc, and the other at 217 Mc) that makes use of frequency flexibility. Frequency diversification is also illustrated in the picture --a 2000 Mc radar being installed in the background.

In general, however, the spreading of the sets throughout the entire available band should not be practiced until necessary. This will avoid advance disclosure to the enemy of the total tuning range available for a given type of set and will thus handicap his planning of jamming activities.

It is also important to exploit fully any facilities that may be available for making small changes in frequency, since such changes may determine whether an AJ device will be effective or not against communications or radar jamming. The ability to make small or large changes in frequency quickly is important. When ease of making frequency changes is not inherent in the equipment, it is essential that the operating personnel be thoroughly trained to effect the changes just as rapidly as possible.

In making frequency changes the procedure of first tuning the receiver to the new frequency and then following with the transmitter should always be followed. This will not only result in an exploratory survey of the amount of interference, if any, that exists in the channel it is proposed to use, but will also give the enemy the least warning of the impending change. In many instances, the short respite from jamming that may result from following this procedure may be all that is necessary to obtain vital information of considerable usefulness.

SELECTION OF SITES

In addition to the usual precautions that are taken in selecting communications and radar equipment sites, consideration should also be given to susceptibility to jamming by the enemy. For communications systems in the VHF band and radar systems in general, the site should be selected so as to be screened against jamming from enemy-occupied or controlled territory. Although this is not always possible, advantage should be taken of this AJ technique where a choice exists.

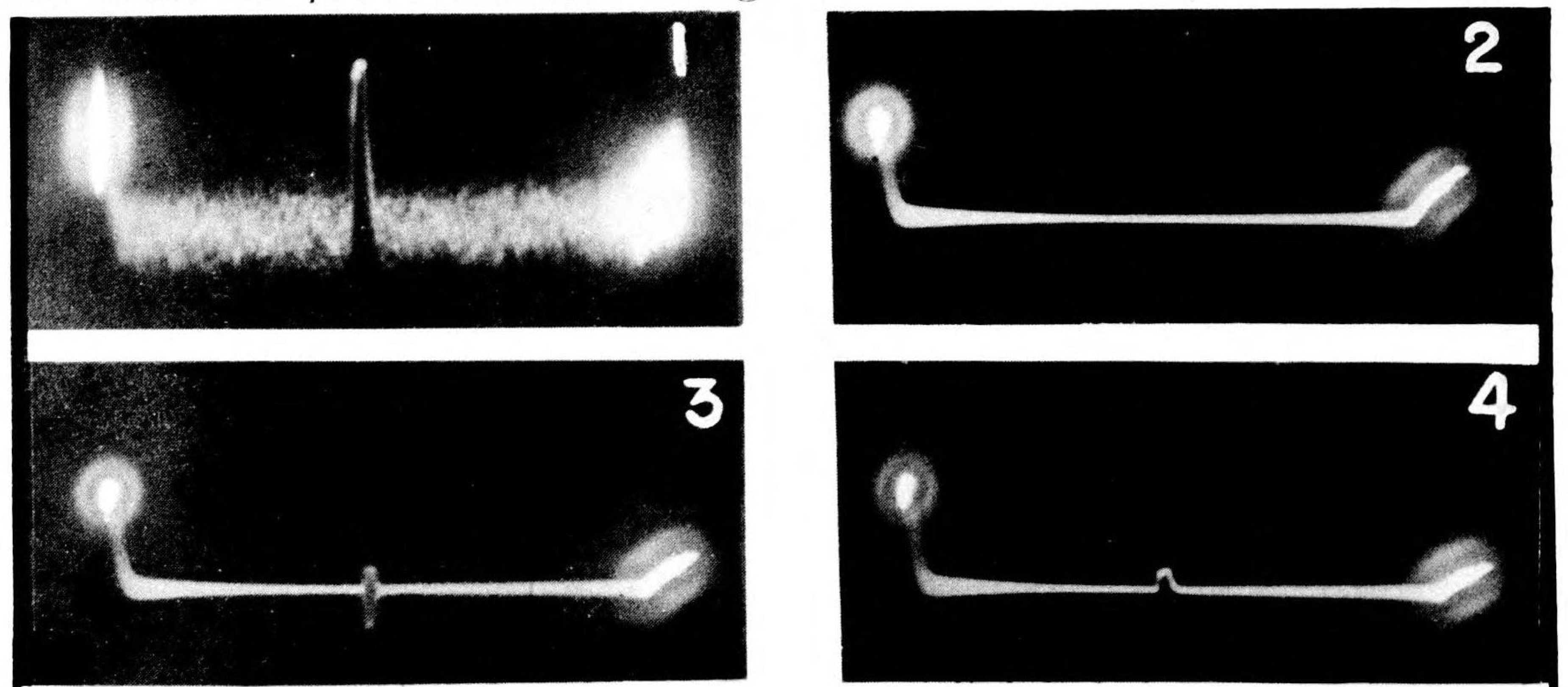
OPERATOR TRAINING

It has been proved by actual operations in the Mediterranean and European Theaters that the efficiency of communications and radar operators is greatly reduced the first time they are exposed to jamming, but that their efficiency improves with successive exposures. This experience can obviously be less expensively obtained during training than in actual operations. Since, as already stated, training, experience and the will to operate through difficulties are the most promising means for combating certain types of jamming, it is evident that too much emphasis cannot be placed upon this phase of the AJ program.

In both communications and radar systems the operator has a variety of controls at his disposal and it is essential that he be familiar with their use in order to minimize the effects of interference. Obviously, the inherent AJ properties of a set cannot be fully realized unless this is done. Often what might be considered abnormal adjustment of the controls (especially the receiver gain control) may result in improved AJ properties. In certain forms of jamming it is important that the operator be fully experienced in this operation. Training in this apparent misuse of the controls is essential, since the orthodox operator might never, of his own accord, hit upon the combination that is most effective.

For example, limiting action in communications receivers will greatly decrease the effectiveness of spark and "sweep-through" (frequency-modulated) types of jamming. However, except for frequency-modulated receivers, very few standard communication equipments have limiters. Nevertheless, limiting action can be obtained by turning-up the volume controls and overloading the receiver, the headphones or even the ear. This will cause the peaks of the jamming signal to be cut-off and will result in a better ratio between the desired and the interfering signal.

Against radar, on the other hand, many kinds of jamming such as continuous wave (cw) and amplitude- or frequency-modulated sine waves are not effective unless overloading does occur. Under these circumstances it is expedient to keep the gain control turned-down in order to prevent overloading.



These photos show the effect of turning down the gain control to combat certain types of jamming. #1 shows a strong signal on an A scope. #2 shows how overloading with CW wipes out the signal. #3 shows how a readable signal was obtained by turning down the gain. #4 shows the scope with no jamming present, and if compared with #1 indicates how much the gain had to be turned down.

The training of communications operators is materially aided by the use of suitably prepared phonograph records, and the training of radar operators is facilitated by the use of films. Whenever possible the operators should have access to this type of material periodically, particularly if they are not currently exposed to jamming operations.

Jamming signal generators for both the communications and radar fields are also important training adjuncts. The use of these instruments should not be limited to training schools, since it is only by constant exposure to jamming signals that an operator gains and maintains his ability to work through interference. Jamming signal generators should be made available in the field and used periodically for operator training.

The maintenance of both transmitting and receiving equipment in the best of condition is an AJ measure that should not be overlooked, since any fault in the system will evidently aid the jamming operation. It is important that this fact be realized by those concerned with the operation of the equipment.

Another factor that should not be overlooked both in planning communications and radar networks and in operator training is the need for close cooperation between the various groups involved. In a radar system, for example, it is unlikely that all types of equipment in a given area will be affected during a raid. For maximum defense, it is imperative that there be close cooperation between Early Warning (EW), Ground-Controlled-Interception (GCI), Gun-Laying (GL) and Search Light Control (SLC) stations so that unaffected equipment may be of most assistance to that which is affected.

WINDOW AJ TECHNIQUES

At present the best anti-jamming methods against Window are the use of equipment in a frequency band not under attack, and adequate operator training in the avoidance of panic, in quick recognition of Window, and in insistence on trying to operate in the holes of the Window cover. Repeated training is the only way an operator can become proficient in these respects, short of gaining experience, the expensive way, under actual attack.

When available, advantage should be taken of an expanded scope range scale so that the resolution inherent in the equipment is fully utilized. Gaps in the window cloud and targets therein will be made most prominent by this procedure. It should also be borne in mind that, if Window is still being dropped, there must be planes in the leading edge.

Care must be taken not to allow the echo received from the Window to saturate or overload the radar receiver, since overloading may cause an otherwise visible target to be obscured.

There are certain other AJ measures that can be employed to minimize the effect of Window but, since these are primarily a matter of equipment design, they will not be discussed here. Attention is called to the fact, however, that where there is any choice, short pulse lengths should be used to cope with Window since this will result in greater resolution and the possibility of finding targets in the gaps of the Window cover. Proper maintenance of existing equipment should be undertaken with this in view.

FEATURES OF ANTI-JAMMING KITS

In connection with the radar AJ devices and kits catalogued on the following pages it is important to note that no AJ device is a cure-all. The various devices cope effectively with certain types of jamming, cope less effectively with other types and are completely ineffective against still other types.

That no one device can be a panacea is evident from the fact that among the types of jamming the enemy can use individually or in practically any combination, are:

(a) Continuous Wave (cw) Jamming,
(b) Amplitude Modulated (AM) Jamming*,
(c) Frequency Modulated (FM) Jamming*,
(d) Carrier-Suppressed Noise Jamming (Dina).

The effectiveness of these various types of jamming will depend upon the combinations in which they are used, the technical characteristics of the radar involved and the skill of the operators.

The circuits used in the anti-jamming kits catalogued in the following pages have two basic purposes. One purpose is to prevent jamming signals from overloading the radar receiver, since as was mentioned earlier in this introduction, certain types of jamming are ineffective unless overloading occurs. The second basic purpose of the AJ circuits is to separate the desired pulse echo signals from jamming signals on the basis of certain differences between the echo and the jamming signals. This separation can be achieved:

a. On the basis of differences in amplitude.

b. On the basis of difference in wave shape (frequency components).

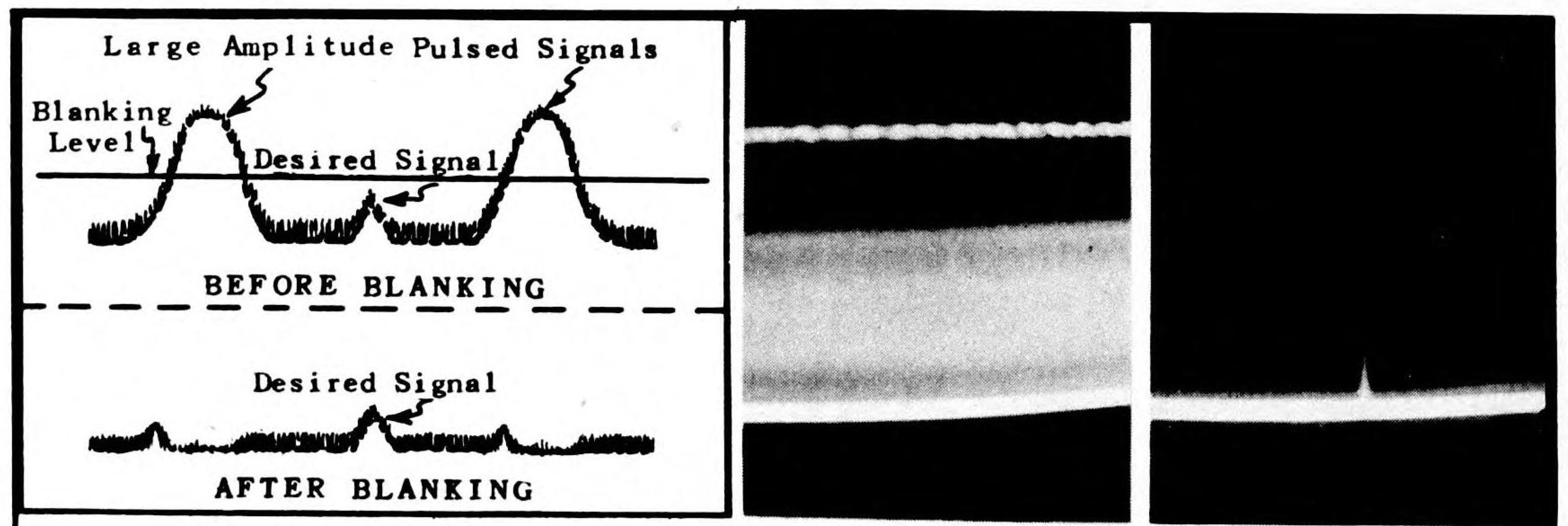
In general, the more nearly similar in these aspects are the echo and the jamming signals, the more difficult is the job of separation.

*Modulated by sine waves, square waves, pulses, noise, etc., at low, medium, high or random frequencies.

Two ways in which separation is accomplished on the basis of amplitude differences are known as blanking and clipping. Separation on the basis of frequency-component differences can be accomplished by use of a filter. One or more of these three actions-- (1) blanking, (2) clipping, (3) filtering --is performed by each of the anti-jamming kits catalogued in this book. A few general aspects of these three actions are indicated in the following paragraphs.

BLANKING: Blanking circuits are used to eliminate jamming signals above a predetermined amplitude-- the circuits responding normally to small desired pulse signals, but cutting off large-amplitude jamming signals. Although used primarily to cut off pulsed jamming signals above a predetermined amplitude, blanking also acts to eliminate the positive modulation peaks of jamming that is heavily modulated (approximately 50 per cent or more) by high-frequency sine waves.

The aim in eliminating the large-amplitude jamming signals is to prevent them from overloading the radar receiver, and hence to allow the receiver gain to be maintained sufficiently high to yield the required small-signal sensitivity. The small desired pulses which come through "between" the pulsed jamming signals, or which ride in the non-overloading troughs of the heavily modulated jamming are thus made easily readable.

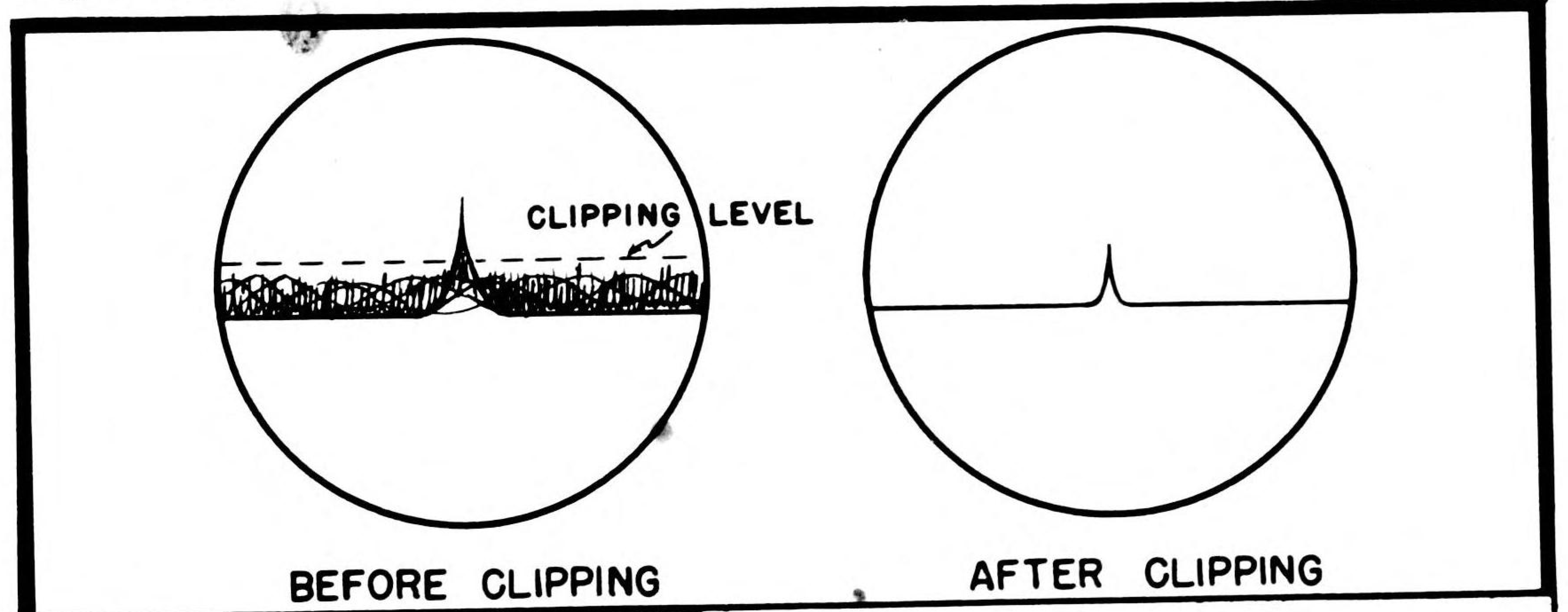


In the drawing at left above the blanking action is indicated in the case of jamming signals that are sufficiently far apart for the desired signal to appear. The two photos show the effect of the blanking circuit in Discriminator BC-1195-A when the desired signal has been completely lost. The center photo shows the normal BC-404 receiver scope of the SCR-270/271 when saturation jamming with 200 kc pulses (space-to-mark ratio 1:1) was encountered. The photo at right shows the same scope after the blanking circuit of BC-1195-A was used.

The usefulness of a blanking circuit will depend chiefly on the type of jamming encountered and technical features of the radar.

The larger the ratio of unoccupied space to space occupied by jamming pulses ("railings") the easier it is to see the desired signal when blanking is on. In the case of CW and weakly modulated CW, the protection of the blanking type circuit cannot be used. For these signals, it is necessary to reduce the receiver sensitivity to prevent video or i-f overload.

CLIPPING: The term clipping in the sense used here refers to the cutting off of unwanted signals below a given magnitude. This can be done, of course, only when the desired signal is higher than the clipping level. In general, clipping does not make the desired signal more apparent, but serves to clean up the radar scope by eliminating any jamming signals that are smaller than the desired signal. After clipping is done, however, the desired signal may be amplified without amplifying the clipped-off signals.



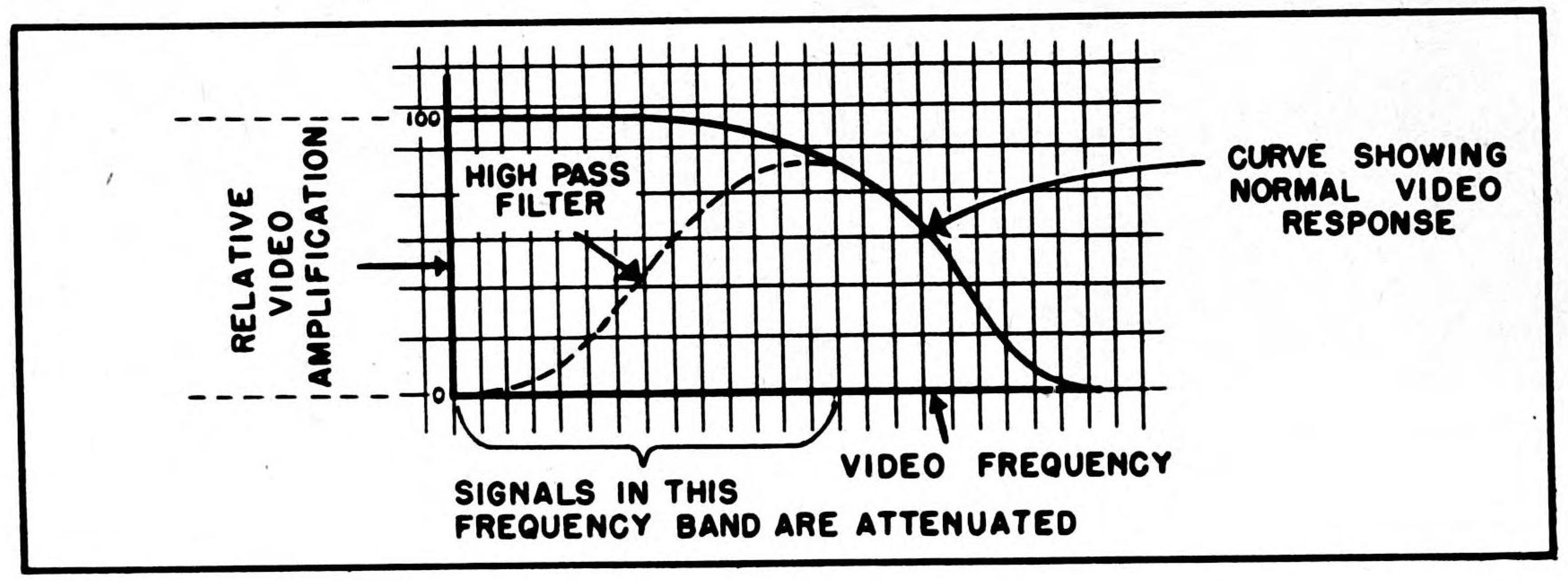
The effect of clipping in cleaning up a radar scope is indicated above. The purpose of a clipping circuit is to separate the desired echo signals from the jamming signals on the basis of differences in amplitude. Clipping is used in only one of the anti-jamming kits catalogued herein (Discriminator BC-1195-A) and is a minor feature of this kit.

FILTERING: Filter devices are used to separate the desired pulse echo signal from jamming signals on the basis of differences in frequency components (wave shape) between the desired and the jamming signals. Catalogued in the following pages are several high pass filters --that is, filters which pass high-frequency components of the desired pulsed signal, but eliminate or reduce in amplitude low-frequency components of the modulation. The net result of this action is that signals having a slow rise (e.g., low-frequency sine-wave-modulated jamming) are eliminated, while a sufficient part of signals having a sharp rise (pulse signals) are passed.

A filter that will remove low-frequency components of jamming signals will at the same time remove the low-frequency components of the desired pulsed signal and introduce some distortion of the pulse. The design of a filter thus must make a compromise between

these two effects. As a result, the filter cut-off is usually set at the value that produces the maximum allowable pulse distortion.

Two types of filters are catalogued herein. The filters developed for Radar Equipment SCR-268 are simple high-pass video filters. The filters that are part of anti-jamming units developed for other radar equipments use additional video amplification so that a considerably higher cut-off frequency may be used. The basic principle of such circuits, however, is the same as that of the simple high-pass filters.

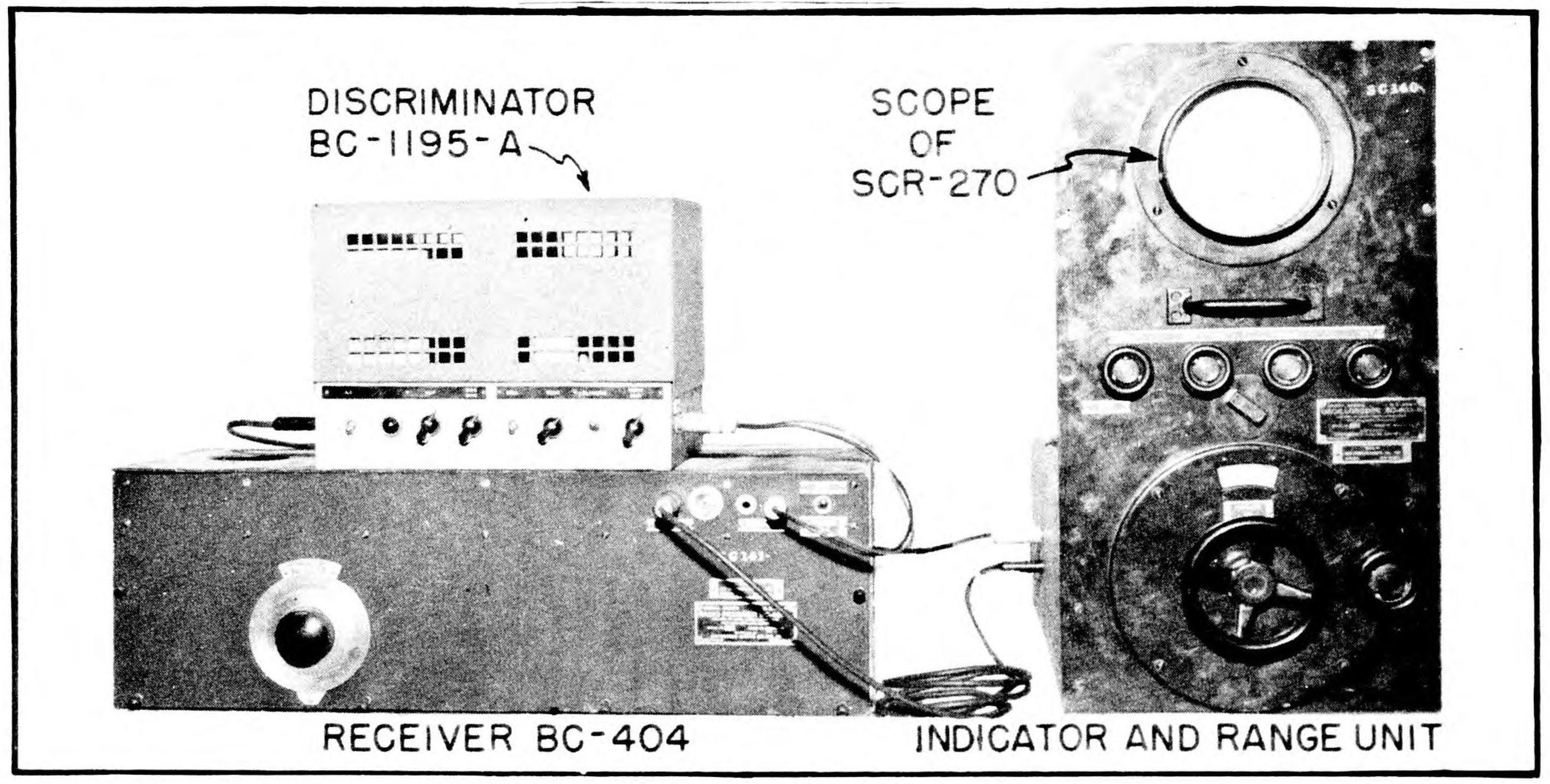


EFFECTS OF AJ DEVICES ON PERFORMANCE

The incorporation of an AJ feature in a radar (or the addition of an AJ kit) to combat jamming, will sometimes result in some impairment in the performance of the radar in the absence of jamming. This is the price that must be paid for the AJ feature. Since it may result in the radar being usable (or partially so) under jamming conditions that would otherwise make the radar inoperative, however, the cost in performance is well worth-while.

If the addition of an AJ circuit appreciably affects the normal operation of the radar, provisions must be made to remove this feature when jamming is not being encountered. It is important, however, that the circuit arrangements are such that the AJ unit can be returned to the circuit with no appreciable delay, and that the personnel are well trained in this operation.

DISCRIMINATOR BC-1195-A (GEORGE AND 1/2 MARY BOX)

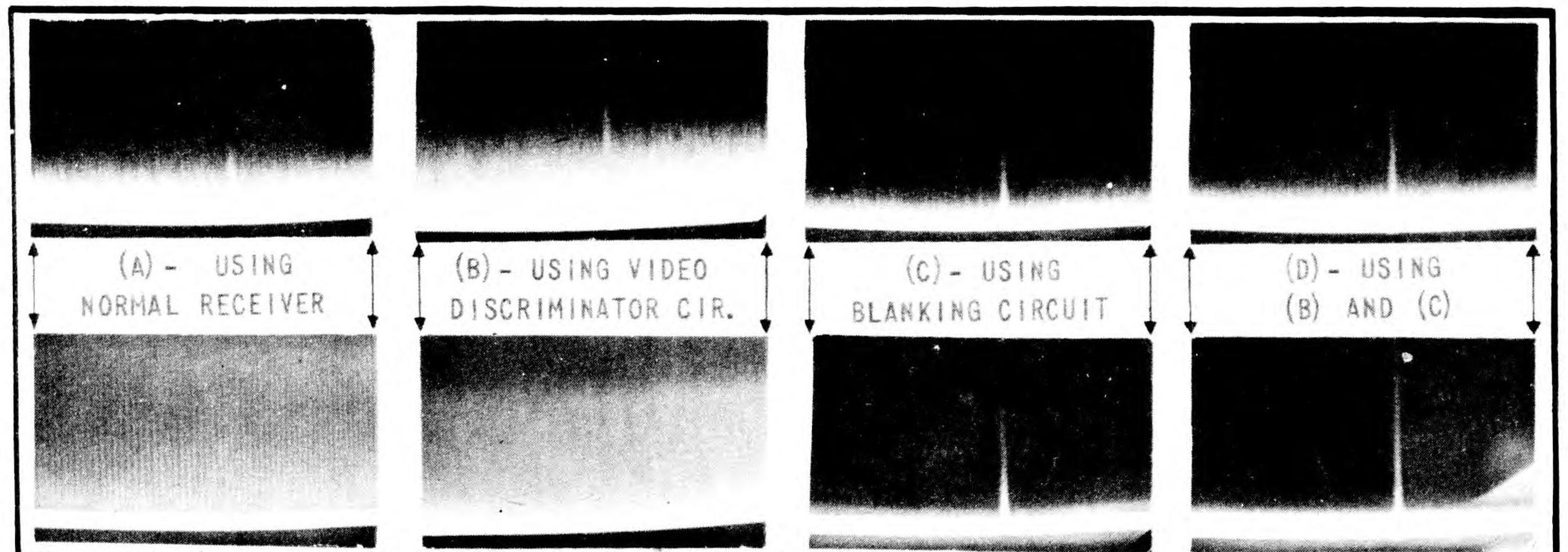


PURPOSE Discriminator BC-1195-A is an anti-jamming kit that is attached to the BC-404 receiver. This receiver is used on many radar sets in the SCR-270/271 series, including the SCR-270-D and E, and the SCR-271-D,E, F, G, H, J, K, L, M. Primary purpose of the kit is to minimize the effects of certain types of enemy jamming of these early warning radars. In addition, the kit eliminates interference from near-by radars on the same (approximately 100 Mc) frequency.

DESCRIPTION The kit is contained in one 10" x 12" x 9" case. Three main anti-jamming actions made possible by this kit are: (1) blanking, which serves primarily to eliminate pulsed jamming signals whose amplitude exceeds a predetermined level ; (2) clipping, which cuts off interference below a given magnitude; (3) high-pass filter action, whereby signals that have a sharp rise (desired pulsed echoes from targets) are passed, while jamming signals that do not have a sharp rise are reduced. (These 3 actions are discussed in more detail under *Features of Anti-Jamming Kits* in the introduction to this section.)

PERFORMANCE By treating jamming signals in the three ways mentioned above, the kit copes effectively with certain types of jamming now used by the enemy. How effective will be the blanking, clipping, or high-pass filter action will depend upon the type of jamming encountered. Laboratory tests indicate marked protection against unsynchronized, high-level pulse jamming at all recurrence rates and at all space-to-mark ratios. Further effective protection is obtained against strong signals that are amplitude- or frequency-modulated at frequencies up to approximately 5 kc. In general, the tests show that as the jamming signal becomes more complex, the effectiveness of the kit decreases. For example, protection against combination CW and pulses is not as complete as against CW or pulses alone. A complex signal such as noise is still more difficult to cope with, and against pure random noise the kit is ineffective.

The kit so effectively eliminates mutual interference between



These photos were taken during laboratory tests. The top series shows how BC-1195-A improved the presentation when 100 microvolt (at receiver input) CW jamming was encountered. The bottom series shows how the presentation was improved when overloading jamming with 50 kc pulses (space to mark ratio 1: 1) was encountered - the blanking circuit providing a readable signal.

adjacent SCR-270/271 radars that the use of Interference Reducer BC-736-( ) is unnecessary with this kit.

INSTALLATION & OPERATION Plugs allow the kit to be inserted between the receiver and indicator units of the radar --no changes in the radar being necessary. During operation careful adjustment is required of the various controls --gain of receiver, gain of BC-1195-A i-f amplifier, gain of BC-1195-A video amplifier, and the switching controls which allow selection of any desired combination of AJ features or complete elimination of them.

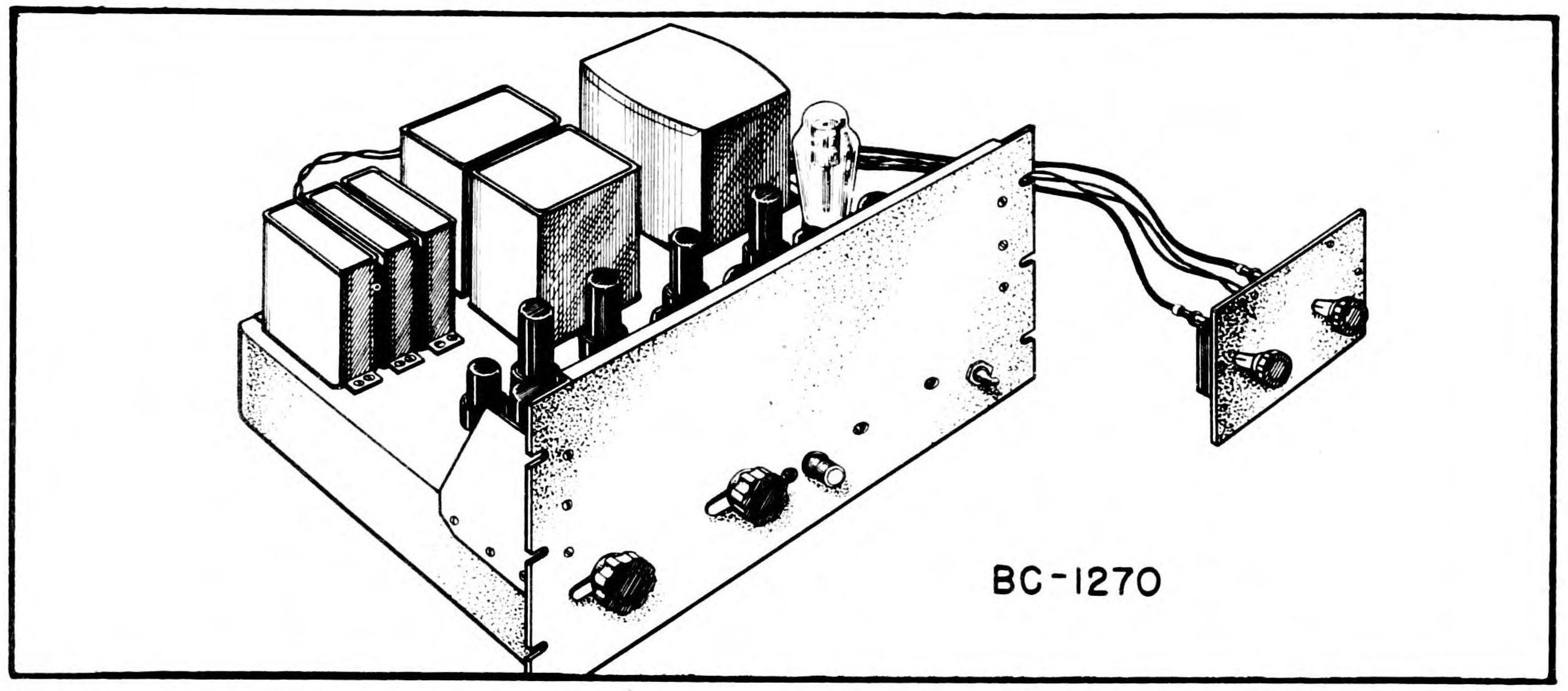
PERSONNEL The regular radar personnel operates the kit. Special training is essential, however, to enable an operator (1) to recognize the various types and combinations of jamming, and (2) to do the necessary experimenting with the possible combinations of the various controls. Practice equipment for training operators to cope with jamming of SCR-270/271 is available; such as AN/TPQ-T1 and AN/TPQ-T2, described elsewhere in this catalogue.

SPECIFICATIONS INPUT POWER: 125 watts, 115 volts, 60 cps.
I-F AMPLIFIER BANDWIDTH: 60 kc 20%.
BAND PASS OF VIDEO AMPLIFIER: In the video discriminator switch position the amplifier has a band pass characteristic whose response is down 3 db at 350 kc and at 80 kc and is peaked at 150 kc. With video discriminator out, the video bandwidth of the system is not appreciably affected by the BC-1195-A.
BLANKING LEVEL: The blanking level is set so that a signal will be blanked out when its amplitude exceeds 3½ volts at the output of the second detector. At full receiver gain (in the average receiver) this is slightly in excess of the maximum noise voltage at this point.
SIZE & WEIGHT: The kit is 10" x 12" x 9". Installed weight is 25 lbs.
TECHNICAL FEATURES: BC-1195-A makes use of the fact that the second detector of the receiver does not completely eliminate the intermediate frequency, which 'rides on top' of the pulses and is amplified by a second i-f amplifier following the receiver. If the pulse amplitude exceeds a certain value, however, the grid of the final stage of the receiver is driven beyond cut-off. Throughout the duration of a high-amplitude pulse, therefore, the output of the receiver, and hence of the i-f amplifier that follows it, is zero. Hence, for undesired pulse or 'railing' jamming or interference from nearby radars on the same frequency, no signal appears at the output during the intervals of the undesired high-amplitude pulses, whereas the normal desired echo pulses appear in the intervening intervals. The IF amplifier section in the BC-1195-A has a bandwidth narrower than that of the BC-404 receiver alone and makes the overall bandwidth near the best value for the radar pulse width used. This results in a slight increase in the maximum range of the set and a corresponding slight improvement in the presence of random noise jamming.

Low amplitude noise and jamming signals are removed by a second clipping circuit, which responds only to the peaks of the pulses that exceed a pre-set clipping level. In other words, the desired pulses are in effect 'skimmed' from the low-amplitude undesired signals. By the use of circuits of short time-constant in the video amplifier that follows the second clipper, the equipment is made to respond only to pulses having a steep wave front, and to minimize effects of a slightly-off-frequency CW, or MCW jamming.

STATUS Light production under way. The equipment is confidential.

INTERFERENCE REDUCER BC-1270



PURPOSE

BC-1270 is an anti-jamming kit that is attached to Receiver BC-1232-B in Receiver-Indicator Unit (console) BC-1239. This receiver unit is used on many radar sets in the SCR-270/271 series, including the SCR-270-BB, CB, DA, EA: and the SCR-271-BB, DA, FA, GA, HA, MA. Primary purpose of the kit is to minimize the effects of certain types of enemy jamming. In addition, the kit eliminates interference from near-by radars of the same frequency.

DESCRIPTION AND PERFORMANCE

The kit is contained on one 19 x 15 x 9 case. Two main anti-jamming actions made possible by the kit are (1) blanking and (2) high-pass filtering. (These two actions are discussed in more detail under *Features of Anti-Jamming Kits* in the introduction to this section.) How effective the kit is will depend on the type of jamming encountered. Laboratory tests have indicated the kit is effective against the same type of jamming as the previously described Discriminator BC-1195-A. In general, the effectiveness of the kit decreases as the jamming becomes more complex.

INSTALLATION OPERATION & PERSONNEL

BC-1270 is installed on top of the console, and operated by the regular radar personnel. Special training is essential, however, to enable an operator (1) to recognize the various types of jamming and (2) to properly adjust the various controls. Practice equipment for training operators to cope with jamming of the SCR-270/271 is available; such as AN/TPQ-T1 and AN/TPQ-T2 described elsewhere in this catalogue.

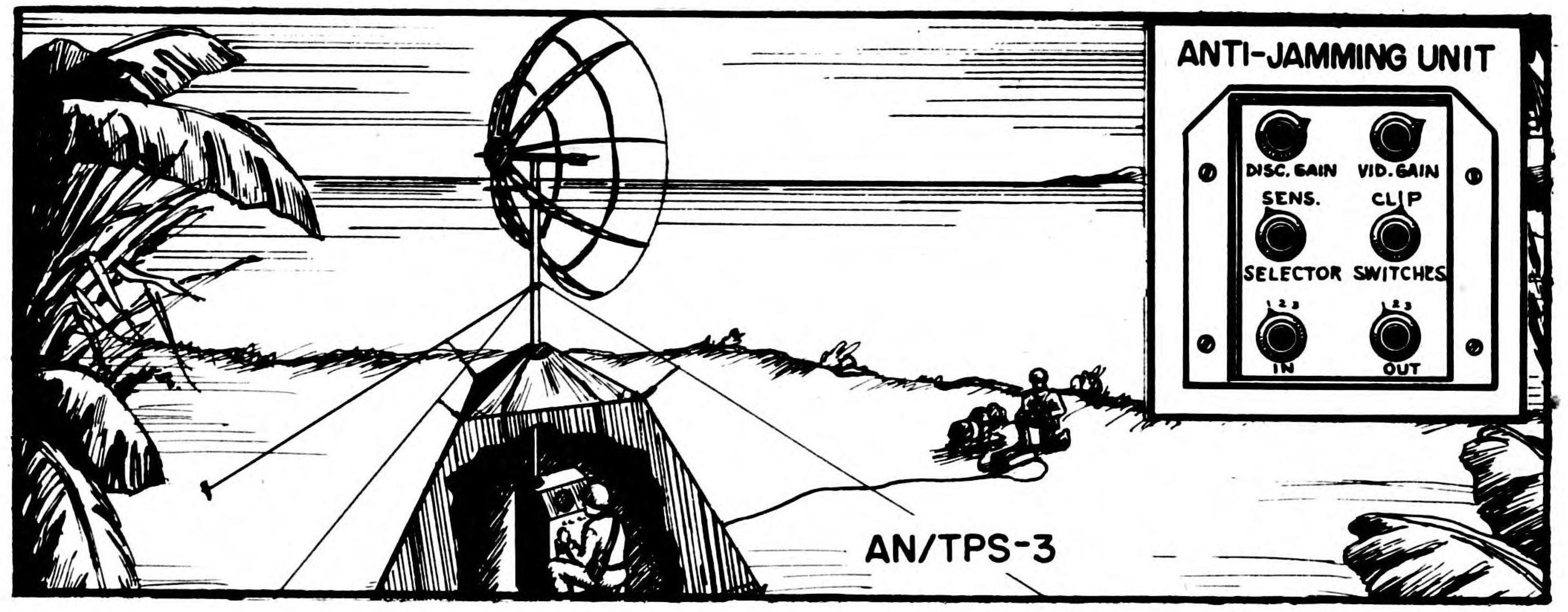
SPECIFICATIONS

INPUT POWER: 100 watts, 120 volts, 60 cps, A-C.
I-F AMPLIFIER BANDWIDTH: 83 KC ± 20%
BAND PASS OF VIDEO AMPLIFIER: In the video discriminator switch position the amplifier has a band pass characteristic whose response is down 3 db at 400 kc and at 70 kc, and is peaked at 150 kc. With video discriminator out, the video bandwidth of the system is not appreciably affected by the BC-1195-A.
BLANKING LEVEL: The blanking level is set so that a signal will be blanked out when its amplitude exceede 3½ volts at the output of the second detector. At full receiver gain (in the average receiver) this is slightly in excess of the maximum noise voltage at this point.
SIZE & WEIGHT: 19" x 15" x 9". Installed weight is approximately 60 lb.
TECHNICAL FEATURES: In basic design, BC-1270 is similar to the previously described DISCRIMINATOR BC-1195-A, differing only in that the resonant frequency of the i-f amplifier of BC-1270 is 36 Mc, and that the blanking stage is located in the BC-1270 unit instead of the receiver. Also, BC-1270 provides no clipping action. The video response is the same. BC-1270 must be used with the modified i-f amplifier in Receiver BC-1232-B, which affords diode-controlled back-bias and the necessary jacks.

STATUS

Medium production under way. The equipment is confidential.
An anti-jamming unit similar to BC-1270 is being developed for SCR-588-A which uses a receiver similar to BC-1232-A.

ANTI-JAMMING UNIT FOR AN/TPS-3



PURPOSE

This anti-jamming unit has been developed for minimizing the effects of enemy jamming of the AN/TPS-3 radar equipment, and for eliminating mutual interference between adjacent radars on the same frequency. AN/TPS-3 (SCR-602-T8) is a light-weight early warning radar for use by assault troops at captured air bases, beachheads, etc., until heavier radar equipment can be installed.

DESCRIPTION AND PERFORMANCE

Total weight of this AJ unit is only 2½ lb. Its performance and circuits are basically similar to the performance and circuits of the previously described BC-1195-A and BC-1270. There is no provision for the clipping action of BC-1195-A, but blanking and high-pass filter actions are provided. (These actions are discussed in more detail under *Features of Anti-Jamming Kits* in the introduction to this section.) The reduction in weight is accomplished chiefly by the elimination of a power supply --the AJ unit deriving its power from the AN/TPS-3 power supply. Smaller tubes are also used. Laboratory tests indicate the AJ unit will operate against the same type of jamming signals as the previously discussed BC-1195-A and BC-1270.

INSTALLATION OPERATION & PERSONNEL

The AJ unit is a separate component that must be inserted in early models of AN/TPS-3, but it will be a component part of the AN/TPS-3 receiver in later models. The controls for anti-jamming operations are readily manipulated from the front panel. The regular radar personnel operates these controls. Special training is required, however, to enable an operator to recognize the various types of jamming and to do the necessary adjusting of the anti-jamming controls. Practice equipment for training operators to cope with jamming of the medium wave (approximately 600 Mc) AN/TPS-3 is available; such as AN/UPT-T1.

SPECIFICATIONS

INPUT POWER: Provided from radar.
I-F AMPLIFIER BANDWIDTH: 900 Kc ± 15%.
BAND PASS OF VIDEO AMPLIFIER: Amplifier has a band pass characteristic whose response is down 3 db at 380 kc and 45 kc, and is peaked at 180 kc.
BLANKING LEVEL: The blanking level is set so that a signal will be blanked out when it exceeds a given value at the output of the second detector. This value is estimated to be 8 volts. At full receiver gain (in the average receiver) the blanking level is slightly in excess of the maximum noise voltage at this point.
SIZE AND WEIGHT: 4' x 6' x 10'; 2½ lb.
TECHNICAL FEATURES: In basic design, this anti-jamming unit is similar to the previously described BC-1195-A and BC-1270. There is no provision for the clipping action of BC-1195-A, and the resonant frequency of the i-f amplifier of the AJ unit for AN/TPS-3 is 17 Mc.

STATUS

This anti-jamming unit is in production. The equipment is confidential.