CHAPTER IV

AIRCRAFT RECEIVERS

55. GENERAL

The RU series are generally used with all equipments. The RU-2A receiver is designed for beacon installation and electrically is identical to the RU-2 receiver. RU-3 receivers are similar to RU-2 except that CW reception and AVC are both incorporated. RU-4 receivers are similar to RU-3. The frequency range provided is 224 to 13,575 kcs., with a tuning condenser ratio of 1.57 to 1, by plug-in coil sets covering the band in 11 ranges. The actual coil sets provided vary with the service for which the receivers are intended. Generally the ranges 224 to 350 kc., 3,000 to 4,525 kc., and 5,200 to 7,700 kc. are provided for receivers with the GF series transmitters, while a complete set of plug-in coils is provided for receivers issued with other transmitting equipment. For single-seat planes, dual coil sets are provided with remote switching so that the pilots of these planes may "throw down" from the HF communication channel to the IF direction finding channel.

The RAM receivers cover the ranges 200 to 1500 kcs. and 1500 to 13,575 kcs. simultaneously in two separate receivers operated from a common dynamotor. In order to conserve cockpit space near the operator, these receivers, which are of the all-wave superheterodyne type, are split into RF units and IF-AF units. The RF units are approximately 8 by 7 by 9 inches and contain all receiver controls on the front panels. Remote controls are provided, however, for quick attachment if conditions do not permit mounting the RF units convenient to the operator. These receivers are used with the model GN transmitters as two-channel equipment in liaison airplanes, but, at the time this pamphlet was written, were not in service and complete information not available.

Also, at the time this pamphlet was written, the RU-2A and RU-3 receivers incorporated all the electrical differences of the RU series receivers, and these two receivers are discussed in detail for this reason.

56. MODEL RU-2A BEACON RECEIVING EQUIPMENT & INSTALLATIONS

Model RU-2A equipment is a complete beacon receiving set designed for use on naval aircraft. It is adapted for installation and operation in airplanes of all types. It may be used to receive CW, MCW, and damped wave signals within the frequency range 200 to 400 kcs. The equipment consists of a type CBY-46012A receiver with mounting base, switch and junction boxes, remote and local tuners, headphones, and a Type CBY-21015 dynamotor unit, which operates from a 12-15 V. battery.

CIRCUIT AND TUBES

The receiver comprises three stages of RF amplification, a heterodyne oscillator for CW reception, a detector, and an audio amplifier. The radio frequency amplifier tubes are Type CBY 38039; the detector and heterodyne oscillator are Type 38036 tubes; the audio output tube is a Type CBY 38038. A sketch of receiver circuit is shown in Fig.56

The receiver uses plate type detection and has manual gain (sensitivity) control. When used to receive modulated signals, the plate voltage is removed from the oscillator tube by an external switch located on the receiver switch box. No means are provided for controlling the strength of oscillation of the heterodyne oscillator; the amplitude of oscillation is maintained automatically at a level suitable for the detector, as the receiver is tuned through any frequency band covered, by the rotation of the gang condenser. The ganged condenser terminates in a dial and is worm-gear driven either from a local handle or through the flexible coupling of the remote control. The output circuit of the audio amplifier tube consists of a filter section feeding into a step-down transformer. The receiver is designed for use with low impedance phones only. Only one coil set is required to cover the frequency range, 200 to 400 kcs.

The switch box contains the main switch for switching from CW to ICW and the knob for controlling the volume of sensitivity of the receiver. The remote tuning control consists of a dial which is worm-coupled to a flexible shaft controlled by a small crank handle.

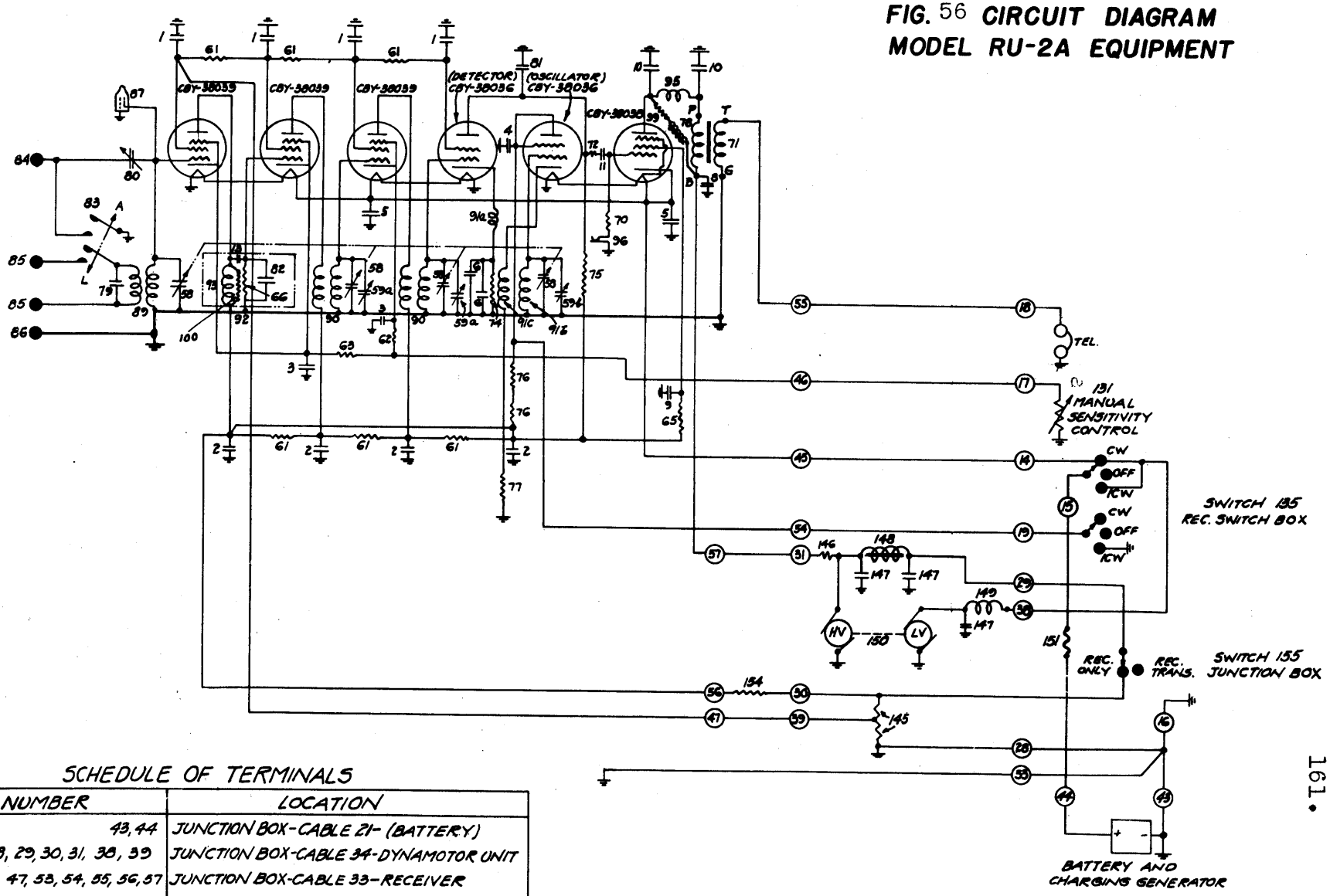
INSTALLATION

While this equipment may be operated locally, it was designed primarily for remote control.

Before installation of the radio equipment, the aircraft engine must be thoroughly shielded and bonded if satisfactory radio results are to be obtained.

The receiver mounting base should be permanently mounted on a plain surface at the chosen location in the airplane, and the receiver attached to it by means of the snapslides on the mounting bracket. An antenna suitable for receiving transmissions from radio beacons should have considerable vertical component when the airplane is in level flight, and will therefore usually have a small capacity external to the fuselage. Additional capacity to the fuselage between the lead-in insulator and the antenna binding posts shunts the receiver and may seriously reduce the signal energy reaching it. If, for physical reasons it is impossible to position the receiver binding posts closer than about one foot away from the lead-in insulator, the harmful shunting effect of this lead may be reduced by: (a) making it as small copper wire as is consistent with mechanical strength; (b) choosing a thinly insulated conductor. Heavy insulation on this lead increases its capacity. Size 18 single conductor, thin rubber insulation and suspended

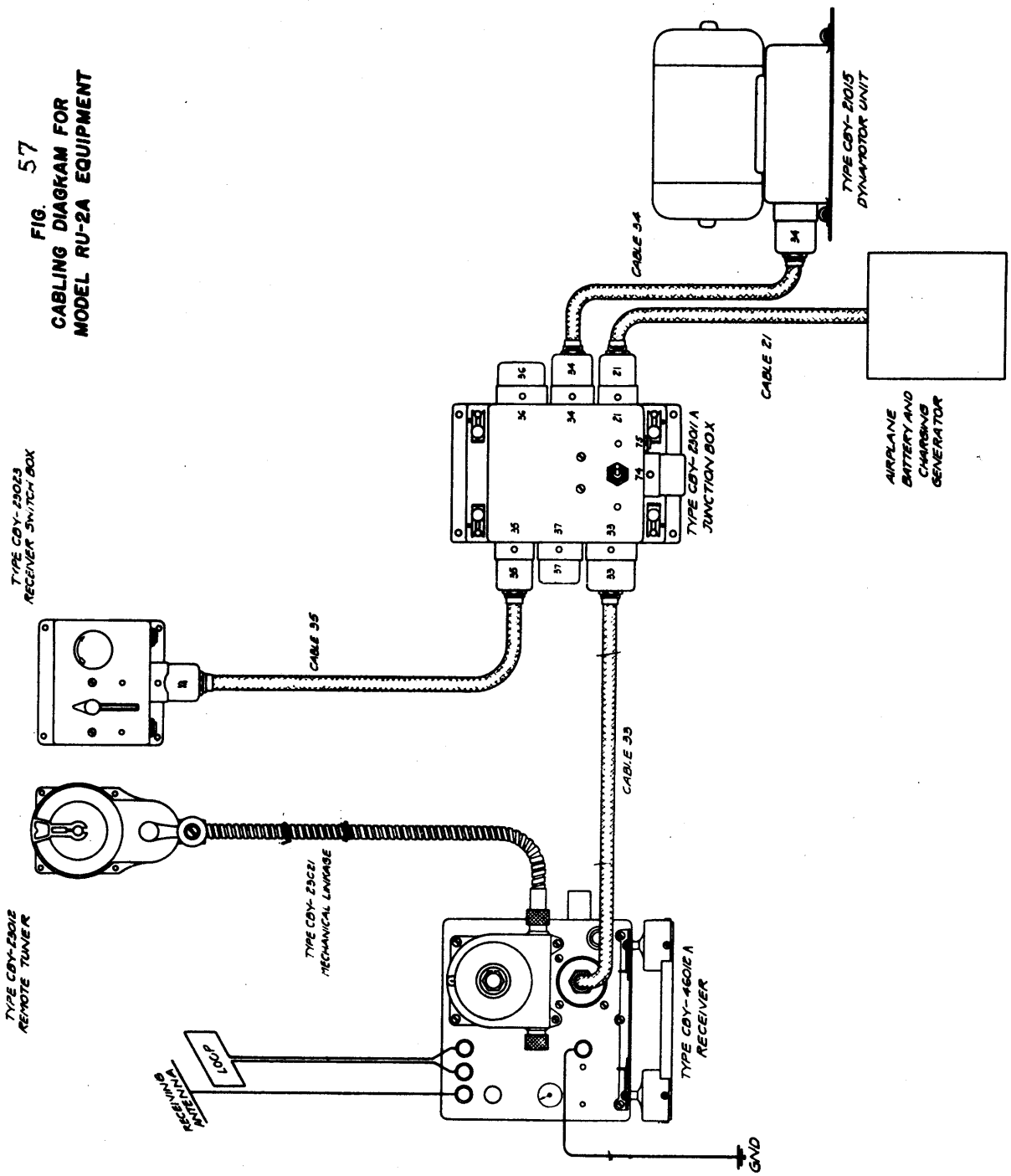
FIG. 56 CIRCUIT DIAGRAM MODEL RU-2A EQUIPMENT



SCHEDULE OF TERMINALS

NUMBER	LOCATION
43, 44	JUNCTION BOX-CABLE 21-(BATTERY)
28, 29, 30, 31, 38, 39	JUNCTION BOX-CABLE 34-DYNAMOTOR UNIT
45, 46, 47, 53, 54, 55, 56, 57	JUNCTION BOX-CABLE 33-RECEIVER
14, 15, 16, 17, 18, 19	JUNCTION BOX-CABLE 35-REC. SWITCH BOX

FIG. 57
CABLING DIAGRAM FOR
MODEL RU-2A EQUIPMENT



in the air throughout its length would be a desirable lead. The lead-in should be kept as far away from metal parts of the airplane as possible. The control cables and leads to the receiver must have slack to allow the receiver freedom of movement on its mounting base. The grounding post should be connected by a slack wire to the nearest metal member of the fuselage. Locations for the receiver which meet the above mentioned requirements can usually be found back of the observer's seat in single-seat airplanes, and either back of the observer's seat or on the shelf in front of it in two-seat airplanes. For a serviceable antenna for the RU-2A equipment, see the section on RECEIVING ANTENNAS.

A LOOP antenna cannot be used for the reception of radio range beacon signal, but on occasions the receiver may be used as a navigation instrument with a rotatable radio compass loop, or fixed homing loop, for use on non-directive transmitted signal. The technique of radio compass loop design and calibration is an expansive subject and is discussed elsewhere in this pamphlet. It may be stated as a general principle, however, that a loop which is effectively shielded must be used with Model RU-2A receiver for best results.

By "effectively shielded" is meant a loop either having its conductor inclosed in a metal housing, or position in close proximity to metal members of the airplane. A BELLINI-TOSI system may be used provided that the goniometer search coil (connected to the loop terminals of the receiver) has a center-tap ground. There is no ground on the circuit inside the receiver between its loop binding posts. The loop, or equivalent inductive circuit connected between the loop terminals, should have an inductance of approximately one hundred microhenries and a capacity of approximately one hundred micromicrofarads if the receiver is to be operated throughout the radio compass frequency bands.

RECEIVER SWITCH BOX REMOTE TUNER

The receiver switch box must be accessible to the operator whether the receiver is remotely controlled or locally controlled. In many installations for operation by an observer or navigator, the receiver may be tuned directly by means of the local, and the remote tuner is not needed. Dismissing this case from consideration, both the switch-box and the remote tuner should be mounted within easy reach of the operator.

DYNAMOTOR UNIT

The location of the dynamotor unit is a matter of comparative indifference, as far as the operation of the unit itself is concerned, but it is not advisable to mount it close to the receiving antenna lead-in.

CABLES AND MECHANICAL LINKAGE

The cables which interconnect the various units will normally be lashed or clamped to structural members of the airplane along their length. There is one important point to be observed in the installation of these cables: They are armored with metal braid and their outer surfaces may produce an electrical noise in the receiver unless they are carefully bonded to metal airplane members wherever they are likely to touch or rub thereon.

ADJUSTMENT OF INPUT ALIGNMENT CONDENSER

The final installation operation of the Receiver is the alignment of the antenna circuit of the Receiver by means of the input condenser 80, adjusted by knob 244. Set the switch 83 on its "A" position. The receiver is operated with the switch at "ICW". A signal is tuned in at the high frequency end of the tuning range. The volume control must be progressively retarded during the adjustment to keep the signal at the lowest audible level. Knob 244 is turned until the signal is a maximum. Then the receiver tuning must be readjusted for maximum, and knob 244 adjusted again for resonance.

Do not operate the receiver if, owing to the size or arrangement of the antenna and lead-in, it is impossible to adjust knob 244 for resonance, as indicated by maximum signal. The overall sensitivity will be low and the results will be unsatisfactory unless condenser 80, controlled by knob 244, is accurately adjusted.

Table No. 1 gives typical plate, screen, and bias voltages in this type receiver.

OPERATION

The Type CBY-23023 Receiver Switch Box turns off all power to the equipment. The connections of the power and control circuits in each of the operating positions have each been described in connection with the circuit diagram, Fig. 56. The Junction Box Switch 155 must be permanently in the "Rec Only" position in Model RU-2A Equipment.

OPERATING TEST

After installation, a receiver operating test must be made before flying with the equipment for which detailed instructions follow:

Plug the coil set into the Receiver. See that the full frequency range on the Remote Tuner dial can be swept through for the chosen position of the pointer without encountering the stops on the Remote Tuner. The Tuner should turn smoothly and easily.

Plug telephone receivers into the Receiver Switch Box. Turn switch to ICW. The dynamotor should start and as soon as the receiving tubes are warm a slight hum should be heard in the telephones, indicating that the receiver is operating.

Atmospherics and electrical "noise" are usually heard at the maximum "Increase" position of the volume control, particularly on the lower-frequency Coil Sets. Switch to CW; the noise in the telephones should increase in the CW position.

Before flying with the Receiver, the installation should be further checked with the airplane engine running. If with the volume control set at maximum at any position of the tuning dial, the electrical noise in the telephones increased on starting the airplane engine, this indicates imperfect shielding of the ignition or generator system, or difficulty with the voltage regulator of the charging generator. If circumstances render necessary the operation of the Receiver under these conditions only those radio signals can be receiver which are of greater electrical intensity than the local disturbance.

If the Receiver is installed for use on a radio compass loop in addition to the antenna, turn the switch 83 to its L position and repeat the tests on signal reception, with the Switch Box at both CW and ICW. Check the operation of condenser 80, controlled by knob 244, at a number of frequencies. It should be possible to resonate the input circuit at any position of the tuning control.

NOTE: For satisfactory direction finding or homing operations on any loop the signal should be received in the CW position of the switch regardless of whether the transmission is modulated of not.

OPERATING DIFFICULTIES AND POSSIBLE CAUSES

The following general principle should be remembered and constantly followed in connection with this equipment:

WHEN LOOKING FOR TROUBLE IN A RADIO SET ALWAYS EXAMINE THE SIMPLE CAUSES OF FAILURE FIRST.

Operations performed on the interior of the equipment, which are suggested in the following paragraphs, should be done only as a last resort, and after it is certain that the fault is not to be found outside the Receiver. Follow the routine given below for localizing the fault in one or more particular units of the Equipment.

RECEIVER OPERATIVE BUT NOISY

Probably the most common cause of poor radio reception in all airplane installations of high sensitivity Receivers is electrical "Noise" of both local and atmospheric origin. Operators of the Receiver should learn by experience to identify those "noises" in the telephone receivers which indicate faults in the apparatus or installation. Such identification by ear will greatly facilitate the correction of the fault. The following tabulation should be used as a guide.

(a) Atmospherics (static) , external man-made interference. Should be identified on the ground, engine not running. Static will be heard with Type CBY-47030A coil set at all seasons of the year and most times of the day. The general static level grows progressively lower with increasing

frequency. The Receivers cannot be adequately tested or inspected in ground locations where power line interference, motor interference and the like are excessive. Disconnecting the antenna of the Receiver binding post will generally give a satisfactory test, since if the noise encountered is static or power line interference it will greatly diminish or disappear when the antenna is disconnected.

(b) Dynamotor noise. Should be identified on the ground, engine not running; usually related to the speed of the machine and can be identified by switching the power on and off at the Switch Box.

(c) Intermittent contact in phone cord, plug, or contacts to telephone receivers should be identified on ground, engine not running.

(d) Loose bond or terminal plug on any Receiver cable. Should be identified on ground, engine not running.

(e) Ignition noise. Should be identified on ground, engine running, by varying the speed of the engine and by switching from one magneto to the other.

(f) Generator noise. Should be identified on ground, engine running, by advancing the throttle to the point at which the generator cuts in. If it originates on the generator itself, it will be a characteristic "machine noise"; if in the voltage regulator it will be intermittent and appear only above a certain critical engine speed (Usually 800 to 1000 R.P.M.) Noise originating in the generator or voltage regulator can be distinguished from ignition noise by the fact that generator and voltage regulator noise is usually suppressed by opening the airplane main line switch.

(g) Vacuum tube noise. Should be identified on ground, engine running; usually a crackling or ringing sound. It will sometimes appear under sustained vibration and never be heard at all when the Receiver set box is jarred intermittently by hand.

(h) Intermittent contact in an internal circuit of the Receiver. May be identified with the engine running or by jarring the Receiver by hand. Disconnecting the antenna and vibrating the Receiver is not necessarily a test because noises of this character may be increased to audibility by a strong incoming signal.

With regard to (a) it should be noted that it is no uncommon occurrence for man-made interference to be received with destructive force when flying over certain areas, and to be of such nature that it is easily confused with generator or dynamotor noise on the airplane itself. If"machine" noise on the airplane itself. If "machine" noises are suddenly heard in flight they may possibly be identified solely with a particular ground area. Also it should be remembered that when flying through mist, rain or snow, a noise is sometimes heard which sounds like a machine noise;

it is produced by the impact of the charged particles on the receiving antenna and airplane, and is irremediable.

With regard to (b), the interruption of current in the commutators of the dynamotor machine sets up radio frequency oscillations in the connecting Cables, which oscillations enter the Receiver by way of the antenna (never through the conductors of the Cables themselves; this fact may be verified by disconnecting the antenna at the Receiver binding post). The transmission of dynamotor noise to the Receiver is related to the condition of bonding of the Cables, particularly at high frequencies. A dirty commutator will produce more noise than a clean one, but complete suppression can never be obtained if the shielded Cables are not thoroughly bonded and grounded. This fact should be remembered when making bench installations of the Radio Set for test purposes. When this noise occurs in an airplane installation the bonding of all cables to the airplane should be checked for poor contacts. If the noise persists, the commutators of the machine may be cleaned with FINE SANDPAPER, grade 000 or finer, while the machine is turning over. All grit and dust produced by this cleaning process must be carefully removed from brush holders and commutators. NEVER USE EMERY ON A COMMUTATOR. A trace of oil or grease on a commutator may cause more trouble than a dirt deposit. The low-voltage commutator is more apt to produce noise than the high voltage commutator. Access to the brushes and the commutators of dynamotor 150 is obtained by removing end covers 213 which are secured by screws 216. Under normal operating conditions the commutators of these enclosed machines should not require cleaning oftener than about 300 hours. But if the dynamotor is noisy or inefficient and the cause of the trouble cannot be located elsewhere the commutator may be cleaned with fine sandpaper as described above.

(c) Is a very common, but easily remedied cause of complete interruption of service, because of the severe wear to which these items are subjected.

With regard to (f), generator and voltage regulator noise is frequently a more elusive fault than ignition interference. A temporary remedy, if the generator becomes noisy in the air, is to open its field while receiving, but this is not a cure, and should not be permanently tolerated. Complete shielding will not always cure voltage regulator interference. For best results the voltage regulator out-put should be electrically filtered. A method of doing this, which is effective in many installations, is to connect a condenser of 1 2mfd. capacity between the positive generator field terminal and ground, and a second condenser of 1 2mfd. between the positive 14 volt out-put terminal and ground. To be effective this must be done AT THE GENERATOR, using the shortest possible leads.

With regard to (g) an intermittent contact inside a tube is sometimes the first indication that its useful life is over.

Noises originating in the tubes are GREATLY ACCENTUATED BY THE PRESENCE OF A STRONG INCOMING RADIO SIGNAL, particularly an unmodulated signal, and this may be used as a means of identifying such noise. The faulty tube must be isolated by replacing the tubes one by one with new ones and observing when the disturbance vanishes.

If the trouble is due to (h) the receiver must be dismounted and inspected internally for loose connections. To remove the receivers chassis from its case, first take out the coil set, then remove from the set box twelve bright finished screws. Do not lose the lock washers from these screws; these washers must all be replaced when screws are replaced. The front panel may be then separated from the case, which slides backward off the frame. Black-headed screws and rivets must not be removed from any part of the receiver. Do not disarrange the internal wiring of the receiver during this inspection.

Operating the receiver at excessively high voltages tends to make it noisy during operation and to increase the residual cause of noise. NEVER ALLOW THE RADIO SET TO BE OPERATED AT A SUPPLY VOLTAGE GREATER THAN 15 VOLTS. Operation at less than 12 volts will not damage the equipment, but the radio reception will be unsatisfactory.

RECEIVER DEAD. NO SOUNDS.

Having checked all plug and cable connections, dismount the junction box with cables attached and check all voltages. Inspect junction box for open-circuits. Check position of junction box switch 155. It must be at "REC ONLY". Try another coil set. Be sure that coil sets are securely seated. If dynamotor does not run; (a) check fuse 151 and renew if it is open; (b) substitute another dynamotor unit and if it runs, look for an open circuit at the low voltage brushes of the first machine; (c) check circuit through switch box switch in CW and ICW position, starting at 44 and ending at 38 in junction box. If dynamotor runs, but voltage on terminal 29 or 31 is low, check the continuity of high voltage circuits through resistor 146, choke 148 in dynamotor unit base. Check condensers 147 for short circuits. If all voltages on receptacle 165 are normal, check volume control circuit through terminal 17 to ground. If this circuit is normal and the receiver is still inoperative it should be dismounted for a bench test.

Remove the receiver case and inspect the wiring for short circuits. Check transformer 71, condenser 78 and coil 95 for open circuits between their respective terminals. Check the coil set for open circuits between the respective pairs of terminals which are closed by windings. Inspect contacts of all tube sockets.

IMPORTANT NOTE: All readings of electrode bias voltages and supply voltages in the receiver should be made with the switch on CW and the control grid of each of the three

CBY-38039 tubes CONNECTED TO GROUND and with the control grid clips in place on their respective tubes. If this condition is not fulfilled the receiver will oscillate, since it is out of its shielding case, and the voltage readings will be abnormal.

If there is no plate voltage on one tube, check the contacts made between the various pin plugs and their respective receptacles on the coil set. These pin plugs may become distorted after long use; their ability to make contact can be restored, unless the springs are fractured, by tapping each plug on the end to spread the contact springs. If the cathodes or screen grids do not show approximately the same voltages as those in the table, check the circuits through the various decoupling resistors in supply lines from 46 to the cathodes, 47 and 56 to the screen grids, and 56 to the plates. If an ohmmeter is available check the values of these resistors. Check all by-pass condensers 1, 2, 3, 4, 5, 6, 7, 8, and 9 for internal short circuits. Check resistors 66, 62, 67, 68, 70, and 72 for short circuits. Check the neon tube 87 for a short circuit. Under normal service conditions this tube will last for the life of the receiver without replacement.

57. MODEL RU-3 RECEIVING EQUIPMENT

GENERAL

Model RU-3 receiving equipment is a complete radio receiving set designed for use on aircraft. It is adapted for installation and operation in airplanes of all types. It may be used to receive modulated, unmodulated, and damped-wave signals in the frequency range 224 - 13,575 Kc.

Model RU-3 receiving equipment consists of a Type CBY-46036 receiver, Type CBY-46011 receiver mounting base, Type CBY-62003 junction box, Type CBY-21108 dynamotor unit, Type CBY-23046 receiver switch box, Type CBY-23012 remote tuner, Type CBY-23021 remote tuner mechanical linkage, and 15 sets of coils covering the frequency range.

These units are also parts of Model GF and Model RU-2 equipments and may be used interchangeably in Models RU-2, RU-3, GF, and GF-1. No other items listed herein may be used in Model RU-2 or Model GF equipment. Fig. 58 shows cabling diagram while Fig. 59 and Fig. 60 shows schematic circuit.

RECEIVER.

Type CBY-46036 receiver consists of a set-box including the supply and coupling terminals, tube sockets, power terminals and plug-in coil terminals.

Electrically the receiver comprises three stages of radio frequency amplification, a detector and one audio amplifier, an A.G.C. stage , and a heterodyne oscillator. The radio amplifier tubes are Type CRP-38078; the detector and