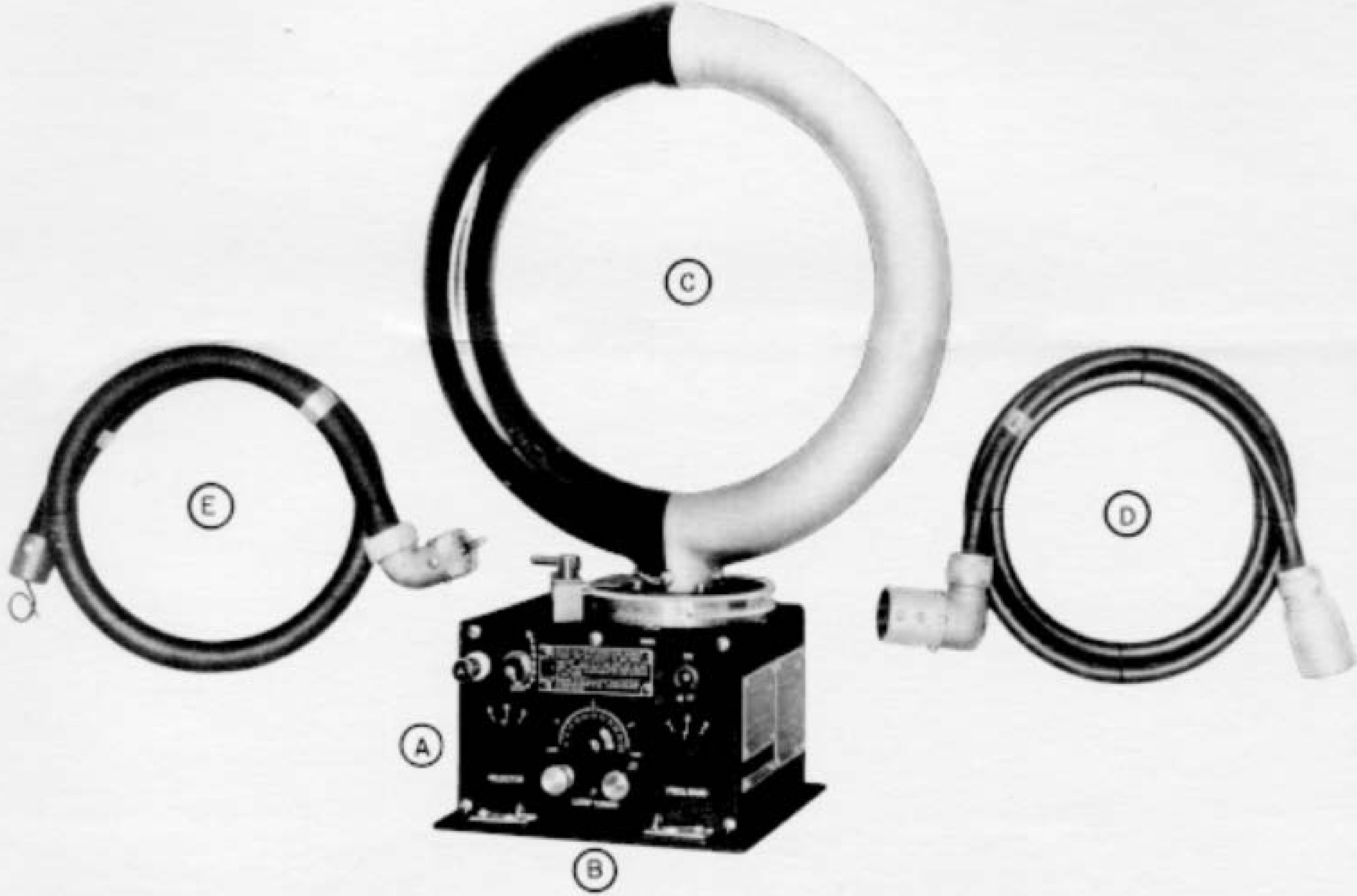

SEE SECTION 1-2 FOR DESCRIPTION OF ITEMS

1824

FIG. 1–COMPOSITE VIEW, MODEL DU-1 EQUIPMENT

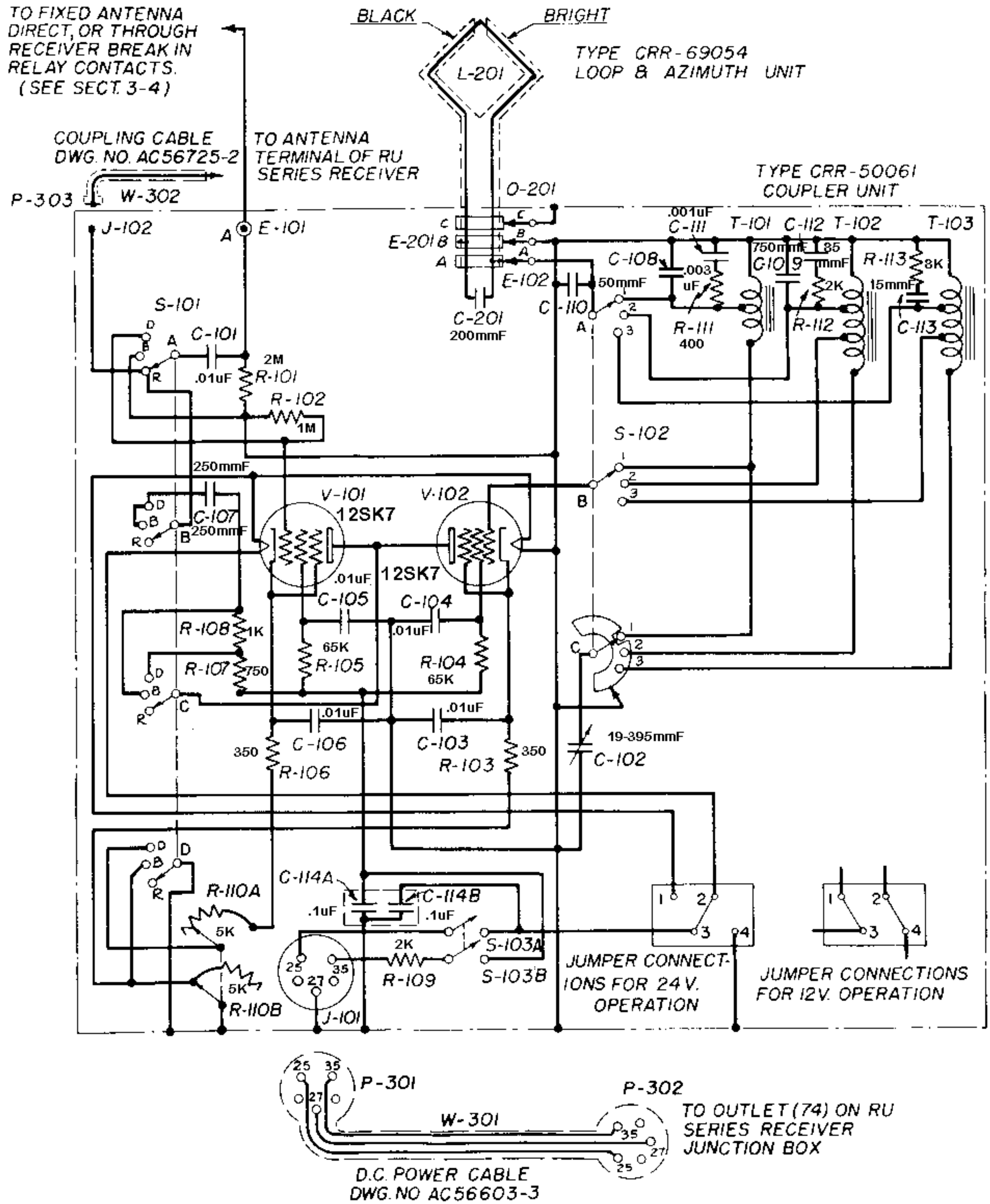

FIG.12- SCHEMATIC DIAGRAM

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Table II

PARTS LIST BY SYMBOL DESIGNATIONS FOR MODEL DU-1 RADIO DIRECTION FINDING EQUIPMENT

Symbol Desig.	Function	Description	Navy Type Desig.	Mfr.	Mfr's. Desig.	Bendix Dwg. Number
SECTION 1 (101 TO 199)—TYPE CRR-50061 COUPLER UNIT						
CAPACITORS						
C-101	Antenna Coupling	.01 Mfd, ±10%, 500 V DCW, Mica	-48848-B10	2	1467	C56303-103
C-102	Tuning	19-395 ±2%	.	4	MC-400M	C56689
C-103	Loop Amp Cathode Bypass	Same as C-101	.	.	.	.
C-104	Loop Amp Screen Bypass	Same as C-101	.	.	.	.
C-105	Ant Amp Screen Bypass	Same as C-101	.	.	.	.
C-106	Ant Amp Cathode Bypass	Same as C-101	.	.	.	.
C-107	Output Coupling	250 Mmf, ±10%, 500V DCW, Mica	-48690-B10	2	1468	C56306-251
C-108	Loop Trimmer, Band 1	.003 Mfd, ±10%, 500V DCW, Mica	-481036-B2	2	1467	C56736-302
C-109	Loop Trimmer, Band 2	750 Mmf, ±2%, 500V DCW, Mica	-481158-B2	2	1468	C56734-751
C-110	Loop Trimmer	50 Mmf, ±2%, 500V DCW, Mica	-48895-B2	2	1468	C56734-500
C-111	Loop Equalizing, Band 1	.001 Mfd, ±2%, 300V DCW, Mica	-481070-B2	2	1468	C56734-102
C-112	Loop Equalizing, Band 2	85 Mmf, ±2%, 500V DCW, Mica	-481157-B2	2	1468	C56734-850
C-113	Loop Equalizing, Band 3	15 Mmf, ±2%, 500V DCW, Mica	-48840-B2	2	1468	C56734-150
C-114A	HV Bypass	0.1 Mfd, 10% −3%, 400V DCW,				
C-114B	LV Filament Bypass	Oil Paper	.	3	A26903	A26903
MISCELLANEOUS ELECTRICAL PARTS						
E-101	Antenna Terminal	Push Type, Brass, Nickeled	.	1	.	AA18736-2
E-102	Loop Brush Assembly	3 laminated brushes	.	1	.	AA26684-1
RECEPTACLES						
J-101	Power Receptacle	5-contact, for 1¼" plug	-49036	1	.	AA306-2
J-102	RF Output Receptacle	1-contact, 11/16" bushing	.	1	.	AA11893-2
MISCELLANEOUS MECHANICAL PARTS						
O-101	Tuning Dial Pinion	32P, 12T, .043" F, .218" hole	.	1	.	A26686
O-102	Tuning Dial Gear	32P, 48T, .062" F, .875" hole	.	1	.	A26688

Symbol Desig.	Function	Description	Navy Type Desig.	Mfr.	Mfr's. Desig.	Bendix Dwg. Number
RESISTORS						
R-101	Antenna DC Leak	2,000,000 ohm, ±10%, ½W, Comp	-63360	6	BT-½	A11207-59
R-102	Ant Amp Grid Return	1,000,000 ohm, ±10%, ½W, Comp	-63360	6	BT-½	A11207-57
R-103	Loop Amp Fixed Bias	350 ohm, ±10%, ½W, Comp Pigtail	-63360	6	BT-½	A11207-6
R-104	Loop Amp Screen Dropping	65,000 ohm, ±10%, ½W, Comp	-63360	6	BT-½	A11207-44
R-105	Ant Amp Screen Dropping	Same as R-104	.	.	.	.
R-106	Ant Amp Fixed Bias	Same as R-103	.	.	.	.
R-107	Unilateral Plate Load	750 ohm, ±5%, ½W, Comp Pigtail	-63355	6	BT-½	A18191-751
R-108	Bilateral Plate Load	1000 ohm, ±5%, ½W, Comp	-63355	6	BT-½	A18191-102
R-109	HV Filter	2000 ohm, ±10%, ½W, Comp	-63360	6	BT-½	A11207-17
R-110A	Ant Amp Gain Control	5000 ohm, ±10%, ½W, Variable, Special taper	-63811	7	18-010-015	C56737
R-110B	Loop Amp Gain Control	5000 ohm, ±10%, ½W, Variable, Special taper	.	.	.	.
R-111	Loop Equalizing, Band 1	400 ohm, ±5%, ½W, Comp	-63355	6	BT-½	A18191-401
R-112	Loop Equalizing, Band 2	2000 ohm, ±5%, ½W, Comp	-63355	6	BT-½	A18191-202
R-113	Loop Equalizing, Band 3	8000 ohm, ±5%, ½W, Comp	-63355	6	BT-½	A18191-802
SWITCHES						
S-101A-D	Reception Selector	4-pole, 3-position, 2 decks	.	8	.	C56729
S-102A-C	Frequency Band	3-pole, 3-position, 1 deck Shorting sector on front of deck	.	8	.	C56730
S-103A-B	Power On-Off	DPST, Toggle, 3A at 250V	-24025	9	.	A10677-2
RF TRANSFORMERS						
T-101	Loop Tuning, Band 1	Litz winding, Iron core	.	1	.	AL71791-18
T-102	Loop Tuning, Band 2	Litz winding, Iron core	.	1	.	AL71791-19
T-103	Loop Tuning, Band 3	Litz winding, Iron core	.	1	.	AL71791-20
VACUUM TUBES						
V-101	Antenna Amplifier	Single-ended Pentode, Metal	-12SK7	10	12SK7	A27850
V-102	Loop Amplifier	Same as V-101	.	.	.	.
VACUUM TUBE SOCKETS						
X-101	V-101 Socket	Octal socket, Ceramic	-49373	11	SS8	A27517-1
X-102	V-102 Socket	Same as X-101	.	.	.	.

Table II (Continued)

SECTION 2 (201 TO 299)—TYPE CRR-69054 LOOP AND AZIMUTH UNIT

CAPACITOR

Symbol Desig.	Function	Description	Navy Type Desig.	Mfr.	Mfr's. Desig.	Bendix Dwg. Number
C-201	Loop Trimmer	200 Mmf, 500V DCW, Mica	-48675-B2	2	1468	C56734-201

INDUCTOR

Symbol Desig.	Function	Description	Navy Type Desig.	Mfr.	Mfr's. Desig.	Bendix Dwg. Number
L-201	Loop Antenna	6 turns, Litz wire, Phenolic form, Static shielding	.	1	.	AL71779-1

MISCELLANEOUS ELECTRICAL PARTS

Symbol Desig.	Function	Description	Navy Type Desig.	Mfr.	Mfr's. Desig.	Bendix Dwg. Number
E-201A, B	Loop Contact Assembly	2 Monel contact rings	.	1	.	AA26808-1
E-201C	Nut Collector Ring	1 Contact ring	.	1	.	A26806

MISCELLANEOUS MECHANICAL PART

Symbol Desig.	Function	Description	Navy Type Desig.	Mfr.	Mfr's. Desig.	Bendix Dwg. Number
O-201	Azimuth Scale Bearing	.9843″ ID, 2.0473″ OD, .8125″ W.	.	*{12 {16	5205-AN 5205 X138	A1790-1 A1790-1

SECTION 3 (301 TO 399)—ACCESSORIES

PLUG CONNECTORS

Symbol Desig.	Function	Description	Navy Type Desig.	Mfr.	Mfr's. Desig.	Bendix Dwg. Number
P-301	Plug Connector	5-contact, 1¼″ OD, 90°	-49114	13	.	A26491-1
P-302	Plug Connector	5-contact, 1¼″ OD, Straight	-49115	13	.	A28598
P-303	Plug Connector	1-contact, 90°, Screw-on	.	1	.	See Fig. 19

CABLES AND CONDUIT

Symbol Desig.	Function	Description	Navy Type Desig.	Mfr.	Mfr's. Desig.	Bendix Dwg. Number
W-301	Power Cable	3-conductor, Internally shielded .500″ OD	.	14	.	A27583
W-302	Coupling Cable	Shielded conduit, Rubber covered	.	1	.	See Fig. 19

* Obtained from either manufacturer.

1-3. ADDITIONAL EQUIPMENT REQUIRED

The following additional equipment, not supplied as a part of this contract, will be required for each standard installation of the Model DU-1 Radio Direction Finding Equipment:

1. Radio receiving equipment of the Navy Model RU series, complete, including 11- to 15-volt DC primary power source, antenna collector of substantially nondirectional characteristics, operator's headphones, etc. (the junction box of the Model RU equipment must be a Type CBY-23011A or later issue, provided with an auxiliary power outlet receptacle).

1-4. POWER REQUIREMENTS

All power required for the direction finding operation of this equipment is drawn from the junction box of the Navy Model RU series receiving equipment. The maximum requirements are:

0.32A at 12V and 0.016A
at 200V approx.

2. DETAILED DESCRIPTION

2-1. EXPLANATION OF DIRECTION FINDING PRINCIPLES

If a loop collector is connected to the antenna and ground input terminals of a radio receiver, and the voltage induced by a signal from a fixed transmitting station is plotted for various angles as the loop is rotated about its vertical axis, the resultant curve will be a figure-of-eight. Such a polar diagram is shown at B, Figure 10, from which it will be seen that zero voltage is produced at the two positions in which the plane of the loop is parallel with the wave front, and that maximum voltages of opposite phase are produced respectively at the two positions where the plane of the loop is at right angles with the wave front (this is true only when the design of the loop and its associated circuits are such that no vertical or antenna effect is present due to imperfect loop shielding or unbalance of capacity between opposite terminals of the loop and ground, and when there is no direct reception or signal pick-up independent of the loop). In other words, a loop collector displays a bilateral directional characteristic, showing two sharply defined *minima* of practically zero pick-up essential for obtaining accurate *bearings*, and two relatively broad maxima.

The action of a vertical antenna, when connected to the same receiver, is very different from that of a loop. This could be shown by moving a transmitter in a complete and true circle about the vertical antenna as a center, and plotting the voltage induced in the antenna against the angular position of the transmitter. The resultant polar diagram would be as shown at A, Figure 10, from which it will be seen that the induced voltage is of the same amplitude and phase for all angles. In other words, a vertical antenna displays no directional properties. Likewise, ordinary fixed and downward trailing airplane antennas are only slightly directional.

If both loop and antenna are now connected to the receiver, and the antenna voltage and phase are adjusted to equality with that

obtained at one maximum position of the loop, the resultant output will be twice that obtained for either collector alone. At the opposite loop maximum, the resultant output will be zero since the loop voltage is then equal in amplitude but opposite in phase to that of the antenna. At the two loop minima, the resultant output will be equal to that picked up by the antenna alone. Plotting these values in a polar diagram produces a heartshaped reception pattern, or *cardioid*, as shown at C, Figure 10. It will be noted that the minimum obtained with this combination is not so sharply defined as the two minima obtained with loop reception alone. Moreover, if the phasing of antenna and loop is not absolutely correct, the cardioid pattern will be distorted and the position of the minimum will be correspondingly shifted. The most discernible characteristic of the cardioid is the great difference between receiver outputs at or near the two positions where the maximum output is obtained with the loop alone. In other words, an antenna-loop combination displays a sense characteristic which permits unmistakable determination of the direction to the source of a transmitted wave, but is not capable of the sharply directive bearings obtained with the loop collector alone.

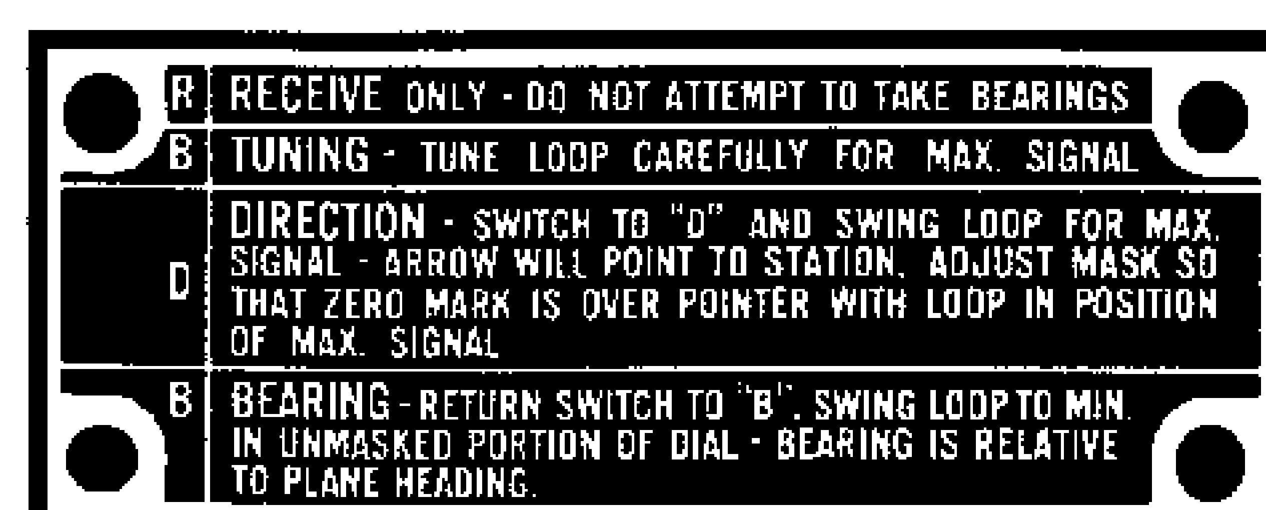
2-2. GENERAL

The Model DU-1 Aircraft Radio Direction Finding Equipment consists of a loop antenna, vacuum tubes, and suitable signal coupling circuits for determining, without ambiguity, the bearing of a radio transmitting station when the equipment is used with a suitable vertical antenna. The equipment is designed for use over the frequency range 200 to 1600 Kcs. This range is covered by three manually switched bands: 200 to 400 Kcs; 400 to 800 Kcs; and 800 to 1600 Kcs.

2-3. TYPE CRR-50061 COUPLER UNIT

The Model DU-1 Radio Direction Finding Equipment combines the output of the loop antenna with that of the vertical antenna to provide nonambiguous bearing indications on radio transmitting stations when used in conjunction with the auxiliary equipment listed in Section 1-3.

This is made possible by the selector switch S-101 on the coupler unit, which arranges the circuits in proper sequence for each of the operating procedures involved. These operations, which are explained on an instruction plate mounted on the front panel, are reproduced here for the reader's convenience:



R, B, and D are the initial letters of the words naming the particular operations referred to. They are also the designating letters of the three positions of the ganged selector switch S-101, in each of which the circuits necessary to the desired operation are automatically arranged. During the following discussion it may prove helpful to refer to the fundamental circuit diagrams (Figure 11) and the schematic diagram (Figure 12).

Filament and plate operating power is introduced at the lower input receptacle J-101 and controlled by sections A and B respectively of the power on-off switch S-103.

In the R position of the selector switch, the antenna post E-101 is connected through C-101 and S-101A to the output receptacle J-102, hence, the radio signal passes directly from the vertical antenna to the ship's radio receiver. This position is used for communication reception only, the direction finding equipment being inoperative. Note that this circuit is independent of any other circuit within the coupler unit. Consequently, it is not necessary for S-103 to be on for the equipment to function in this switch position.

In the B position of the selector switch, the antenna post E-101 is grounded to the chassis through C-101 and S-101A; J-102 is connected through S-101B and C-107 to the plate load network. V-101 is rendered inoperative by the open circuit existing in its cathode return at S-101D, so that only the signal picked up on the loop is amplified by V-102. The plates of V-101 and V-102 are connected to the high voltage bus through S-101C, R-107, and R-108 which thus act as the plate load for V-102 for bilateral operation of the equipment.

It should here be noted that S-102 is the frequency band switch which selects the range of frequencies tuned by the equipment. Three transformers are used to cover the required range: T-101 for Band 1, T-102 for Band 2, and T-103 for Band 3. These transformers are iron core auto-transformers. The loop L-201 is connected to the selected transformer primary through S-102A, the control grid of V-102 is connected to the secondary, or to a tap on the secondary, of the selected transformer through S-102B; while S-102C performs the dual function of short circuiting the windings of unused transformers, and connecting the tuning capacitor C-102 to the secondary of the selected transformer.

The RF signal from the loop passes through the loop transformer of the band selected, thence to V-102 where it is amplified and finally out to J-102, the output receptacle.

In the D position of the selector switch, the antenna post E-101 is connected to the control grid of V-101 through C-101 and S-101A, so that the signal picked up on the vertical antenna is amplified by V-101. The signal picked up on the loop is amplified by V-102. J-102 is connected through S-101B and C-107 to the plate load network. The plates of V-101 and V-102 are connected to the high voltage bus through S-101C, R-107, and R-108, which thus act as the plate load for V-101 and V-102 for unilateral operation of the equipment. In this switch position, R-108 serves to insure constant

output impedance into the receiver. S-101D completes the cathode circuit of V-101. Mixing of the loop and antenna components takes place in the common plate circuit of V-101 and V-102.

2-4. TYPE CRR-50062 COUPLER MOUNTING BASE

The coupler mounting base, as shown in Figure 14, consists of a rectangular aluminum plate which is drilled for rigid mounting to the airplane structure. It is fitted with four grooved metal studs to which the coupler unit may be firmly secured by means of its snapslide fasteners.

2-5. INTER-UNIT CONNECTIONS

As shown in Figure 12, all electrical connections between the direction finder and the receiver with which it is used are made through shielded cable and plug assemblies which are supplied as component parts of this equipment.

2-6. AZIMUTH SCALE AND ROTATING MECHANISM

By reference to Figure 14, it will be seen that the major component units of this equipment (listed as Items A, B, C, in Section 1-2) are combined into a single mechanical assembly when installed. Although the azimuth scale assembly, the thumbwheel clamp, and the loop are functional elements of the azimuth scale and rotating mechanism, actually they are built integral with the cabinet of the coupler unit.

The adoption of a low impedance loop and associated input circuits enables the use of a one-piece winding L-201 of insulated Litz wire, thereby eliminating the possibility of short circuits developing between turns as a result of vibration during flight. The employment of this principle also reduces appreciably such RF losses as would otherwise result from moisture leakage or condensation. The loop winding is enclosed in an electrostatic shield comprising a circular form of welded aluminum tubing, the gap at the top being reinforced mechanically, then taped and weather sealed.

The azimuth scale assembly comprises a bearing O-201 and supporting member mounted into the top right* surface of the coupler unit cabinet, a rotatable base member, the scale and mask, and a cover plate provided with a loop fitting. The 360° drum type aluminum scale is held clamped between the base member and thumbwheel with four machine screws. The design is such that the scale may be adjusted with respect to the lower shaft member when these screws are loosened. The azimuth scale is normally read from an index pointer mounted on the top front edge of the coupler unit cabinet. Another unmarked pointer is provided on the top left side* of the cabinet (the operators right) for taking readings under certain special conditions (see Section 5-1).

*Throughout the book, any references to position are designated by using the equipment itself as a reference in accordance with the following concept. The right side of the equipment is that side which, with the equipment resting on its base, coincides with the observers right as the unit is viewed from the rear, i.e., in the same sense as starboard. Any side so defined retains that reference regardless of the position of the unit in subsequent observations.

The top surface of the thumbwheel is engraved with two arrows, the stems of which are parallel to the plane of the loop. The electrical connections are such that these arrows always point to the station when the loop has been adjusted for a D maximum signal.

The mask consists of an independently rotatable knurled edge segment that covers approximately 180° of the azimuth scale. A zero mark near one end of this segment, when manually aligned with the front index pointer (the loop having been set previously for a D maximum signal), places the mask in position to blank out that portion of the scale in which the reciprocal bearing will fall.

The thumbwheel clamp is mounted to right on the top surface of the coupler unit cabinet. It consists of a supporting block and a dual jawed clamp which can be operated by a bar screw to secure the loop shaft assembly at any desired angle.

The loop shield fitting projects down into the coupler unit cabinet and carries a 3-ring loop contact E-201 at its lower extremity which engages with the loop brush assembly E-102 mounted on the rear of the coupler unit panel. The upper ring contact E-201C serves to connect the loop shield to the coupler (ground), and leads are brought up from the other two direct to the loop winding.

2-7. VACUUM TUBE DATA

The following tabulation is provided to furnish information concerning the static characteristics of the vacuum tubes employed in the equipment. These characteristics should be used in determining the serviceability of the vacuum tubes through the use of the Navy Model OD Tube Tester and should not be confused with the typical operating conditions.

STATIC CHARACTERISTICS OF 12SK7

SPECIFIED LIMITS

Maximum Voltage Rating	E_f	E_p	E_g	E_{g2}	E_{shell}
	12.6DV	250DV	−3DV	100DV	0

Base: Small Wafer Octal 8-Pin, Phenolic

		Minimum	*Maximum*
Dimensions: d: 1.32″ (max)	h	2.40″	2.63″
Vibrations: R_p: 10,000	E_p	0	100 AmV
Grid Current:	I_g	0	−1.0 DuA
Plate Current:	I_p	7.0	11.4 DmA
Screen Current:	I_{g2}	1.6	3.2 DmA
Transconductance:	S_m	1600	2400 uMo
Transconductance: (E_g cut-off)	S_m	1	30 uMo
Emission E_p, E_g, E_{g2}; 50DV	I_s	60	DmA
Heater Current: E_p, E_g, E_{g2}: Zero	I_f	135	165 DmA
Capacitance:	C_{gp}	0	0.005 uuf
Capacitance:	C_{gk}	4.9	7.1 uuf
Capacitance:	C_{pk}	5.2	8.8 uuf
Insulation:	I_{hk}	0	20 DuA

Cathode: Coated Unipotential

Base Connections: 1-shell; 2-heater; 3-grid #3; 4-grid #1; 5-cathode; 6-grid #2; 7-heater; 8-plate

End Useful Life: S_m: 1500-1550 uMo

NOTE: ALL TUBES SUPPLIED WITH THE EQUIPMENT OR AS SPARES ON THE EQUIPMENT CONTRACT, SHALL BE USED IN THE EQUIPMENT PRIOR TO EMPLOYMENT OF TUBES FROM GENERAL STOCK.

3. INSTALLATION

3-1. OPERABLE UNITS

Since the coupler unit, coupler mounting base, and the loop and azimuth unit comprise a single mechanical assembly, numerous conditions must be considered in the selection of a suitable location for this equipment.

The loop proper should be installed so that its axis is coincident with or as close to the fore-and-aft center line of the airplane as possible. The loop should, moreover, be located in a position of minimum turbulence, as regards the slip stream, and of maximum possible separation from other fuselage structures. In this connection it should be borne in mind that if the loop is surrounded by nearby metallic members, considerable deviation and loss of sensitivity will be experienced unless undesirable (especially athwartship) circulating currents are eliminated by inserting suitable insulating pieces in the affecting structures. Cockpit enclosing hoods are most suitably broken up electrically by leaving a gap in the top of each of the athwartship metal bows, reinforcing them mechanically with insulating material. Insulation of the hood structure itself from the airplane structure is not desirable.

The coupler unit should be located inside the cockpit, preferably with its front panel facing aft, and so that (a), the loop proper will project above the top of the plane's fuselage and have sufficient clearance to allow full 360° rotation; (b), the azimuth scale thumbwheel and all the coupler panel controls will be accessible to the operator; (c), the azimuth scale and the coupler panel nomenclature will be readily visible from the operator's position; (d), convenient access will be provided for manipulation of the snapslides; (e), sufficient clearances will be allowed to permit connection and removal of the two cables; (f), the coupling cable and the DC power cable will reach between and secure to their respective termini without strain or damage; and (g), none of the various components, when assembled and operatively connected, will offer any obstruction to normal radio, direction finding, or flight operations.

In addition, the coupler unit should be located as far as possible from the receiver with which it is used; otherwise, multiple bearings and poor directional indications may result, especially when receiving weak CW signals.

From the data given in Figure 14 with respect to the axis of the loop, drill the holes for the coupler mounting base in the position which will provide the best visibility and accessibility of the coupler panel controls. Loosen the snapslides, remove the mounting base from the coupler unit, and secure the former to the mounting surface with four No. 10 screws. Replace the coupler on the mounting base, and secure the snapslides. It should now be possible to rotate the loop freely and continuously and to lock it firmly at any angular position by means of the bar screw clamp which operates on the edge of the azimuth scale thumbwheel.

3-2. CABLES

The DC power cable, (Dwg. No. AC56603-3, Figure 15), is equipped with a straight plug at one end and a right angle plug at the other. This cable may be connected from outlet 74 of the Type CBY-23011A (or corresponding power outlets on similar junction boxes of later issues of the Navy Model RU series) to the 5-contact receptacle at the rear of the coupler unit. The right angle plug should be the one used at the coupler end of the cable. The design of this plug is such that the L may be set to face in any one of eight directions. To change it to a direction other than that for which it was adjusted prior to shipment, the four screws in the elbow casting must first be removed, the elbow may then be rotated to the most desirable of the eight possible angles, and the four screws replaced. While the screws are withdrawn, extreme care should be exercised to avoid breaking the conductors; therefore, do not twist the elbow more than one-half turn relative to its original position, in either direction.

As shown in Figure 14, the 90° plug on the coupling cable (Dwg. No. AC56725-2), should be secured to the fitting on the rear of the coupler unit, and the bare wire end should be connected to the antenna binding post on the Navy Model RU series receiver. The clamp furnished must be secured under one of the screws holding the front panel of the receiver, in such a manner that the cable leads directly to the antenna post. The clamp may be secured either on the side or top of the receiver; whichever is the most convenient in the particular installation. A short bend on one lip of the clamp serves to hold the cable parallel to the front panel of the receiver.

3-3. ANTENNA AND GROUND CONNECTIONS

The Model DU-1 Radio Direction Finding Equipment should be used with a fixed antenna at least 5 feet in length and extending upward above the airplane and loop as much as possible; the standard fixed airplane antenna ordinarly installed for operation of the Navy Model RU series receiving equipment being usually quite satisfactory if recommendations of the receiver manufacturer have been properly followed. The use of a fixed or trailing antenna extending downward will cause a 180° error in the indicated direction unless the connections to the loop are reversed to compensate therefor. The antenna should be connected to the push type binding post (marked A) at the upper right corner of the coupler unit front panel. Preferably, this connection should be made direct to the antenna lead-in insulator with the shortest possible lead. It may be run through the receiver break-in relay contacts, however, if the resultant capacity to ground, within the fuselage, is not excessive.

When installed in any airplane, make the ground connections as short as possible. If the Model DU-1 Radio Direction Finding Equipment should be installed in any location other than in an airplane, care must be exercised in the selection of a ground. A ground lead of even a few feet in length tends to function as an antenna, but it cannot be isolated from the circuits in the manner

in which the regular antenna is controlled. No ground at all is much to be preferred. A counterpoise of metal directly beneath the equipment is satisfactory.

3-4. ADDITIONAL ELECTRICAL CONNECTIONS

The coupler units supplied with the Model DU-1 Radio Direction Finding Equipment are wired for 12/14-volt operation. Should it be required to adapt the coupler unit to 24/28-volt operation, it will be necessary to remove the coupler unit chassis from its case and alter the connections to the four terminal studs located immediately above R-104 on the underside of the chassis. The jumper connections from terminal 1 to terminal 3 and that from terminal 2 to terminal 4 should both be unsoldered and removed. Terminal 2 should then be connected to terminal 3 without altering the connections to these studs in any other way.

4. INITIAL ADJUSTMENTS AND CALIBRATION

4-1. PHASING

After installation, preliminary adjustments must be made on the Type CRR-50061 Coupler Unit in order to obtain proper operation of the equipment with the particular fixed antenna used. These adjustments are best made as follows:

With the proper DC power source connected, and all cables plugged into place, turn the receiver and coupler unit power switches ON.

On each band there is one point at which, when the equipment is properly adjusted, the loop output voltage is exactly equal to the fixed antenna voltage. These points are termed crossover points and are the points in the tuning spectrum at which it is most desirable to adjust the equipment for best directional indications. The approximate location of these points is given below:

Band	*Crossover Frequency*
1	210 Kcs
2	435 Kcs
3	840 Kcs

As will be outlined below, it is possible to adjust the equipment although there may be no signal source available at the frequency of a crossover point. However, the accuracy of adjustment with this modified method is not so good, in general, as that obtained by adjustment at the crossover point.

Place the SELECTOR switch of the coupler unit on R and tune in a signal on the receiver as close to one of the crossover points as possible. Do not use frequencies more than 1% lower than a crossover point. Frequencies up to 10% greater than that of a crossover point may be used without any correction. A CW carrier is best, however, a nearby broadcast station supplies a satisfactory signal, with the receiver on CW, using MANUAL volume control. Adjust the alignment of the receiver antenna trimmer (Antenna-Loop switch on A) for maximum sensitivity.

Turn the SELECTOR switch to B and carefully TUNE the loop to resonance, as indicated by the maximum signal obtained. In this position the unit is acting as a bilateral direction finder, and rotation of the loop will change the signal strength. The loop is most easily tuned in either maximum position, after appropriate adjustment of the receiver volume control. A receiver output meter can be used to advantage while proceeding with these phasing adjustments.

Switch the SELECTOR to D without disturbing the setting of the LOOP TUNING control. Unscrew the knurled cap from the GAIN control located near the upper right corner of the front panel. Swing the loop to determine whether one or two maxima are obtained. If one maximum is of considerably greater amplitude than the other, set the loop to the maximum signal position of the *weaker maximum*, and adjust the GAIN control with a screw driver until the weaker maximum disappears or becomes very weak. Readjust the LOOP TUNING control, if necessary, to assist in reducing the output at this point. Rotation of the loop back and forth over twenty or thirty degrees will often assist, since the maximum being worked on is sometimes distorted as it is being balanced out and may shift slightly. The use of an output meter will be of considerable help in making these adjustments. In most installations an output voltage ratio of better than eight to one between the D maximum and its reverse will be obtained. Check the adjustments by tuning in other stations and, if necessary, repeating the procedure until settings are found whereby good ratios are obtained throughout the frequency range. Disregard the azimuth scale readings while making the phasing adjustments, other than to work for the highest possible maximum to minimum ratios at approximately opposite positions of the directional arrows. The procedure for orienting the scale to proper azimuth will be explained in Section 4-2.

Should there be no signal source available within the prescribed limits of any one of the crossover frequencies it is permissible to use a frequency higher than the crossover frequency. In this case the initial adjustment will be closer if the equipment is so adjusted that there are two minima, spaced from a 90° azimuth reading by 10° to 20°, at which the signal vanishes completely.

The direction finder is so designed that, when used with the prescribed equipment, it will be properly adjusted on all bands after being adjusted for proper operation on any one band. Thus, it may be phased on any band.

In case no distinct single D maximum is obtained with the adjustment described above, or in case the indications are very erratic, the trouble may be due to excessive capacitance between the receiving antenna connections to the coupler unit and the airplane fuselage. To remedy such a condition, it may be necessary to provide a separate short direction finder phasing antenna connected directly to its antenna terminal; or to provide a clip lead for direct connection at the fixed antenna entering insulator, without passing through the break-in relay, while using the direction finding equipment. Due to local conditions, distance, and various other circumstances, it is practically impossible to obtain a perfect cardioid pattern on all stations. When operating properly, a voltage ratio of eight to one may be obtained on the stations throughout the frequency range. With the equipment operating in such a manner that unmistakable direction indications are obtained with ease, the screw cap may be replaced.

No future alterations should be necessary to these adjustments unless the antenna or rigging of the airplane is changed. NOTE: These adjustments are made on the fixed antenna with the trailing antenna (on airplanes so equipped) in the reeled in position, and the latter should occupy the same position when the equipment is used at any subsequent time; that is, it should always be reeled in when taking bearings.

4-2. AZIMUTH SCALE CORRECTION

It is stated in Section 3-1 that the coupler unit should be installed at that angle which will provide the best visibility and accessibility of the panel controls. Since the azimuth scale index pointer is fixedly mounted on the front panel, rotating the coupler unit changes the resultant readings correspondingly. The azimuth scale must, therefore, be accurately aligned, prior to calibrating the installation for deviation, in order that the readings obtained will be relative to plane heading.

In the Model DU-1 Equipment, four equally spaced machine screws are employed to clamp the azimuth scale proper between a base member and the scale cover plate (the thumbwheel on which the directional arrows are engraved). As shipped from the factory, the azimuth scale is assembled for installation with the front panel of the coupler unit facing directly aft. However, the position of the azimuth scale may be corrected for any angular deviation from this installation position (as long as the deviation lies in a horizontal plane) without danger of disturbing the necessary fixed relationship between the plane of the loop and the directional arrows. Such correction may be readily accomplished after loosening the four clamping screws slightly (not more than one-half turn each) and proceeding as itemized in the next paragraph.

The final azimuth scale correction may be most easily accomplished on the ground by first heading the airplane accurately toward a station, the exact bearing of which is known, and mooring it firmly on course with the tail elevated to bring the ship to flight position and with the motor operating at cruising speed. Proceed as follows:

A. With the SELECTOR switch on D, adjust all controls to obtain the cardioid maximum (see Section 5-1). The directional arrows on the thumbwheel will then point toward the head of the ship.

B. Holding the loop in this D maximum position, rotate the mask to where its ZERO MARK falls over the front index pointer.

C. Switch to B and rotate the thumbwheel to the signal minimum which occurs in the unmasked portion of the scale.

Set the loop on the exact minimum which is best determined with the aid of an output voltmeter. Lock the loop in this position by tightening the bar screw.

D. Loosen the four screws on the top of the thumbwheel one-half turn each. Grasp the azimuth scale itself (not the thumbwheel or the mask ring), rotate it to the reading of 0° at the front index pointer, and secure the four screws.

E. Unlock the loop and check this scale setting by taking at least three successive bearings on the same station, the average of which should give an indicated relative bearing of 0°.

4-3. DEVIATION

Practically all airplane radio direction finder installations give definite errors in relative bearings which vary in a regular pattern throughout the 360 degrees. They are known as quadrantal errors or quadrantal deviation. These errors are caused by the effect of the metallic fore-and-aft mass of the fuselage structure, the athwartship mass of the wing structure, and the effect of closed circuits (such as formed by wing bays, or the struts in biplanes and braced monoplanes). If the loop is mounted on the exact centerline of the airplane and the azimuth scale is properly aligned, there is generally no appreciable error on bearings taken dead ahead (0°), or astern (180°). Advantage may be taken of this condition, when exact bearings are desired before it has been possible to calibrate the installation, or to determine the exact reference bearings of a station for calibration purposes.

It has also been noted, in most installations, that a direction finder is somewhat more sensitive to bearings over the tail than to bearings from ahead, due to a slight shielding action of the wing structure, if this is ahead of the loop. The poorest bearings are frequently obtained, in the case of biplanes, at angles of around 60 to 70 and 290 to 300 degrees, where these bearings pass through the outer wing struts. Since the deviational errors in unfavorable directions are generally of the order of 10 to 20 degrees, and often still greater (especially on the higher frequencies), it is highly desirable to measure such deviations by swinging the ship, preferably on a compass rose, in a suitable location. The calibration data thus obtained are used to calculate the various deviations, which may then be transposed and plotted against indicated bearings to form a correction curve.

By correction is meant that value which, when algebraically added to the indicated radio bearing (relative to ship's heading), gives the actual relative bearing of the incoming signal. Hence, if the actual bearing is numerically less than the indicated bearing, the correction is negative and is preceded by a minus sign (plotted below the zero line); but when the actual bearing exceeds the indicated bearing, the correction is positive, has a plus sign, and is plotted above the zero line. Correction is often confused with deviation, whereas the former term applies to the indicated bearings, while the latter refers to the actual relative bearings. They are numerically equal, but opposite in sign.

The deviation generally increases toward the high-frequency end of the range, due to partial resonance of portions of the airplane. At intermediate frequencies, correction curves generally hold over 150 to 200 Kcs from the frequency at which the calibration was made, and some installations may show only slight change over the entire frequency band.

To perform the deviation calibration for plotting the correction curve, proceed as follows:

A. Select a suitable location for calibration, preferably a compass rose. This should be several hundred feet removed from high buildings, power lines, and other absorbing or conducting metal structures.

B. Select a suitable transmitter to calibrate upon. A local transmitter or broadcast station, preferably at a distance between one and ten miles, is satisfactory. Its direction should be exactly known, or may be determined with fair accuracy by turning the airplane to give a zero bearing right over the nose.

C. Tune in the calibrating signal and adjust the receiver and direction finding equipment (SELECTOR switch on B), as outlined in Section 5, OPERATION. Starting with a head-on bearing, swing the plane by fifteen or thirty-degree steps until a complete revolution has been made, so that the final observations will serve as a check upon the first set of readings. For greatest accuracy, it is desirable to elevate the tail approximately to normal flight position (a fifteen-degree fore-and-aft slope of the plane will result in one-degree bearing changes at certain loop positions) and to run the engine at cruising speed.

D. For each 15 or 30-degree heading, record the following data:
   1. Actual magnetic heading, by compass rose or by corrected ship's compass.
   2. Indicated radio bearing, relative to ship's head.

E. The deviation is calculated as follows:
   1. Add the magnetic heading to the indicated radio bearing.
   2. Subtract 360 if the sum obtained in (1) permits.
   3. If the resultant of operations (1) and (2) is more than the magnetic bearing of the station, subtract the magnetic bearing. The difference is the plus deviation. For example, if a certain transmitter has a magnetic bearing of 184° and the plane heading is 225°, the indicated radio bearing might be 340°. The sum, as obtained under (1), is therefore 565; and since this is more than 360, we subtract, as in operation (2), obtaining 205. This resultant is more than the magnetic bearing of the station; so the latter is subtracted from the former, as in (3), giving a deviation of plus 21°.
   4. If the resultant of operations (1) and (2) is less than the magnetic bearing of the station, subtract the resultant. The difference is the minus deviation. Thus, using

the same transmitting station (the magnetic bearing of which was 184°), the indicated radio bearing might be 37.5° when the plane heading is shifted to 135°. The sum, as obtained for operation (1), is then 172.5°; and since this is less than 360°, operation (2) is omitted. However, the resultant is now less than the magnetic bearing of the station, so the former is subtracted from the latter, as in operation (4), and the deviation is minus 11.5°.

F. In all cases, the desired corrections will be numerically equal to the deviations thus obtained, but opposite in sign. For example, a deviation of plus 10° would require a correction of minus 10° to the indicated radio bearing.

G. When all values for correction have thus been determined, plot the correction curve by showing plus corrections upward and minus corrections downward, starting with 0° indicated radio bearing at the left, ending with 360° at the right side of the graph sheet. Connect the points by as smooth a curve as possible. If the calibration has been carefully performed, this curve will approximate a sine wave, having two peaks and two dips through the 360°. If the peaks and dips are not about equal, or if the curve does not cross the zero axis at 0°, 180°, and two intermediate points (approximately 90° and 270°), recheck the loop alignment and centering in the airplane, and verify the actual direction of the transmitting station as used in the calculations.

H. Repeat the calibration for different frequencies, as desired. Do not fail to indicate the calibration frequency on the different calibration curves thus obtained.

CAUTION: Any metallic masses, structures, or conductors in which circulating RF currents may be induced (if later added, removed, or altered in the field of the loop) may destroy the accuracy of the calibrations. This applies to the bonding of the airplane, any change in fuselage structure, re-location of wiring or of shielding, and spare parts or gear stowed near the loop. Check the calibration in flight at frequent intervals by taking bearings on stations of known direction. The corrected indicated radio bearing, added to the corrected magnetic heading, should give the actual magnetic bearing to the transmitting station (subtract 360° if necessary).

5. OPERATION

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OPERATING PERSONNEL MUST AT ALL TIMES OBSERVE ALL SAFETY REGULATIONS.

5-1. DIRECTION FINDING

After completion of the initial adjustments as outlined in the preceding section, the successive steps involved in the proper and successful operation of this equipment can be readily acquired from the following brief review of the SELECTOR switch functions:

R—RECEIVE (nondirectional)

In this first position, the fixed antenna on the plane feeds through the coupler unit to provide nondirectional reception with the receiver. The receiver is tuned and trimmed as for ordinary antenna reception. The loop should be detuned for best communication; otherwise, through stray couplings, it may produce slight variations of the output. The coupler unit power switch may be left in the OFF position, if desired, for this condition of operation only.

B—TUNE LOOP

The coupler unit power switch should be turned to the ON position. The loop must be tuned to resonance in order to match the output of the fixed antenna in preparation for direction indications. Tuning the loop gives a great increase in sensitivity and prevents error. When the loop is improperly tuned, it is impossible to obtain the correct phase relationship with the fixed antenna, and directional indications cannot be obtained. Rotate the loop (by means of the thumbwheel) to either maximum signal position to facilitate proper and accurate adjustment of the LOOP TUNING control (the frequency range for each position of the FREQuency BAND switch is noted on an etched plate mounted on the inside rear wall of the coupler unit box).

D—DIRECTION (approximate, but unilateral)

Rotate the loop for a maximum signal output. The arrows on the azimuth scale thumbwheel (if installed as recommended in Section 3-1) will point toward the transmitting station when the maximum signal is being received. When the loop and fixed antenna components are properly matched, the indication of direction will always be unmistakable. Hold the loop in this position of maximum signal output and rotate the mask on the azimuth scale so that the ZERO MARK coincides with the position of the front index pointer. Next return the SELECTOR switch to the B position.

B—BEARING (sharply directional)

Rotate the loop, without moving the mask, until the signal minimum is found at which the exposed sector of the azimuth scale is presented to the front index pointer. The observed reading when the signal is at a minimum is the indicated radio bearing of the transmitting station, relative to the heading of the airplane. The calibrated correction factor must then be applied to this reading in order to obtain the actual relative bearing. In most cases, the minimum will be less than a degree in width as observed on a meter. The ear may not be able to make so accurate an estimate, so that it becomes necessary to rotate the loop from one definite signal level, through the minimum, to an equal level on the other side. Observe the amount of rotation, and the center of that area is the correct indicated bearing (the sharpness of the B minima may be improved by open-circuiting all fixed and trailing antennas). Note that there is another minimum which may be obtained on the opposite side, but no bearing can be taken since the scale numbers are covered by the mask. Under no conditions should the mask be moved between the time it is set on the D position and the taking of the bearing on the B position. There can be no ambiguity of bearing when the proper procedure, as outlined above, is followed.

Bearings, when so taken over the intermediate frequency range (200-1600 Kcs) in the daytime, are reliable. At night (particularly at dawn and dusk), they must be interpreted with caution. Destruction or shifting of the minimum in a loop direction finder, due to "night effect," is caused by down-coming (reflected) horizontally polarized components of the radio wave.

In some installations, conditions may exist which do not allow good unilateral indications under normal operating methods. The cardioid figure may often be improved under these conditions by a very slight readjustment of the LOOP TUNING dial. The change must be very slight and very carefully made. If it is changed too much, no direction at all will be indicated, the signal being of practically equal intensity at all loop settings.

It may become necessary at times to obtain approximate bearings without interrupting the reception of communications. In such a case, the equipment may be operated with the SELECTOR switch on D, and the loop adjusted to the center of the maximum signal zone (where reception compares favorably with that obtained in the R position). The approximate bearing relative to the plane heading, is then obtained by reading the azimuth scale from the pointer on the left side (operator's right) of the coupler unit. An even more rapid, but less accurate, method is merely to note the position of the arrows engraved on top of the scale; or, more easily still, note that the side of the loop painted in the lighter color always points toward the station when the loop is swung to the maximum signal on the D position.

When for any reason broadcast station carriers are being used, care must be exercised in the selection of stations. Two stations operating on the same frequency may tend to indicate more than one direction, or may fail to give any indication of direction whatever. Stations operating on clear channels will always give the most satisfactory results. Note that broadcast transmitting stations are often situated a considerable distance outside of cities controlling them.

The use of AUTOmatic volume control (AVC) in the receiver is generally undesirable for direction finding as it prevents normal change in signal strength with loop direction. MANUAL volume control should be used. The receiver should also generally be used in the CW position; however, if the incoming signal is strong and has a steady tone modulation, then only may better results be obtained with the receiver non-oscillating, on ICW.

CAUTION: When taking radio bearings on a weak signal with the receiver adjusted for CW reception, care should be exercised to insure that the bearing taken is that of the desired station, unaffected by spurious radiation from the CW oscillator within the receiver. It is possible, under certain installation conditions, that the direction finder loop may respond to the emission from inadequately shielded receiver oscillator circuits.

An output meter can be used to advantage in observing the minima. In so doing, it is most advisable to listen in with headphones at the same time, so that no mistake as to the identity of the signal will be made.

5-2. FIXED LOOP HOMING

The equipment may be used as a fixed loop homing device instead of operating it as a rotating loop direction finder. For this purpose, adjustments should first be made as with the rotating loop, and the airplane headed in the direction of the desired station as denoted by a signal maximum at 270° reading of the azimuth scale when the SELECTOR switch is in the D position. The loop is then swung athwartship (0° azimuth reading); the thumbwheel bar screw clamp is locked; and, with the SELECTOR switch on B, the airplane is kept headed in the direction giving minimum signal strength. Check direction from time to time, when flying on the minimum signal with the loop locked athwartship, by throwing the SELECTOR switch to D and swinging the plane 90° to the left; when, if the plane had previously been flying toward the station, the signal should be stronger than for any other heading. The desired course is then resumed by swinging the plane back 90° to the right, returning the SELECTOR switch to B, and continuing the flight in the direction which gives minimum signal response.

This method of homing becomes more tedious as the target station is approached because the receiver output and the sharpness of the bilateral minimum both increase rapidly in the general vicinity of the transmitter. Also, it is possible to fly through the no-minimum zone over the station without being aware of it. It is then advisable to shift the SELECTOR switch to D and to complete the flight on the cardioid maximum, with the loop locked at 270°. An output voltmeter can be employed to advantage in defining the cardioid maximum. Use the 1.5- or 6-volt scale, and continue to reduce the receiver volume control (manual condition) as necessary to prevent overload.

Under these conditions the signal level will drop to a low value when passing over the target station. The signal level will not return to its former value after passing, unless the loop is rotated 180°, because the station then lies in the position of the cardioid minimum. Stations have been located to within 500 feet by using this method in an airplane, flying blind, at an altitude of 6000 feet. This method is also feasible for distant homing under conditions of excessive fading and when simultaneous reception of communication is desired.

In types of airplanes where the loop is located in an air stream of considerable turbulence, such as near the tips of the propellers, there are certain angular positions (generally not more than a degree or so wide) at which the loop will vibrate and whip. These areas should be determined for each installation, and locking of the loops therein should be avoided during flight.

During all fixed loop homing, it is desirable to secure the LOOP TUNING dial at resonance by means of the knurled LOCK knob located to the left of the TUNE control. This will avoid frequency shift, otherwise caused by vibration, and its resultant loss of bearing or error of direction.

6. MAINTENANCE

6-1. LUBRICATION

The clicker mechanisms of the selector and frequency band switches in the coupler unit should be lubricated with petrolatum or hard grease at such times as they become unduly stiff in action. No lubrication, as such, will be required for any other parts of this equipment.

NOTE: The azimuth scale bearing is packed with sufficient grease (PD403A manufactured by Standard Oil Co. of N. J.) to provide satisfactory lubrication throughout the life of the equipment.

6-2. REPLACEMENT OF AZIMUTH DIAL BEARING (O-201)

A. Release the snapslides and remove the coupler unit from its mounting base.

B. Unscrew the five screws around the periphery of the panel and remove the chassis from the box.

C. Remove the two screws (accessible from inside the cabinet) which secure the bar screw clamp assembly. Loosen the bar screw and remove the clamp. This and the following operation will be facilitated by the use of an offset screwdriver.

D. Take out the loop and azimuth unit, after removing the tie wire and four retaining screws which hold the unit to the box.

E. Identify the bottom slip ring wire with a dab of paint or by some other suitable method and unsolder the loop leads from the two bottom slip rings. The capacitor C-201 must also be removed and should be set aside for use in the reassembly of the equipment.

F. Remove the loop from the assembly by removing the tie wire and four retaining screws which hold it to the assembly.

G. The nameplate, rotor disc assembly, mask, friction ring, and the azimuth dial assembly may be removed by taking out the four screws on the top of the nameplate and rotor disc assembly.

H. The bearing retaining ring may be removed by unscrewing the six machine screws which secure it.

I. Drill out the four rivets securing the tube and ring assembly to the shaft and plate assembly. The tube and ring assembly may then be removed by twisting it off of the shaft. The grounded ring E201C should then be unscrewed from the shaft assembly.

J. The shaft and plate assembly may be pressed out of the bearing, after which the bearing may be pressed out of the housing by the use of a suitable fixture and in most cases in conjunction with an arbor press.

K. The new bearing may now be pressed into place and the equipment reassembled in the reverse order of its disassembly.

6-3. ROUTINE INSPECTIONS

The regular flight and service inspections recommended by the receiver manufacturer should be augmented to include the following tests of the Model DU-1 Radio Direction Finding Equipment:

A. Make certain that the snapslides and the mounting units are secure.

B. See that all cable plugs are securely locked in their receptacles.

C. See that the loop tuning dial rotates freely, and test the action of its lock screw.

D. Remove the chassis from the box and push the vacuum tubes all the way into their sockets.

E. Set the receiver switch on manual with full output, turn the coupler unit power switch on, and the selector switch to D. Make certain that the frequency band switch setting corresponds with the coil in the receiver, and rotate the loop tuning dial rapidly throughout its scale range. Any sharp clicks or sudden stoppage of the normal noise output, as heard in the phones, will indicate that the variable condenser is short circuiting as a result of bent plates or loose wiring.

F. Set the selector switch to R and tune in at least one station on the receiver, then check for normal operation of the direction finding equipment on the two remaining positions, B and D, against that station.

G. Check the deviation calibrations and correction curves, particularly after any modifications have been made to the plane's structure or antenna rigging. An occasional check of the calibration in flight is of considerable value.

6-4. OPERATING FAILURES AND PROBABLE CAUSES

6-4-1. General

The design of this equipment includes the highest quality of material and parts best suited for each individual function; the structure being as rugged as weight and space limitations permit. However, the strains imposed in aircraft service are extremely severe, so that operational failures may develop in time. As an aid to rapid identification and location of trouble, the probable causes of such failures are tabulated below, the various possible faults being grouped under headings which denote the effects they would produce.

6-4-2. No Signals on Any Position of the Switch

A. Open or grounded coupling cable.

B. Open connection in selector switch wiring.

C. Defective receiver equipment. Test by transferring antenna from coupler unit direct to receiver antenna terminal and disconnecting the DC power cable at the receiver junction box.

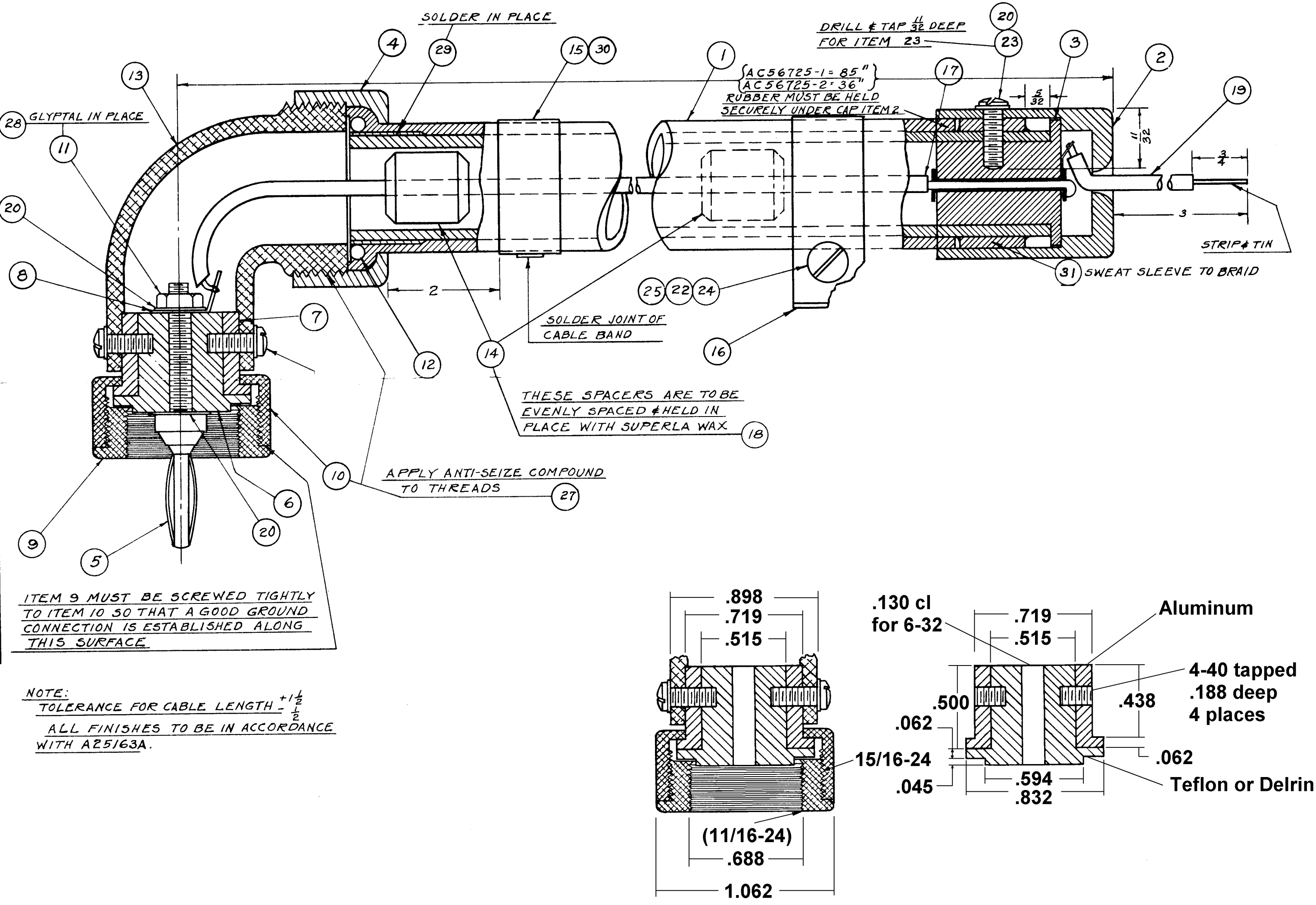


FIG. 19—RECEIVER COUPLING CABLE ASSEMBLY