WAR DEPARTMENT
TECHNICAL MANUAL

TM 11-2003

U. S. Dept. of Army

CARRIER HYBRID CF-7

WAR DEPARTMENT • 2 NOVEMBER 1943

War Department Technical Manual

TM 11-2003

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WAR DEPARTMENT • 2 NOVEMBER 1943

WAR DEPARTMENT

WASHINGTON 25, D. C., 2 November 1943

TM 11-2003, Carrier Hybrid CF-7, is published for the information and guidance of all concerned.

[A.G. 300.7 (13 November 1943)]

By order of the Secretary of War:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

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TECHNICAL MANUAL

CARRIER HYBRID CF-7

CHANGES No. 1

WAR DEPARTMENT
WASHINGTON 25, D. C., 31 January 1945

★ ★

TM 11–2003, 2 November 1943, is changed as follows:

The frontispiece is rescinded and the following is substituted therefor:

Carrier Hybrid CF–7.

3. Size and weight.—The equipment is mounted on a metal chassis and is housed in a plywood box. **This box is provided with a detachable cover which is removed by opening four drawbolts, two at each end of the box.**

AGO 464C—Jan. 622603—45

This cover must be replaced after wire connections are made, in order to make the unit resistant to driving rain. The various binding * * * half of the chassis panel. **The unit, which is provided with an adjustable carrying strap, is approximately 19 inches long by 10 inches wide by 8 inches deep, and weighs approximately 54 pounds.** It will exclude * * * 19-inch relay rack.

FIGURE 1.—Carrier Hybrid CF–7—rear view **(serial numbers 1 to 200).**

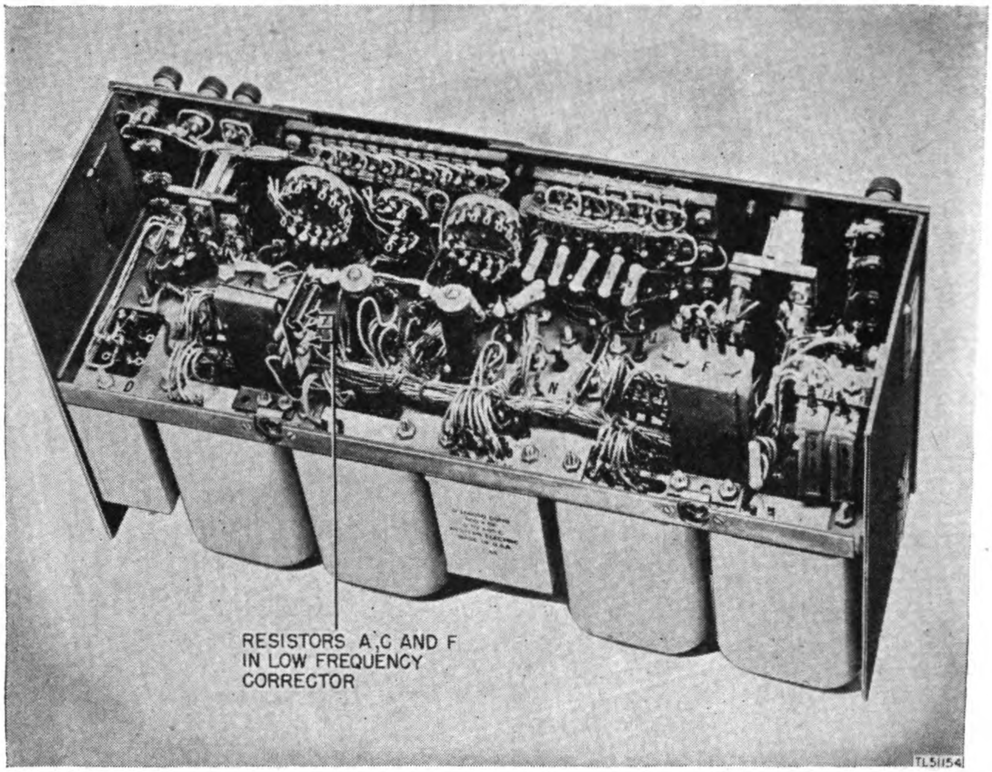

FIGURE 1.1.—Carrier Hybrid CF–7—rear view (serial numbers over 200).

4. Major components.—*a.* The carrier hybrid unit includes a repeating coil hybrid arrangement, an adjustable balancing network, a variable building-out condenser unit, protectors, and a small amount of miscellaneous apparatus. A d-c telegraph * * * also are included.

* * * * * * *

8. Drawings.—A schematic circuit * * * of the cover. **The** drawing **for all models of Carrier CF–7 bearing serial numbers 1 to 200 inclusive** is included in this manual as figure 9. **A schematic circuit label for**

all units having serial numbers over 200 is shown as figure 9.1. Brief instructions for * * * the control panel.

14. Repeater spacing.—*a.* The repeater spacings * * * rubber-covered cables. In this table balances of 15 db have been assumed **for the loaded cable, and balances of 25 db for the nonloaded cable.** In some cases, however, * * * not be possible.

* * * * * * *

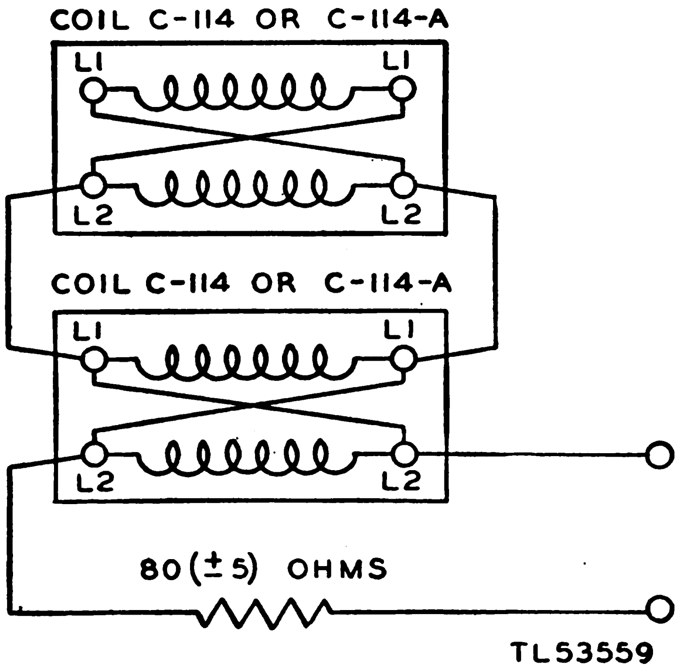

FIGURE 3.—Equalizer for nonloaded wire W–143.

e. The length of unequalized * * * R binding posts. If not available, the equalizers can be assembled locally as indicated in figure 3, each equalizer being formed from any available 80 (±5)-ohm resistor and **two 88-millihenry loading Coils C–114 or C–114–A. The equalizer shown in schematic form in figure 3 can be made up in the field by using two Coils C–114 or C–114–A and connecting the windings of each coil in parallel aiding. Then connect the two coils in parallel and in series with 80-ohms resistance, as shown in figure 3. Each winding of Coil C–114 or C–114–A has 88-millihenry inductance. Then the two windings of the two coils**

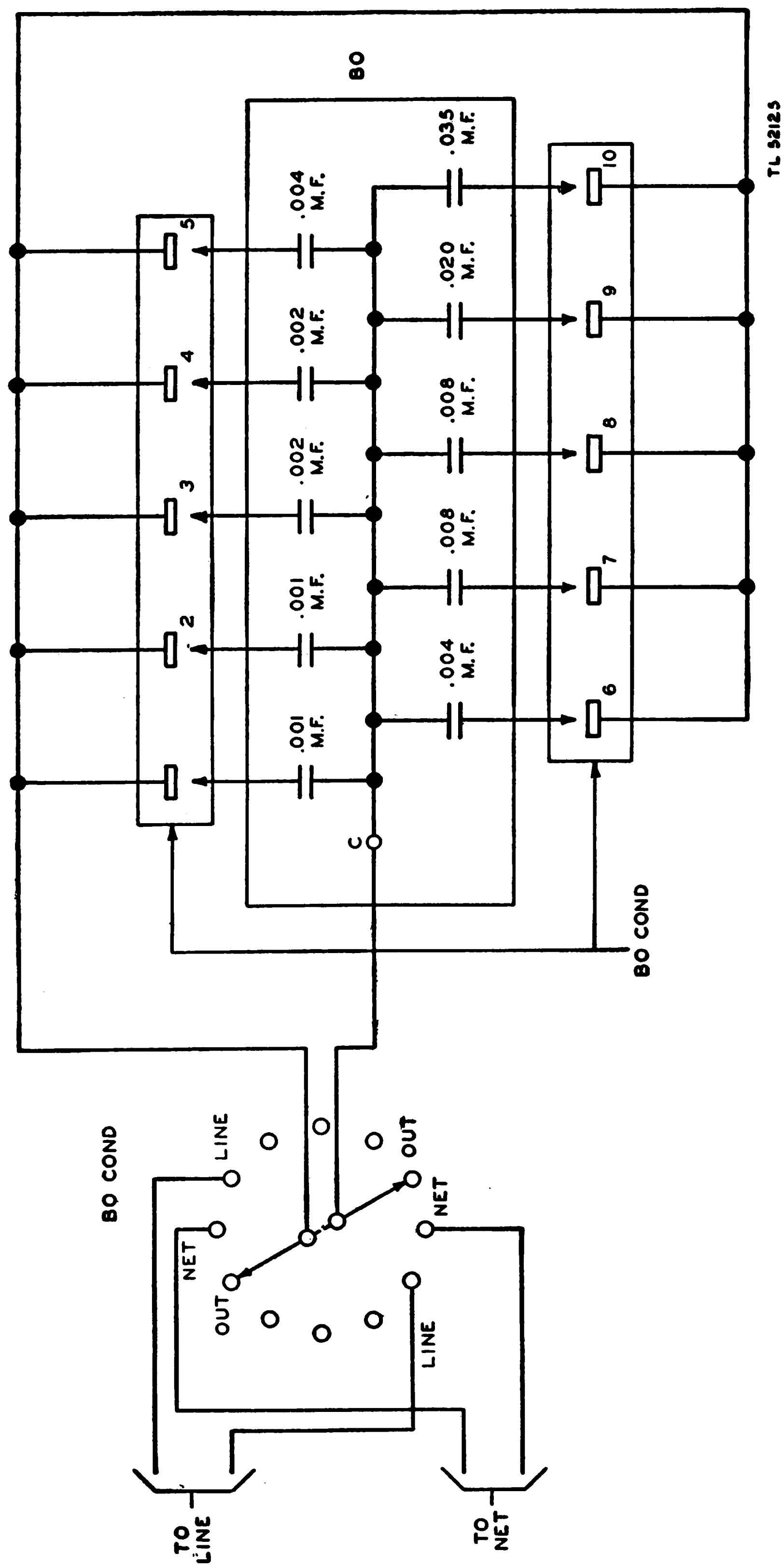

FIGURE 5.—Arrangement of building-out condenser unit.

in parallel have about 11-millihenry inductance. The balancing and * * * in this manual.

29. General description.—The circuit of Carrier Hybrid CF–7 is shown schematically in figure 9 **or figure 9.1.** A simplified schematic * * * 2W-LINE binding posts.

SECTION IV

MAINTENANCE

NOTE: Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on WD AGO Form 468 (Unsatisfactory Equipment Report). If Form 468 is not available, see TM 38–250. Failure or unsatisfactory performance of equipment used by Army Air Forces will be reported on Army Air Forces Form 54 (unsatisfactory report).

41. General maintenance.—Ordinarily, no maintenance * * * for Carrier Hybrid CF–7. **The purpose of the protector blocks is to protect the equipment against excessive external potentials that may arise in line conductors to which the Carrier Hybrid CF–7 is connected. These excessive external potentials may be due to lightning discharges or to severe unbalances in nearby power lines. Protector blocks should be checked periodically and after each electrical storm for excessive pitting, for cracks in the porcelain frame, and for evidence of heat sufficient to melt the cement holding the carbon insert. Blocks with this type of damage, or that are otherwise defective, should be replaced. Where carbon blocks are found to be only slightly pitted, clean them by rubbing together lightly the flat surfaces of two blocks, or by rubbing them lightly with a fine abrasive, taking particular care not to remove an excessive amount of the blocks or to leave particles of the abrasive adhering to the surface of the blocks.**

42. Location of trouble.

* * * * * * *

c. Diagrams.—A schematic circuit * * * of the case. A copy of this drawing also is included in this manual as figure 9 **for all units bearing serial numbers 1 to 200 inclusive, and is shown in figure 9.1 for all models having serial numbers over 200.** The lines on * * * wires are paired. **The letter D not used to identify a particular unit indicates short wires run directly between apparatus units.**

43. (Superseded.) **Moistureproofing and fungiproofing.**—*a. General.*—The operation of Signal Corps equipment in tropical areas where temperature and relative humidity are extremely high requires special attention. The following items represent problems which may be encountered in operation.

(1) Resistors, capacitors, coils, etc., fail.
(2) Electrolytic action takes place in resistors, coils, etc., causing eventual break-down.
(3) Hook-up wire and cable insulation break-down. Fungus growth accelerates deterioration.
(4) Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs and crosstalk.

b. Treatment.—A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment involves the use of a moisture- and fungi-resistant varnish applied with a spray gun or brush. Refer to TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, for a detailed description of the varnish-spray method of moistureproofing and fungiproofing, and the supplies and equipment required in this treatment.

Caution: Varnish spray may have toxic effects if inhaled. To avoid inhaling spray, use respirator if available; otherwise fasten cheesecloth or other cloth material over nose and mouth.

c. Step-by-step instructions for treating Carrier Hybrid CF–7.—(1) *Preparation.*—Make all repairs and adjustments necessary for proper operation of the equipment.

(2) *Disassembly.*—(*a*) Remove the chassis from the carrying case. The carrying case is not to be treated.

(*b*) Unscrew and remove the LINE PROTECTORS, CABLE PROTECTORS, and CXT-CXR CONN cover plates (not to be treated).

(*c*) Clean all dirt, dust, rust, fungus, oil, grease, etc., from the equipment to be processed.

(3) *Masking.*—(*a*) Mask the openings in the front panel which were created by the removal of the cover plates.

(*b*) Cover the face of the front panel.

(*c*) Cover the LINE PROTECTOR and the CABLE PROTECTOR so that their receptacles are protected and their base connections are exposed.

(*d*) Cover each of the three selector switches.

(*e*) Cover the backs of the BO COND and BAL RES contact strips.

(4) *Drying.*—Place the equipment in an oven or under heat lamps and dry for 4½ to 5½ hours at 135° F. Do not exceed 135°.

(5) *Varnishing.*—Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-resistant, Spec. No. 71–2202 (stock No. 6G1005.3) or equal) as follows:

(*a*) Spray all parts and cables on the wiring side of the chassis only.

(*b*) After three spray coats have been applied, remove all masking.

(*c*) Brush all wires and connections which were covered by the masking.

(*d*) Brush the front of the CXT-CXR CONN strip without coating the screws.

(*e*) Brush the surfaces of the BO COND and BAL RES contact strips as completely as possible without allowing the varnish to flow onto the ends of the adjusting screws which project out of the backs of the strips.

(6) *Reassembly.*—(*a*) Remove all masking tape.

(*b*) Clean all contacts with varnish remover, and burnish the contacts.

(*c*) Reassemble the set and test its operation.

(7) *Marking.*—Mark the letters MFP and the date of treatment near the name on the outside front of the equipment.

Example: MFP—3 Oct 44.

Figure 9.—Carrier Hybrid CF–7, circuit label **(serial numbers 1 to 200). The three resistors designated A, C, and F which are associated with the low-frequency corrector in the balancing network, are supported by their pigtail leads.**

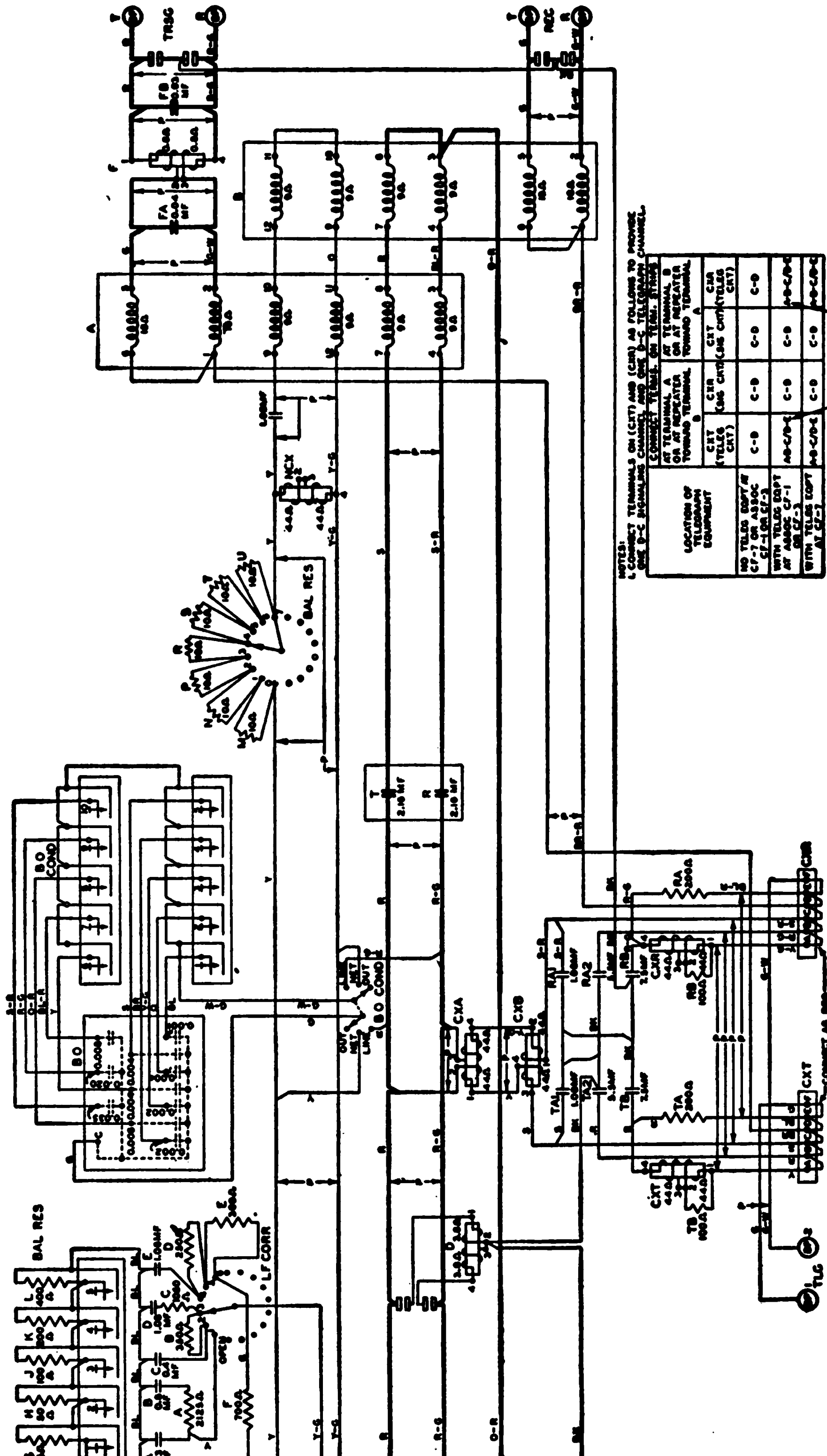

Figure 9.1.—Carrier Hybrid CF–7, circuit label (serial numbers over 200). The three resistors designated A, C, and F are mounted on a card-type mounting. This change results in a minor change in wiring, but does not change the circuit.

[AG 300.7 (24 Oct 44)]

BY ORDER OF THE SECRETARY OF WAR:

OFFICIAL:
J. A. ULIO
Major General
The Adjutant General

G. C. MARSHALL
Chief of Staff

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For explanation of symbols, see FM 21–6.

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DESTRUCTION NOTICE

WHY — To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN — When ordered by your commander.

HOW — 1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools, etc.

2. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades, etc.

3. Explosives—Use firearms, grenades, TNT, etc.

4. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT — 1. Smash—Carrying case, including cover; panel and all associated equipment.

2. Burn—Carrying case; Technical Manual.

3. Bury or scatter—Any or all remaining pieces after destroying them.

DESTROY EVERYTHING

Carrier Hybrid CF-7.

SECTION I

DESCRIPTION

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1. Use.— *a.* Carrier Hybrid CF-7 is a unit for connecting a 2-wire line to either a Telephone Terminal CF-1-A (Carrier) or a Repeater CF-3-A (Carrier), both of which are designed for 4-wire operation. With this equipment four two-way telephone circuits can be obtained over a single pair of wires. In addition, two grounded d-c telegraph circuits or a d-c signaling circuit and one d-c telegraph circuit may be operated over the pair. In place of one of the telephone circuits four voice-frequency telegraph channels can be made available by applying Telegraph Terminals CF-2-A or CF-2-B (Carrier) at the telephone terminals.

b. Carrier Hybrid CF-7 is suitable primarily for open-wire lines but may be used also on Wire W-143 or on one pair of Cable Assemblies CC-358. The maximum length of line and the repeater spacings which can be employed are limited by the balance which can be obtained between the line and the balancing network included in the unit. In general, when used with 080 copper-steel open-wire pairs, it should be possible to operate over a distance of about 150 miles with repeater spacings of the order of 35 to 50 miles. More detailed information with regard to the distance which can be spanned with this equipment is given in paragraph 14.

c. The use of more than one 2-wire carrier system with Carrier Hybrid CF-7 units on a given line is limited by crosstalk because both directions of transmission use the same frequency bands. Consequently, only one or two such systems can be operated on the same open-wire pole line with good crosstalk performance, and it will be impossible to operate two systems over the two pairs in Cable Assemblies CC-358. Generally, crosstalk also will prevent satisfactory operation of a system using Carrier Hybrid CF-7 units on the same line with a system using Converter CF-4-A (Carrier, 2-wire—

4-wire) and Repeater CF-5-A (Carrier, 2-wire) or with a Type C carrier telephone system. A further discussion of crosstalk appears in paragraph 12.

d. The use of Carrier Hybrid CF-7 is illustrated in figure 8. This drawing shows a block schematic of a system operated partly over open-wire on a 2-wire basis and partly over Cable Assemblies CC-358 on a 4-wire basis. The two repeater sections on the left-hand side of the figure are open-wire sections and a Carrier Hybrid CF-7 is used with the terminal on the left, on each side of the first repeater and on the left side of the second repeater. The last repeater section is operated 4-wire so that no hybrid unit is required on the right-hand side of the second repeater or with the terminal on the right. Other arrangements involving all 2-wire or combinations of 2-wire and 4-wire facilities are possible.

2. Power supply.— Carrier Hybrid CF-7 uses no power and requires no power connections.

3. Size and weight.— The equipment is mounted on a metal chassis and is housed in a plywood box. The various binding posts, controls, etc., are mounted on the front half of the chassis panel. The box, which is provided with an adjustable carrying strap, is approximately 18⅜ inches long x 9½ inches wide x 7⅜ inches deep and weighs approximately 48 pounds. It will exclude moisture under ordinary outdoor weather conditions, but will not withstand complete immersion in water. The chassis may be removed from the box and mounted on a standard 19-inch relay rack.

4. Major components.— *a*. The carrier hybrid unit, shown in figure 1, includes a repeating coil hybrid arrangement, an adjustable balancing network, a variable building-out condenser unit, protectors, and a small amount of miscellaneous apparatus. A d-c telegraph composite set and two associated telegraph noise filters also are included.

b. The network is designed to balance the following types of lines:

080, 104 or 128 copper-steel lines of 40 per cent conductivity, 6–12 inch spacing.

080, 104, 128 or 165 copper wires, 6–12 inch spacing.

Cables Assemblies CC-358 with connections made by Cable Stubs CC-356.

Wire W-143 pairs nonloaded.

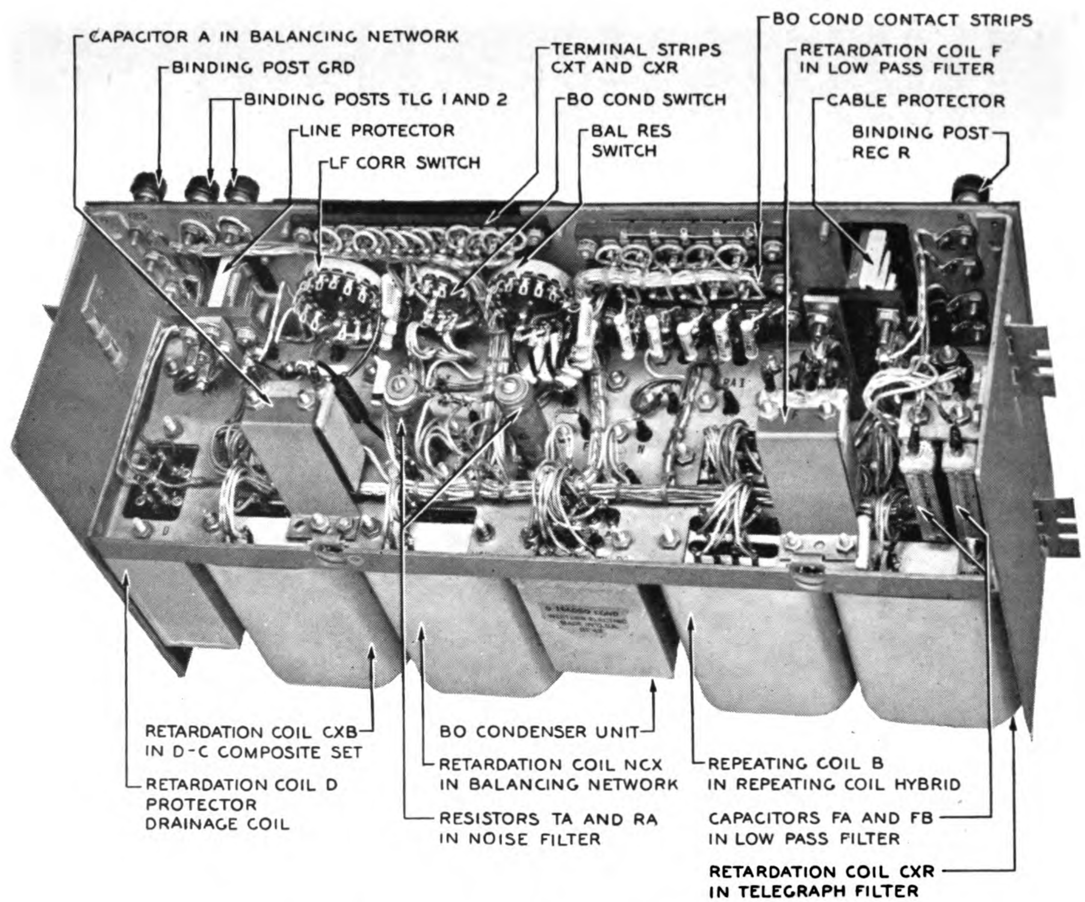

Figure 1.— Carrier Hybrid CF-7, rear view.

c. In addition to these facilities, some other types of lines may be balanced by appropriate adjustment of the network. The network also includes arrangements for balancing moderate lengths of non-loaded cable at the near end of a repeater section. Such cable must be of a kind that is stable with respect to weather conditions.

5. External connections.— Binding posts are provided for all external connections as indicated in figure 2. This shows a face view of the panel. The 2W-LINE binding posts are for connection to the 2-wire line. The TRSG and REC binding posts are for connecting to Telephone Terminal CF-1-A (Carrier) or Repeater CF-3-A (Carrier) equipment. Binding post PH is for making connection to the phantom circuit and normally is connected to the GRD (ground) binding post by a removable metal link. Two other binding posts marked EXT NET are for connecting an external network into the balancing network circuit. A soft rubber gasket between the box and cover permits the connecting wires to be brought out with the cover closed.

6. Switches and controls.— *a.* The balancing network is adjusted by the LF CORR switch, the BAL RES contact strip, and the BAL RES switch. The location of these controls is shown in figure 2. The LF CORR switch has seven positions including an OPEN position and is operated with a screw driver, coin, or other suitable device. The BAL RES contact strip consists of a number of contact plates and associated screw contact posts. A resistor, the value of which is indicated on the face of the panel, is connected between each plate and its corresponding contact post. The resistor is included in the circuit when the post is unscrewed as far as possible and is short-circuited when the post is screwed down tight against the contact plate. The BAL RES switch has eight positions and is similar to the LF CORR switch. Each position on the BAL RES switch, beginning with position 1, adds 10 ohms in series with the resistance component of the balancing network. The setting of this switch, together with the adjustment of the contact posts on the BAL RES contact strip, determines the total value of this resistance.

b. The building-out condenser unit is switched across either the line or the network, or disconnected from the circuit entirely by the BO COND switch. The capacitance of this unit is determined by the position of the contact posts on the two BO COND contact strips. These contact strips are similar to the BAL RES contact strip. Each contact post controls a capacitor, the capacitance of which is marked on the panel. When a post is screwed down tight against its contact plate, this capacitance is included in the circuit. Thus, the total capacitance of the building-out condenser unit is determined by the sum of the capacitances associated with the screw posts which are in the screwed-down position. The locations of the BO COND switch and the BO COND contact strips are shown in figure 2.

c. The telegraph noise filters are connected into or out of the telegraph circuits by two terminal strips designated CXT and CXR, respectively. These terminal strips also provide access to the simplex circuits associated with each of the 4-wire circuits. The terminal strips are located just below the small faceplate marked TLG–SIG CONN as shown by dotted lines in figure 2. Each of these terminal strips contains six screw terminals lettered A, B, C, D, E, and F, respectively, which are strapped as specified in the instructions.

7. Protection.— Open space cut-out protectors are provided across the 2-wire line and across both pairs of the 4-wire line. The protectors use Western Electric 26-27 blocks. The protectors on the 2-wire side of the equipment are located under a faceplate on the left side of the panel which is marked LINE PROTECTORS. The protector blocks for the 4-wire circuit are located under a similar faceplate on the right-hand side of the panel marked CABLE PROTECTORS.

8. Drawings.— A schematic circuit label, which is also a wiring diagram, is cemented to the inside of the cover. This drawing is included in this manual as figure 9. Brief instructions for operating the equipment are also given on the cover and on the upper part of the control panel.

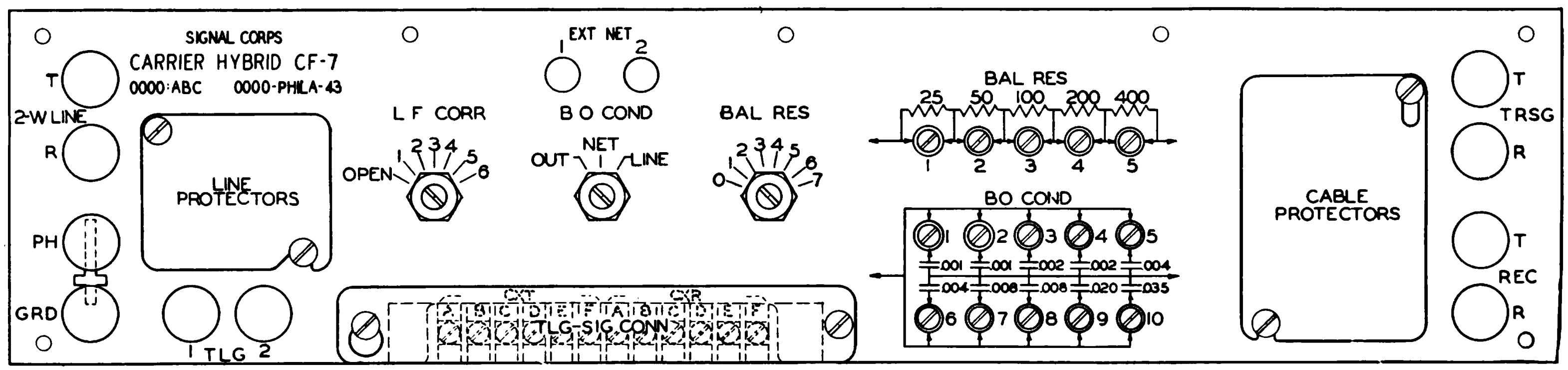

Figure 2.— Control panel.

SECTION II

INSTALLATION AND OPERATION

9. General.— This section covers the application, installation, initial tests and lineup procedure for Carrier Hybrid CF-7 in association with Telephone Terminal CF-1-A (Carrier) or Repeater CF-3-A (Carrier). The installation and operation of the terminal and the repeater are not covered in this manual since the procedure is the same as that given in Technical Manual TM 11-341. However, minor points of difference are covered. These include settings of the gain and equalizer dials for open-wire and Wire W-143 circuits.

10. Line requirements.— Successful operation of a 2-wire system requires that the line be regular in construction so that the impedance characteristic will be smooth. Regularity implies the use of the same gauge and spacing of wire throughout a repeater section and the absence of sections of intermediate cable, etc. Before applying 2-wire carrier operation to a line, make an inspection of the line condition to determine whether the regularity of the line appears sufficient for the purpose. A discussion of the factors to be considered in judging the regularity of a line is given below.

a. Changes in gauge and spacing of the wire of the open-wire pair more than a few miles from the ends of the repeater section may cause substantial irregularities in impedance and thus impair the balance seriously.

b. Lengths of entrance cable or wire located at the end of a repeater section will also affect the impedance of the line. If not longer than the lengths given in table I below, these cables can be balanced fairly satisfactorily by means of the building-out condenser unit. For this balance to be effective, however, it is essential that the characteristics of the cable or wire used be stable with respect to weather conditions so that a suitable adjustment of the network will hold over a period of time. This restriction definitely excludes the use of unstable wire such as Wire W-110-B, Wire W-50, etc., for entrance cable except for very short lengths. The types of stable cable or wire which may be used for this purpose are:

(1) One pair of Cable Assemblies CC-368 (or salvaged cable from Cable Assemblies CC-358 with the connectors and loading coils removed).

(2) Wire W-143, nonloaded.

(3) Paper-insulated, lead-covered cable.

(4) Loaded insulated cable consisting of one or more 210-foot sections of fractional Cable Assemblies CC-358 as described in TM 11-368, paragraph 17.

c. Lengths of intermediate cable or wire generally cannot be balanced by network adjustments. Therefore, any length of intermediate cable will decrease the balances which can be obtained. The allowable length of intermediate cable will vary widely with the location and length of the cable. However, the figures for intermediate cable in table I will be useful as guides. These figures are for one intermediate cable located ¼ mile from one end, 4 miles from one end, and at the middle of a repeater section. For intermediate cables at other locations the approximate allowable lengths may be estimated from the figures given. Where more than one intermediate cable is encountered in a repeater section, the balance will be further reduced.

TABLE I

APPROXIMATE LIMITING LENGTHS OF ENTRANCE AND INTERMEDIATE CABLE FOR ONE REPEATER SECTION

Type of cable	Entrance cable	Cable ¼ mile from one end	Cable 4 miles from one end	Cable at middle of repeater sections
Cable Assemblies CC-368[a]	1,800 ft	600 ft	150 ft	600 ft
W-143 non-loaded	1,200 ft	400 ft	100 ft	400 ft
Paper-insulated, lead cable	3,400 ft	1,200 ft	300 ft	1,100 ft

[a] Or Cable Assemblies CC-358 with connectors and loading coils removed.

d. If cables longer than the limiting lengths are used, 2-wire operation will be feasible in many cases, but the balance will be degraded and an allowance for this should be made in laying out the repeater sections. Similar considerations also will apply if unstable wire is used.

e. The 210-foot loaded insulated cable section formed from fractional Cable Assemblies CC-358 described in Technical Manual TM 11-368, paragraph 17, is designed to have an impedance approximately equal to that of open-wire lines. Consequently, one or two such sections at one or more points in an open-wire line can be used without materially decreasing the balance. Also short stretches of insulated wire twin-pairs (the two wires of the pair in parallel serving as one conductor of the open-wire line and the two wires of the other pair as the other conductor) using Wire W-143, Wire W-110-B, or Wire W-50, if suspended above the ground and if the pairs are well separated, can be employed at any point in the open-wire line.

f. Cable Assemblies CC-358 cannot be used at or near the end of an open-wire line because the balance will be very low. This facility can be used near the center of a repeater section, but, in such cases, the balance may be considerably degraded.

11. 4-wire extensions.— *a.* In some cases it may not be possible to keep the amount of entrance cable down to a length which can be balanced by the network, or the entrance cable may be quite long for camouflage reasons. Also, this entrance cable may be made up of Cable Assemblies CC-358 (terminated by Cable Stubs CC-356) which cannot be balanced very well as a short entrance cable by the arrangements provided. Provision for these contingencies has been made by arranging the apparatus so that the hybrid unit and the Telephone Terminal CF-1-A (Carrier) or Repeater CF-3-A (Carrier) equipment can be located at different points and connected together on a 4-wire basis. The arrangements provide for connecting the telegraph channels over the 4-wire extensions on a simplex basis. It will be desirable to use stable types of cable or wire for these 4-wire extensions. Cable Assemblies CC-358 (terminated by Cable Stubs CC-356) are preferred because they are stable and have a low loss. Both sides of the quad in Cable Assemblies CC-358 are required. In emergencies, nonloaded or unstable wire can be used, but allowance should be made for the higher loss of such wire.

b. Separation of the hybrid unit from the carrier equipment introduces some difficulties in the maintenance of the system and makes it awkward to adjust the balancing networks initially. Therefore, it may be advisable to restrict the use of long 4-wire extensions to essential cases. As an alternative arrangement, an additional repeater can be placed at the Carrier Hybrid CF-7 unit and the cable section operated on a 4-wire basis. In this case the Carrier Hybrid CF-7 unit and Repeater CF-3-A would be operated as a 2-wire—4-wire repeater as discussed in paragraph 15. The other end of the cable could be either a terminal or another 2-wire—4-wire repeater, as required.

12. Selection of pairs.— *a.* When there is a choice of pairs for operation of a carrier system using Carrier Hybrid CF-7 equipment, generally the controlling consideration will be crosstalk. If only one system is to be on the line any pair may be used, but it generally will be desirable to use an outside pair so that a second system can be added later. If two systems are to be worked on the line, the pairs selected should be as widely separated as possible. This means that on a 4-pair line pairs 1-2 and 9-10 should be used. Where good crosstalk performance is desired, it is generally useless to attempt to work two systems on pairs which are horizontally, vertically or diagonally adjacent, although in some cases this may be done if the circuit net losses can be increased to 20 or 30 db or if the upper frequency channels are not used.

b. Ordinarily, a carrier system using Carrier Hybrid CF-7 equipment cannot be operated on the same line with a type C system, or a system using Converters CF-4 (Carrier, 2 wire—4 wire) and Repeaters CF-5 (Carrier, 2 wire), unless the pairs are widely separated and high net losses or very high crosstalk can be tolerated, or unless the upper frequency channels of the Carrier Hybrid CF-7 system are not used.

c. On the other hand, the crosstalk ordinarily will permit operation of a Carrier Hybrid CF-7 system together with voice-frequency circuits, either repeatered or nonrepeatered, on the side circuits of all other pairs on the line. However, excessive crosstalk may be experienced between channel 1 of the carrier system and voice-repeatered phantoms.

d. Noise is not likely to be a consideration in the selection of pairs for a carrier system using Carrier Hybrid CF-7 equipment. However, crosstalk from carrier systems using different frequency allocations, and beat tones resulting from single frequencies due to carrier telegraph systems or carrier leak on other pairs on the line, are potential sources of noise and should be guarded against. Noise from such sources should not be serious if the crosstalk between the carrier systems involved is kept low.

13. Estimation of balance.— *a.* Repeater spacings for the 2-wire carrier system usually will be determined by the balance which can be realized between the line and its balancing network. The magnitude of the balance depends upon the accuracy of adjustment of the balancing network and the smoothness of the impedance characteristic of the line. The latter will be high when the construction of the line is very uniform, thus permitting a high balance. On the other hand, if the line involves changes of gauge and spacing and includes intermediate cable, there are likely to be impedance irregularities and the balance which can be obtained may be quite low.

b. It is often necessary for layout purposes to make some estimate of the balances which may be obtained before a system is installed. Some approximate rules for making such estimates are given below.

(1) If the line consists of open-wire and is of moderately uniform construction with some entrance cable, but has little or no intermediate cable, few or no bridges, and no definite changes in gauge or spacing within a repeater section, it should be possible to obtain and maintain a balance of 25 db.

(2) If the line consists of open-wire with changes of gauge and spacing and includes intermediate cable, a balance greater than 20 db should not be assumed for layout purposes and in some cases even lower balances may be experienced.

(3) If the line is composed of loaded cable, a balance of about 15 db should be obtained.

14. Repeater spacing.— *a.* The repeater spacings and maximum circuit lengths which can be used with the 2-wire carrier system generally are determined by balance and crosstalk considerations. Estimated maximum spacings are given in table II for various types of open-wire line facilities having net losses of 6 and 30 db respectively. The figures are based on balances and crosstalk conditions which may be expected in practice for a well-constructed line transposed in accordance with instructions in Technical Manual TM 11-368. Figures are given for balances of 20 and 25 db in accordance with the discussion of paragraph 13. A similar table, table III, is given for rubber-covered cables. In this table balances of 15 db

TABLE II

ESTIMATED MAXIMUM REPEATER SECTION LENGTHS, 4-PAIR OPEN-WIRE LINE

Description	Repeater section lengths—miles							
	6 db net loss						30 db net loss	
	20 db balances			25 db balances			20 db balances no reps.	25 db balances no reps.
	No reps.	1 rep.	3 reps.	No reps.	1 rep.	3 reps.		
080 copper-steel (40%)	57	43	34	65	57	48	125	134
104 copper-steel (40%)	87	65	52	97	83	70	191	201
128 copper-steel (40%)	125	94	75	135	116	97	275	285
080 copper	118	88	70	131	113	95	259	272
104 copper	167	125	100	185	155	135	367	380
128 copper	200	150	120	210	180	150	440	450
165 copper	241	181	144	246	210	173	530	535

NOTE: The above figures are for one system on any pair of a 4-pair open-wire line or for two systems on pairs 1–2 and 9–10. Generally, other combinations will require much shorter repeater sections.

have been assumed. In some cases, however, balances as high as this may not be possible.

b. The figures given in tables II and III assume that all repeaters are lined up to have the same output levels. Somewhat longer lengths can be obtained on multi-repeatered circuits by "tapering" the output levels. Tapering here means employing progressively lower repeater output levels proceeding along the circuit from terminal A to terminal B and vice versa. However, the repeater output levels

TABLE III

ESTIMATED MAXIMUM REPEATER SECTION LENGTHS, RUBBER-COVERED CABLES

Description	Repeater section length—miles			
	6 db net loss			30 db net loss no rep.
	No rep.	1 rep.	3 reps.	
One pair of Cable Assemblies CC-358	16	11	7	42
W-143 nonloaded with special equalization (see par. 14*e*)	12	10	9	23

must not be reduced so far that the circuit becomes noisy. In this arrangement the intermediate repeater gains are made less than the loss of the preceding line section but more gain is allowable at the circuit terminals. This permits the over-all length of the circuit to be increased.

c. When noise is high, or for purposes of coordination of output power between a carrier system using Carrier Hybrid CF-7 units and other systems on the line, it may be desirable to increase the output power of the associated Telephone Terminals CF-1-A as outlined in paragraph 11*e*(2) of TM 11-341. This will be of advantage where balances are high and noise or crosstalk controls the repeater spacing.

d. The attenuation of the line is also an important factor in determining the repeater spacing. The attenuation of the several facilities likely to be employed in a system using Carrier Hybrid CF-7 units is accordingly given in table IV. Included in the table

TABLE IV

APPROXIMATE ATTENUATION OF LINE FACILITIES

Description	Approx. gauge	D-c resistance ohms per loop mile	Approximate attenuation—db per mile									
			Dry					Wet				
			1 kc	8 kc	11 kc	20 kc	30 kc	1 kc	8 kc	11 kc	20 kc	30 kc
080 copper-steel (40%)	14	42.8	.23	.31	.32	.33	.33	.25	.34	.35	.36	.37
104 copper-steel (40%)	12	25.3	.16	.20	.20	.21	.21	.18	.22	.23	.24	.24
128 copper-steel (40%)	10	16.7	.12	.14	.14	.14	.15	.13	.16	.16	.17	.18
080 copper	14	17.5	.11	.13	.14	.16	.19	.13	.15	.17	.20	.24
104 copper	12	10.3	.074	.089	.099	.13	.15	.083	.11	.12	.16	.19
128 copper	10	6.8	.052	.071	.080	.11	.13	.061	.088	.10	.14	.16
165 copper	8	4.1	.034	.056	.064	.084	.10	.042	.072	.083	.11	.13
Cable Assemblies CC-358	—	77	Approx. same as wet					.75	.85	.95	1.5	—
Wire W-143 nonloaded	—	35	Approx. same as wet					1.2	2.1	2.2	2.5	2.9

NOTES: (1) The attenuation figures for open wire are for side circuits at 70° F and assume 8-inch wire spacing and 200-foot pole spacing except for 080 copper which is 150 feet. They also assume that construction practices outlined in TM 11-368 are followed.

(2) The figures for the rubber-covered wire are for 70° F under wet weather conditions. In dry weather the attenuation will be slightly less.

are the d-c resistance and the approximate attenuation of the several facilities for a number of representative frequencies.

e. The length of unequalized nonloaded Wire W-143 which can be spanned satisfactorily by a carrier system using Carrier Hybrids CF-7 with associated Telephone Terminals CF-1-A and Repeaters CF-3-A is so short as to be impracticable. However, by providing supplementary equalization for this wire, it is possible to operate over distances as indicated in table III. The supplementary equalization consists of an 80-ohm resistance and 11-millihenry inductance connected in series and the combination shunted across

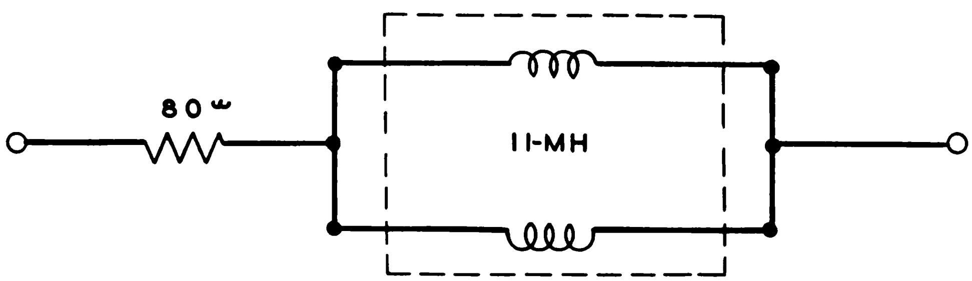

Figure 3.— Equalizer for nonloaded Wire W-143.

the input circuit or circuits associated with each Telephone Terminal CF-1-A or Repeater CF-3-A equipment. In the case of Repeater CF-3-A, one equalizer is connected to the AB IN binding posts T and R and a second equalizer to the BA IN binding posts T and R. Only one equalizer is required at a terminal and it is connected to the REC T and R binding posts. If not available, the equalizers can be assembled locally as indicated in figure 3, each equalizer being formed from any available 80(±5)-ohm resistor and a 44-millihenry loading coil with the two windings of the coil connected in parallel to provide the 11-millihenry inductance. The balancing and lineup procedures when the carrier equipment is used with equalized nonloaded Wire W-143 are included in this manual.

15. 2-wire—4-wire repeater.— *a.* In some layouts a Repeater CF-3-A may be operated between a 2-wire line and a 4-wire line. This arrangement of the repeater is illustrated by the right-hand repeater in figure 8. In such cases, only one carrier hybrid unit is required and is connected between the 2-wire line and the repeater. In carrying out the adjustments and lineup of the Repeater CF-3-A equipment, the procedure outlined in this manual is employed for the adjustments of the equalizer panel associated with transmission from the 2-wire toward the 4-wire line. On the other hand, the equalizer panel associated with the opposite direction of transmission is treated in the normal manner as outlined in Technical Manual TM 11-341.

16. Telegraph circuits.— *a.* Composite equipment is provided as a part of the carrier hybrid unit for obtaining two grounded direct-current circuits over an open-wire pair. Normally d-c circuit 1 will be used for the signaling circuit and d-c circuit 2 for a telegraph circuit, but if the signaling circuit is omitted, two telegraph circuits can be obtained.

b. The composite equipment includes means for changing the capacitance in each shunt path to ground in accordance with the telegraph equipment associated with the hybrid unit. This is accomplished by the aid of two pairs of capacitors, one capacitor of each pair being associated with each shunt path. The capacitors forming one pair have a capacitance of 1.08 microfarads each and the capacitors forming the other pair have a capacitance of 5.5 microfarads each. At a telegraph terminal one capacitor from each pair is connected in each shunt path in a parallel arrangement to provide a total capacitance of 6.58 microfarads. At an intermediate point, where the telegraph currents are by-passed, only the 1.08-microfarad capacitor is connected into each shunt path. The proper arrangement of capacitors to be used is controlled by strappings on the CXT and CXR terminal strips. The terminal strip connections also provide means to connect the direct-current paths directly through the carrier equipment or to the TLG 1 and TLG 2 binding posts. The TLG 1 binding post is associated with the CXT terminal strip and the TLG 2 binding post with the CXR terminal strip.

c. Ordinarily, in a 4-wire carrier system employing Telephone Terminal CF-1-A and Repeater CF-3-A equipment, the signaling circuit is associated with the pair used for the A-to-B direction of transmission and the telegraph circuit is associated with the pair used for the B-to-A direction of transmission. Accordingly, in a 2-wire carrier system using the above equipment and Carrier Hybrid CF-7 units, the signaling circuit (d-c circuit 1) appears at the CXR terminal strip at the carrier hybrid unit associated with terminal A, and at each odd-numbered carrier hybrid unit along the line. Likewise, the telegraph circuit (d-c circuit 2) appears at the CXT terminal strip at these hybrid units. At the alternate carrier hybrid units and terminal B, the signaling circuit appears at the CXT terminal strip and the telegraph circuit appears at the CXR terminal strip.

d. The terminal strip connections also make it possible to include telegraph noise filters in each of the direct-current paths, or to omit them, as required by noise considerations. A noise filter is not required for the signaling circuit. Generally, any telegraph equipment such as Telegraph Repeater TG-30 (Terminal) and Telegraph Repeater TG-31 (Intermediate) will be connected at the Telephone Terminal CF-1-A and the Repeater CF-3-A rather than at the TLG 1 and TLG 2 binding posts of the hybrid unit. When such telegraph equipment is employed at the terminal or repeater (or at the hybrid unit), a telegraph noise filter should be included in the telegraph circuit. If, on the other hand, a telegraph circuit is bypassed through the carrier equipment, with no telegraph equipment connected at that point, the noise filter should be omitted.

17. Signaling circuit.— *a.* A signaling circuit for maintenance of the system ordinarily is provided over one of the d-c composite circuits. The signaling circuit makes use of the arrangements normally included in the Telephone Terminal CF-1-A and Repeater CF-3-A equipment. This signaling circuit was designed for cable circuits and will be subject to certain limitations when used over open-wire as discussed below.

b. In dry weather the signaling circuit should operate satisfactorily, but in wet weather the open-wire line leakage may become sufficiently high to cause the circuit to be partially inoperative. At such times the signaling circuit should function satisfactorily from the carrier terminal at which the battery is applied to the next one or two repeater stations. Beyond these points, the line leakage, if great enough, may prevent sufficient signaling current from reaching the following repeaters or distant terminal. Likewise, no signal can be transmitted back from these points since the signaling circuit will be grounded through the leakage path. The specific portions of the circuit over which signaling can be accomplished during wet weather cannot be predicted since these will depend on the amount and location of the line leakage. When the signaling circuit is out of operation due to leakage effects, some relief can be afforded by breaking the signaling circuit into two sections by applying battery at each terminal and ground at an intermediate point. This arrangement, however, provides no means for getting the signal past the intermediate point.

18. Installation.— *a. General*— It is recommended that two men be employed at each point in setting up Carrier Hybrid CF-7 and its associated carrier equipment. While the equipment can be placed in service by one man working alone, it will be found that, in making the necessary adjustments, two men working as a team are much more efficient.

b. The Carrier Hybrid CF-7 unit.— The installation of the Carrier Hybrid CF-7 unit is relatively simple. Place the equipment so that it is protected from the elements, and if it is at the same point as the carrier terminal or repeater, locate it as close as possible to this equipment. Establish the ground connection and the connections to the carrier equipment as outlined in paragraphs 19 and 20.

c. Telephone Terminal CF-1-A and Repeater CF-3-A equipment.— Set up and place this telephone terminal and repeater equipment in working condition as described in TM 11-341. Make normal connections for signaling and telegraph circuits. Connect any telegraph equipment to be used to the binding posts on the Telephone Terminal CF-1-A and Repeater CF-3-A in the normal manner.

19. Grounding arrangements.— *a.* If the hybrid unit is located with the terminal or repeater equipment, connect the GRD binding post by a 14-gauge, or larger, copper wire to the ground provided for the carrier equipment.

b. If the hybrid unit is located at a distance from the terminal and repeater equipment, so that it is not feasible to use a common ground, establish a new ground. The ground should be of as low resistance as possible. This may be a buried water supply system, buried gas pipes, underground tanks or other buried metallic structures, or, if necessary, a number of driven ground rods connected together. Connection to the ground should be by 14-gauge or larger copper wire.

20. Connections.— *a.* Connect the conductors from the 2-wire line to the 2W-LINE binding posts.

b. Connect the leads from the Telephone Terminal CF-1-A or from either side of the Repeater CF-3-A to the TRSG and REC binding posts of the hybrid unit as indicated in table V.

c. If an external network is to be used with the hybrid unit, con-

TABLE V

CONNECTIONS BETWEEN CARRIER EQUIPMENT AND CARRIER HYBRID CF-7

Connect binding posts as follows:

Telephone Terminal CF-1-A (Carrier)		Carrier Hybrid CF-7
REC	to	TRSG
TRSG	to	REC

Repeater CF-3-A (Carrier) toward terminal A		Carrier Hybrid CF-7
AB IN	to	TRSG
BA OUT	to	REC

Repeater CF-3-A (Carrier) toward terminal B		Carrier Hybrid CF-7
BA IN	to	TRSG
AB OUT	to	REC

TABLE VI

SIGNALING AND TELEGRAPH CIRCUIT CONNECTIONS

Location of telegraph equipment	Connect terminals on terminal strips			
	At terminal A or at repeater toward term. B		At terminal B or at repeater toward term. A	
	CXR (sig. ckt)	CXT (teleg. ckt)	CXR (teleg. ckt)	CXT (sig. ckt)
No telegraph eqpt. at CF-7 or assoc. CF-1-A or CF-3-A	C-D	C-D	C-D	C-D
With telegraph eqpt. at assoc. CF-1-A or CF-3-A	C-D	A-B-C, D-E	A-B-C, D-E	C-D
With telegraph eqpt. at CF-7	C-D	A-B-C, E-F	A-B-C, E-F	C-D

TABLE VII

NOMINAL ADJUSTMENT OF BALANCING NETWORK

Type of circuit	Spacing (O.W. only)	LF CORR Set sw. to	B.O. COND.[a] Set sw. to	B.O. COND.[a] Screw down contacts	BAL. RES. Set sw. to	BAL. RES. Screw down contacts	BAL. RES. Total res. ohms
080 copper-steel (40%)	8″	1	OUT	None[a]	3	1, 2, 3	630
	12″	1	OUT	None[a]	3	1, 3	680
104 copper-steel (40%)	8″	2	OUT	None[a]	3	1, 4	580
	12″	2	OUT	None[a]	4	1, 2, 3	640
128 copper-steel (40%)	8″	3	OUT	None[a]	3	3, 5	305
	12″	3	OUT	None[a]	3	2, 5	355
080 copper	8″	3	OUT	None[a]	4	2, 5	365
	12″	3	OUT	None[a]	3	1, 2, 3, 4	430
104 copper	8″	4	OUT	None[a]	4	1, 4	590
	12″	4	OUT	None[a]	4	1, 2, 3	640
128 copper	8″	5	OUT	None[a]	4	2, 5	365
	12″	5	OUT	None[a]	3	1, 2, 3, 4	430
165 copper	8″	5	OUT	None[a]	3	1, 2, 5	330
	12″	5	OUT	None[a]	4	1, 5	390
CC-358 full coil term.		5	LINE	1, 3, 5, 7	3	3, 5	305
W-143 1650-6-mid-sec. term.		6	OUT	None	4	1, 2, 4, 5	140
W-143 nonloaded with special equalization		4	OUT	None	3	1, 3, 4, 5	80
Circuit requiring external network		OPEN	OUT	None	0	None	0

[a] The BO COND adjustments shown for open-wire circuits apply when entrance cable or wire is not used. When open-wire circuits are connected to the hybrid unit by an entrance cable or wire, set the BO COND switch on NET and screw down the proper contacts on the BO COND contact strips to obtain a total capacitance equal to the capacitance of the entrance cable or wire, as determined from the cable length and the nominal values listed below:

Type of cable	Capacitance per 100 feet—microfarads
Wire W-143	0.0033
Cable Assemblies CC-368 (or CC-358 with connectors and loading coils removed)	0.0022
Paper-insulated lead-covered cable	0.0012

nect the network to the binding posts marked EXT NET. This arrangement will seldom be used.

d. The GRD and PH binding posts normally are strapped together for nonphantom operation. To derive one side of a phantom connection from the 2-wire line, remove the strap and connect one wire of the phantom circuit to binding post PH.

21. Initial adjustments.— *a.* Connect the terminals of the CXT and CXR terminal strips according to table VI to obtain a signaling channel over the d-c path associated with the A-to-B direction of transmission through the Telephone Terminal CF-1-A and Repeaters CF-3-A, and a telegraph channel over the d-c path associated with the B-to-A direction of transmission through these equipments. This will be the most usual condition for the d-c channels. The connections for other conditions of the d-c channels are indicated in paragraphs 30 and 31. Access to the terminal strips is gained by removing the cover plate marked TLG–SIG CONN.

b. Adjust the LF CORR, BAL RES and BO COND dials and the contact posts of the BAL RES and BO COND contact strips according to table VII, for the facility being used. Be sure the adjustment of the BO COND dial and the contact posts of the BO COND contact strips take into consideration any entrance cable or wire (par. 10*a*(2)).

As an example of the adjustment of the BO COND, assume that there is an entrance cable consisting of 275 feet of nonloaded Wire W-143. The required building-out capacitance would be

$$2.75 \times 0.0033 = 0.009075 \text{ microfarad}$$

Approximately this value of building-out capacitance would be obtained by screwing down the contact posts marked 1 and 7 on the BO COND contact strip.

c. If the facility is not known or not covered in table VII, adjust the balancing network initially as follows:

	L.F. CORR. sw. setting	B.O. COND sw. setting	BAL. RES.		
			Set sw. to	Screw down contacts	Total res. ohms
Open wire	3	OUT	0	1, 2, 3	600
Nonloaded cable or field wire	5	OUT	0	1, 2, 4, 5	100

d. Make preliminary dial settings on the EQL panels at all Telephone Terminals CF-1-A and Repeaters CF-3-A associated with Carrier Hybrid CF-7 units as follows:

(1) Set dial 1 on 18, dial 4 on 0 and dial 2 on 4.

(2) Set MILES dial in accordance with table VIII for facility and length of preceding repeater section.

e. Establish communication between the carrier terminals and repeater points on channel 1.

(1) Singing (sustained tone) should rarely, if ever, be heard at this point in the lineup. If it is, reduce the EQL dials 1 at one or more repeaters until the singing stops. Reduction of gain in this manner may be more effective at a particular repeater than at other repeaters.

(2) If there is difficulty in hearing because of low volume, the gains at one or more repeaters may be increased by increasing the EQL dials 1 above their initial settings of 18. **Be sure not to increase the gain so much that singing occurs.**

f. Set up the signaling circuit. This circuit is made over one wire to ground on the open-wire pair. To form a continuous direct-current path, make a test by which the signaling conductor in one repeater section will be carried through to the signaling conductor in the next repeater section. The signaling circuit is sensitive to leakage effects, so the test described below must usually be made under dry weather conditions.

(1) Throw SIGNAL CUT-OFF key lever down at all stations.

(2) At terminal A, operate key lever on SIG panel to BATTERY.

(3) At first repeater from terminal A, operate key lever on SIG panel to GROUND B.

(4) If signal sounds, the circuit is continuous up to the first repeater.

(5) If signal does not sound, interchange line conductors at 2-W LINE binding posts of hybrid unit on side of repeater towards terminal A. If signal sounds, the signaling circuit is continuous. If signal does not sound, the line is probably in trouble or there may be trouble in the equipment.

(6) Restore GROUND B key lever to normal at repeater. The SIGNAL CUT-OFF key at terminal and repeater may be operated to silence signal, if necessary.

(7) Repeat paragraphs (3) to (6) at other repeaters in turn, working away from terminal A. During this test, disregard signals at terminal A and repeaters not under test.

TABLE VIII

PRELIMINARY SETTINGS OF MILES DIAL ON TELEPHONE TERMINAL CF-1-A OR REPEATER CF-3-A

Facility	Length in miles	MILES dial setting
080 copper-steel (40%) open wire	20-30	0
	30-40	0
	40-50	5
	50-60	15
	60-70	20
	70-80	25
	Over 80	30
104 copper-steel (40%) open wire	30-40	0
	40-50	0
	50-60	5
	60-70	10
	70-80	15
	80-90	20
	90-100	25
	Over 100	30
128 copper-steel (40%) open wire	50-70	0
	70-90	5
	90-110	10
	110-130	15
	130-150	20
	150-170	25
	Over 170	30
080 copper open wire	60-80	0
	80-100	0
	100-120	0
	120-140	5
	140-160	10
	160-180	15
	Over 180	20
104 copper open wire	50-100	0
	100-150	0
	150-200	0
	200-250	5
	250-300	10
	Over 300	15
128 copper open wire	Any	0
165 copper open wire	Any	0
Cable Assemblies CC-358	10	0
	15	0
	20	5
	30	15
	40	25
Wire W-143 nonloaded with special equalization	10-70	30

(8) Repeat paragraphs (3) to (5) at terminal B. During this test, disregard signals at terminal A and repeaters not under test.

(9) When signaling circuit is continuous, leave key lever on SIG panel operated to GROUND at terminal B, and silence signal with SIGNAL CUT-OFF key.

22. Initial lineup.— *a.* An initial lineup of the system is made to determine the equalizer dial settings of the associated terminal and repeater equipment so that the final adjustment of the balancing network can be carried out with the equalizer dials set as closely as possible to the working steps.

b. Line up the system and adjust the net loss of the channels in each direction, using the standard procedure for Telephone Terminal CF-1-A and Repeater CF-3-A, except as noted below.

(1) When lining up the AB direction, have dials 1 and 4 of the BA direction on steps 18 and 0, respectively, at all Telephone Terminals CF-1-A and Repeaters CF-3-A associated with Carrier Hybrid CF-7 units. These settings for the BA direction are specified to hold down the BA repeater gain so that singing will not occur at this point in the lineup.

(2) When lining up the BA direction, have dials 1 and 4 of the AB direction on steps 18 and 0, respectively, at all Telephone Terminals CF-1-A and Repeaters CF-3-A to prevent singing.

(3) The settings of the dials on the EQL panels given in table IX may be used initially in the direction being lined up to facilitate the lineup. (The other directions should have dials 1 and 4 on 18 and 0, respectively, as indicated in paragraphs (1) and (2) above.) In emergencies, when time for a detailed lineup is not available, these settings may be used for both directions and should provide a talkable circuit if singing difficulties are not encountered.

c. Singing should rarely, if ever, occur during the initial lineup because of the precautions referred to in paragraphs *b* (1) and *b* (2). However, if there is difficulty in getting a proper lineup for either direction of transmission, or if singing is suspected, remove the test power and any carrier telegraph from all channels and check each terminal and repeater for singing as follows:

(1) At a terminal, monitor on each channel in turn. A sustained tone on any channel will indicate singing.

(2) At a repeater, depress the MEAS key and observe meter for each

TABLE IX
SETTINGS FOR INITIAL LINEUP

Facility	Length of preceding repeater section, miles	Settings of dials on CF-1-A and CF-3-A EQL panels			
		MILES Dial	Dial 1	Dial 4	Dial 2
080 copper-steel (40%)	20-30	0	19	4	5
	30-40	0	22	5	6
	40-50	5	27	6	6
	50-60	15	29	7	7
	60-70	20	30	8	7
	70-80	25	30	9	8
	Over 80	30	30	10	8
104 copper-steel (40%)	30-40	0	20	4	5
	40-50	0	22	4	5
	50-60	5	25	4	6
	60-70	10	27	4	6
	70-80	15	29	5	6
	80-90	20	30	5	6
	90-100	25	30	6	7
	Over 100	30	30	6	7
128 copper-steel (40%)	50-70	0	22	4	5
	70-90	5	26	4	5
	90-110	10	29	5	5
	110-130	15	30	5	6
	130-150	20	30	6	6
	150-170	25	30	6	7
	Over 170	30	30	7	7
080 copper	60-80	0	22	5	5
	80-100	0	25	6	5
	100-120	0	28	6	5
	120-140	5	30	7	5
	140-160	10	30	7	5
	160-180	15	30	8	5
	Over 180	20	30	9	5
104 copper	50-100	0	21	4	4
	100-150	0	24	6	4
	150-200	0	27	7	5
	200-250	5	30	9	5
	250-300	10	30	10	5
	Over 300	15	30	12	5

(Continued on page 26)

TABLE IX

SETTINGS FOR INITIAL LINEUP (Continued)

Facility	Length of preceding repeater section, miles	Settings of dials on CF-1-A and CF-3-A EQL panels			
		MILES Dial	Dial 1	Dial 4	Dial 2
128 copper	50-100	0	19	4	4
	100-150	0	21	6	4
	150-200	0	23	8	5
	200-250	0	26	10	5
	250-300	0	28	12	5
	Over 300	0	30	14	5
165 copper	100-150	0	18	6	5
	150-200	0	20	8	5
	200-250	0	22	10	5
	250-300	0	24	12	5
	300-350	0	27	14	5
	Over 350	0	30	14	5
Cable Assemblies CC-358	10	0	21	3	4
	15	0	27	3	4
	20	5	30	5	5
	30	15	30	6	5
	40	25	30	8	5
Wire W-143—nonloaded with special equalization[a]	6	30	20	4	4
	8	30	25	6	5
	10	30	30	8	6
	12	30	30	10	7
	14	30	30	12	8
	16	30	30	13	8
	18	30	30	14	8

[a] Equalization of this facility requires an external equalizer consisting of 80 ohms in series with 11 millihenrys connected across the input terminals of each Telephone Terminal CF-1-A (Carrier) and Repeater CF-3-A (Carrier). This is in addition to the equalizer settings given above. For further details refer to paragraph 14*e*.

position of the MEAS switch. A large or off-scale deflection of the meter will indicate singing.

d. If singing occurs, check that the procedures above have been followed exactly. If singing persists, the networks at one or more points are not correctly adjusted, or a trouble condition exists. It may be possible in such cases to complete the initial lineup by reducing the setting of the BA EQL dials 1 in paragraph *b* (1) or the AB EQL dials 1 in paragraph *b* (2).

e. Record the dial settings immediately after the initial lineup in each direction.

23. Final network adjustments.— *a.* After the initial lineup is completed, give the networks their final adjustments to obtain as high a balance as possible at each point. Knowledge of the function of a hybrid coil arrangement and the principles of balance, which are discussed in paragraph 33, will help in making these adjustments. The method for measuring balance is given in paragraph 26. The procedure for making the best network adjustment follows.

b. Measure the balance with the initial network adjustment.

c. Then increase the BAL RES dial one step, and measure the balance.
(1) If the balance has increased or is unchanged, continue to increase the BAL RES dial one step at a time and measure the balance on each step until a maximum balance is reached.
(2) If the balance has decreased, decrease the BAL RES dial one step at a time until a maximum balance is reached.
(3) If the BAL RES dial reaches step 0 or step 7 in paragraph (1) or (2) above, it will be necessary to change the setting of the BAL RES contact strip. If the BAL RES dial is on step 0, adjust the BAL RES contact strip so as to remove 50 ohms (fig. 4), set the BAL RES dial on step 5 and continue to reduce the BAL RES dial as required. If this dial is on step 7, adjust the BAL RES contact strip so as to add 50 ohms (fig. 4), set the BAL RES dial on step 2 and continue to increase the BAL RES dial as required.

d. After the best adjustment of the balancing resistance is obtained, adjust the building-out condenser unit in accordance with paragraph (1), (2) or (3) below.
(1) If the preliminary adjustment of the BO COND switch is OUT, turn the switch to NET and adjust the BO COND contact strips for 0.001 microfarad (fig. 5).

(*a*) If the balance has increased or is unchanged, continue to increase the capacitance of the BO COND until a maximum balance is obtained.

(*b*) If the balance has decreased, turn the BO COND switch to LINE and adjust the BO COND contact strips for 0.001 microfarad.

(*c*) Repeat paragraph (1) (*a*).

(2) If the preliminary adjustment of the BO COND switch is LINE, change the specified setting of the BO COND contact strips to increase the specified capacitance by 0.001 microfarad.

(*a*) If the balance has increased or is unchanged, continue to increase the capacitance of the BO COND until a maximum balance is obtained.

(*b*) If the balance has decreased, reduce the capacitance of the BO COND until a maximum balance is obtained.

(*c*) If the BO COND is adjusted to have 0 microfarads without having reached a maximum balance, turn the BO COND switch to NET and repeat paragraph (2) (*a*).

(3) If the preliminary adjustment of the BO COND switch is NET, change the setting of the BO COND contact strips to increase the specified capacitance by 0.001 microfarad.

(*a*) If the balance has increased or is unchanged, continue to increase the capacitance of the BO COND until a maximum balance is obtained.

(*b*) If the balance has decreased, reduce the capacitance of the BO COND until a maximum balance is obtained.

(*c*) If the BO COND is adjusted to have 0 microfarads without having reached a maximum balance, turn the BO COND switch to LINE and repeat paragraph (3)(*a*).

(4) After the best adjustment of the BO COND is obtained, repeat paragraph *c* above. It may be desirable in some cases to try other settings of the LF CORR switch and to repeat paragraphs *c* and *d*, using a cut-and-try process until the best combination of the LF CORR switch, the balancing resistance and building-out capacitance is determined.

e. When the Carrier Hybrid CF-7 is located at some distance from its associated Telephone Terminal CF-1-A or Repeater CF-3-A, the final network adjustments will require two men, one working at each equipment unit. In this case, communication must be provided between the two points. This may be accomplished by connecting a Telephone Unit EE-105 (lineman's telephone for use on carrier lines) across each end of one of the circuits connecting the Carrier Hybrid CF-7 unit and the carrier equipment, or by using a separate circuit formed from any wire or cable which may be at hand and Telephones EE-8-A at each end. If no Telephone Units EE-105 or extra wire or cable are available, an order circuit may be formed by using ground and the simplex of one of the circuits connecting the

TABLE X

TEMPORARY CONNECTIONS FOR ORDER CIRCUIT

Location of CF-7 unit	Connect terminals D and F on CF-7 terminal strip	Connect Telephone EE-8-A at CF-7 to GRD and binding post	Connect Telephone EE-8-A at carrier eqpt. to GRD and binding post
Terminal A	CXT	TLG-1	SX REC
Repeater towards A	CXR	TLG-2	SX BA OUT
Repeater towards B	CXT	TLG-1	SX BA IN
Terminal B	CXR	TLG-2	SX TRSG

Carrier Hybrid CF-7 unit and the carrier equipment. Ordinarily, the simplex which forms a part of the d-c telegraph circuit should be used, since it is not desirable to break up the signaling circuit between the terminals and repeaters. Such an order circuit may be formed by making the connections indicated in table X.

24. Final lineup.— *a.* After the final network adjustments are made, turn all equalizer and gain dials to the settings determined by the initial lineup for both directions of transmission. Then proceed as follows.

b. Monitor on each channel in turn at either terminal.

c. If singing is not heard on any channel:

(1) Line up the system in the standard manner for the terminal and repeater equipment.

(2) Make singing margin tests at each repeater and terminal as described under *Measurement of singing margin—22 tests,* paragraph 27.

(3) The singing margin should be at least 10 db at a repeater and 6 db at a terminal.

(4) If the singing margin is not sufficient at a given point, proceed as follows:

(*a*) At a repeater, reduce the gain with dial 1 by equal amounts in both directions of transmission to obtain 10 db singing margin.

(*b*) At a terminal, reduce the GAIN dials of each channel to obtain 6 db singing margin on each channel.

(*c*) Measure the net loss of channel 4 in both directions. Adjust the proper GAIN dial to obtain a net loss in each direction equal to the larger of the two values measured.

(*d*) Repeat paragraph (*c*) above for channels 1, 2 and 3.

(*e*) Measure and record the channel outputs at each point with the rotary switch on steps 1, 4 and 2. These will be the normal outputs for all subsequent lineups.

d. If, in monitoring, singing is heard on any channel:

(1) Reduce the gain in each direction at each Repeater CF-3-A, and the receiving gain at each Telephone Terminal CF-1-A, 2 db by reducing dial 1 on each EQL panel two steps.

(2) If singing stops, record all dial settings at all locations.

(3) If singing does not stop, reduce the dial 1 setting at each repeater and terminal an additional step at each point. Repeat until singing stops.

(4) Record all dial settings at all locations.

(5) Make singing margin tests at each point as described under *Measurement of singing margin—22 test,* paragraph 27. The singing margin in this test is the sum of the settings of AB dial 1 and BA dial 1, when singing just occurs, minus the setting of these dials as recorded in paragraph (2) or (4) above.

(6) The singing margin should be at least 10 db at a repeater and 6 db at a terminal.

(7) If the singing margin is not sufficient at a given point, proceed as in paragraph *c* (4) above.

(8) If the singing margin is greater than required at a given point, the repeater gains may be increased but not above the gains determined in the initial lineup.

e. In case it is desired to improve the circuit by the use of more precise lineup methods, refer to paragraph 25, *Special lineup procedures.*

f. Check the ringing over each channel by sending a ringing signal between switchboards in each direction as outlined in TM 11-341.

25. Special lineup procedures.— *a*. The procedure described in paragraph 24 can be modified to obtain improved performance in cases where personnel skilled in the operation of 2-wire circuits is available and when additional complexity in procedure is not a disadvantage. Such improvements in performance might be made after a system has been placed in operation and there is time to make more refined adjustments of gain and equalization.

b. In cases where the singing margin is insufficient at the gains of the initial lineup, the procedure of paragraph 24 specifies that the gains at the critical points be reduced by reducing the setting of the EQL dial 1. This dial produces an equal gain change at all frequencies and therefore affects all channels alike. However, singing is most likely to occur on the highest frequency channel. When singing occurs at a high frequency, the singing margins still may be adequate on lower frequency channels. In such cases, the reduction of gain by reducing the setting of EQL dial 1 unnecessarily penalizes the channels with adequate singing margin. A better, though more complicated, procedure would be to reduce the gain at repeaters by reducing the setting of dial 4. This changes the gain greater amounts at high than at low frequencies. The net effect of this procedure, when used under conditions which warrant it, is to permit considerably lower net losses on some channels than would be obtained otherwise.

c. Control of the singing margin by means of dial 4 alone will sometimes cause the singing frequency to shift from one channel to another. Generally, best results will require the manipulation of dials 1, 4 and 2, the object being to obtain the highest practicable gain over each channel with adequate singing margin. More specific rules for such adjustments cannot be given. However, it will be found that a considerable improvement in system performance can be obtained by this means when there is difficulty with low singing margins. When testing at a repeater or terminal, the singing frequency can be determined by having an attendant monitor on the various channels at one of the terminals. Knowledge of the approximate value of the singing frequency (channel number) is useful as a guide in adjustments of this kind.

26. Measurement of balance—21 test.— *a. If not familiar with balance and its measurement, read paragraph 39 before proceeding with the detailed procedures below.*

b. At repeater—toward terminal A.— (1) At adjacent terminal or repeater, record all dial settings and turn all EQL dials to 0. Record all dial settings at repeater under test.

(2) On AB EQL panel of the repeater under test, turn dial 1 to 0 and other dials to settings determined in the initial lineup. On BA EQL panel, turn MILES dial to 0, dial 1 to 20, dial 2 to 4, and dial 4 to 2.

(3) Disconnect wires from binding posts BA IN and AB OUT and connect BA IN to AB OUT.

(4) Turn the switch on MEAS panel to 4 and hold MEAS key lever

on AB. Adjust EQL AB dial 1, and EQL BA dial 1, if necessary, until singing just occurs as indicated by deflection of meter. Release MEAS key lever IMMEDIATELY so that the meter will not be injured and note sum of EQL AB and EQL BA dial 1 settings. Repeat with the switch on MEAS panel turned to 3, 2 and 1 in turn. Record the lowest sum of EQL AB and EQL BA dial 1 settings found for any of the four switch positions.

(5) Reverse wires connected to AB IN binding posts to reverse poling and repeat paragraph (4).

(6) The lowest sum of dial 1 settings recorded in paragraphs (4) and (5) is indication of balance and should be made as high as possible in the final network adjustment.

(7) Balance in db is sum of dial 1 settings in paragraph (6) plus sum of dial 4 settings minus 23.

(8) Restore all connections and dials to normal.

c. At repeater—toward terminal B.— (1) At adjacent terminal or repeater, record all dial settings and turn all EQL dials to 0. Record all dial settings at terminal or repeater under test.

(2) On BA EQL panel of repeater under test, turn dial 1 to 0 and other dials to settings determined in the initial lineup. On AB EQL panel, turn MILES dial to 0, dial 1 to 20, dial 2 to 4, and dial 4 to 2.

(3) Disconnect wires from binding posts AB IN and BA OUT and connect AB IN to BA OUT.

(4) Turn switch on MEAS panel to 4 and hold MEAS key lever on BA. Adjust EQL BA dial 1, and EQL AB dial 1, if necessary, until singing just occurs as indicated by deflection of meter. Release MEAS key lever IMMEDIATELY to prevent injury to meter and note sum of EQL BA and EQL AB dial 1 settings. Repeat with switch on MEAS panel turned to 3, 2 and 1 in turn. Record the lowest sum of EQL BA and EQL AB dial 1 settings found for any of the four switch positions.

(5) Reverse wires connected to BA IN binding posts to reverse poling and repeat paragraph (4).

(6) The lowest sum of dial 1 settings recorded in paragraphs (4) and (5) is indication of balance and should be made as high as possible in the final network adjustment.

(7) Balance in db is sum of dial 1 settings in paragraph (6) plus sum of dial 4 settings minus 23.

(8) Restore all connections and dials to normal.

d. At terminal.— (1) At adjacent terminal or repeater, record all dial settings and turn all EQL dials to 0. Record all dial settings at terminal under test.

(2) Disconnect all four T leads to 2W binding posts CH1, CH2, CH3 and CH4 at the terminal. Throw OUTPUT key lever (if provided) to NORMAL and REC LEV (or LEV) key downward. Leave all EQL dials on normal setting and turn GAIN dials to 30 on all channels.

(3) On CHAN 4 panel, throw TALK-MON key to MON and monitor. Adjust EQL dial 1 until singing just occurs and note EQL dial 1 setting. Repeat on channels 3, 2, and 1 in turn. Record lowest setting of EQL dial 1 found for any of the four channels.

(4) Reverse wires connected to REC binding posts to reverse poling and repeat paragraph (3).

(5) Lowest setting of EQL dial 1 in paragraphs (3) and (4) is indication of balance and should be made as high as possible in final network adjustment.

(6) Approximate balance in db is EQL dial 1 setting in paragraph (5) plus EQL dial 4 setting minus 4.

(7) Restore all connections and dials to normal.

NOTE: When only one man is available at a terminal for making network adjustments, it generally will be easier to observe singing in paragraph (3) above by throwing the TALK-MON key to TALK (a locking position of the key), rather than to MON (a nonlocking position which requires the use of one hand to hold the key in position). **In following this procedure, take care not to operate the TALK-MON key on more than one channel at a time.** After the best apparent adjustment of the network has been found in this manner, check and make the balance measurements with the key in the MON position.

e. At 2-wire side of 2-wire, 4-wire repeater.— (1) If 2-wire side of repeater is toward terminal A, proceed as in paragraph *b* above. (2) If 2-wire side of repeater is toward terminal B, proceed as in paragraph *c* above.

27. Measurement of singing margin—22 test.— *a. If not familiar with singing margin and its measurement, refer to paragraph 40 before proceeding with the detailed procedures below.*

b. Record dial settings at all points.

c. At a repeater.— (1) At both associated Telephone Terminals CF-1-A turn all EQL dials to 0. Leave EQL dials in normal positions at other repeaters.

(2) At repeater under test, turn switch on MEAS panel to 4 and hold MEAS key lever on AB. With other EQL dials normal, adjust EQL AB dial 1, and EQL BA dial 1, if necessary, until singing just occurs as indicated by deflection of meter. Release MEAS key lever IMMEDIATELY to prevent injury to meter and note sum of EQL AB and EQL BA dial 1 settings. Repeat with switch on MEAS panel turned to 3, 2, and 1 in turn. Record lowest sum of EQL AB and EQL BA dial 1 settings found for any of the four switch positions.

(3) Singing margin for repeater is lowest sum determined in paragraph (2) minus sum of dial 1 normal settings.

(4) Restore all keys and dials to normal.

d. At a terminal.— (1) At the far Telephone Terminal CF-1-A, turn all EQL dials to 0. At repeaters leave dials in normal position.

(2) At terminal under test, throw REC LEV (or LEV) key lever downward. Leave EQL dials on normal settings. Leave connections to all CH binding posts T and R normal.

(3) On CHAN 4 panel, throw TALK-MON key to MON and monitor. Adjust GAIN dial on CHAN 4 panel until singing just occurs. Singing margin for channel 4 is 10 plus setting of GAIN dial on channel 4 when singing just occurs minus normal setting of GAIN dial on channel 4. Restore GAIN dial to normal.

(4) Repeat paragraph (3) on channels 3, 2 and 1 in turn to obtain singing margin on these channels.

(5) Restore all keys and dials to normal.

e. At a 2-wire, 4-wire repeater.— Proceed as in paragraphs *b* and *c*.

28. System operation and maintenance.— *a.* After a system has been lined up initially, certain periodic measurements are required. These include periodic lineups and daily measurements. The procedures for these tests are given in section II of TM 11-341.

b. General procedures for system maintenance are given in section IV of TM 11-341. In the case of 2-wire circuits, however, line changes due to weather and temperature may result in decreases in singing margins. These, in turn, may cause hollowness or singing. If any channel becomes hollow or sings, the procedure outlined in paragraph 24 *d* should be followed. In cases of complete failure due to singing, balance measurements (21 tests) may be of assistance in determining the repeater section in which trouble is located. Low balances will usually indicate line trouble on the side of the repeater or adjacent to the terminal where the low balance is observed.

SECTION III

FUNCTIONING OF PARTS

29. General description.— The circuit of Carrier Hybrid CF-7 is shown schematically in figure 9. A simplified schematic is shown in figure 10. As shown in this figure, incoming currents from the open-wire line enter the equipment at the 2W-LINE binding posts. They then pass through the composite set to the repeating coil hybrid. The composite set separates the d-c telegraph currents from the voice and carrier currents. Associated with it are two telegraph noise filters, one for each d-c circuit, for reducing telegraph thump in telephone channel 1. The repeating coil hybrid separates the two directions of telephone transmission. The incoming voice and carrier currents pass through a low-pass filter after leaving the hybrid arrangement. This helps to avoid possible singing at frequencies outside of the normal transmission band. From the filter these currents go via the TRSG binding posts either directly or over an extension circuit to Telephone Terminal CF-1-A (Carrier) or Repeater CF-3-A (Carrier). In the opposite direction, the voice and carrier currents from the terminal or repeater enter the equipment at the REC binding posts. From this point they pass through the repeating coil hybrid and composite set to the line via the 2W-LINE binding posts.

30. Composite set.— *a.* The composite set, shown within one of the dotted boxes in figure 10, consists of series and shunt elements. The series elements are the two capacitors T and R which are connected between the 2W-LINE binding posts and the line terminals of the repeating coil hybrid. The function of these capacitors is to open up the direct-current path between the line and the repeating coil hybrid. The shunt elements consist of the two retardation coils CXA and CXB and the capacitors RA1, TA1, RA2 and TA2. When the composite set is used as a terminal composite set, the capacitors RA1 and RA2, and TA1 and TA2, respectively, are connected in parallel. When the composite set is used as an intermediate composite set, only the capacitors RA1 and TA1 are used, thus reducing the total capacitance in each shunt path in such cases. The windings of the two retardation coils are connected so that one coil is inductive to currents in the metallic circuit and the other coil is inductive to currents flowing in the longitudinal circuit formed by the two line conductors in parallel and ground. The midpoint at the junction of the two capacitors is grounded. The function of the retardation coils and the capacitors is to provide a path for the flow of direct current without appreciably affecting transmission at voice frequencies and to minimize noise in the telephone circuit.

b. The d-c connections for the composite set are brought out to terminals on the CXT and CXR terminal strips as indicated in figure 10. The CXT terminal strip is for making connections involving the wire of the open-wire line connected to binding post T, and the CXR terminal strip is for connections to the line wire connected to binding post R. Due to the arrangement of the connections between each Carrier Hybrid CF-7 and its associated carrier equipment, in a complete system involving Carrier Hybrid CF-7 units each d-c circuit will be reversed between each two units so that d-c circuit 1 will be associated with terminal strip CXR at the first, third, fifth, etc., carrier hybrid units starting from terminal A, and with terminal strip CXT at the second, fourth, and sixth units. Similarly, d-c circuit 2 will be associated with terminal strip CXT at terminal A and each odd-numbered carrier hybrid unit along the line, and with terminal strip CXR at each even-numbered unit and terminal B.

31. Telegraph filters.— *a.* Two noise filter circuits are provided with the composite set, one for each d-c path. These filter circuits, which are shown within a dotted box in figure 10, are for further reducing telegraph thump in the telephone circuit. For example, each circuit consists of a retardation coil CXR, one-half of which is shunted by a resistor RB; a capacitor RB; and a resistor RA. The input and output terminals of each filter circuit are brought out to terminals on the CXT and CXR terminal strips so that the filters may be used or omitted in the direct-current paths as specified.

b. The filters introduce a certain amount of series resistance and shunt capacitance in the telegraph circuits so that their use is limited to conditions where telegraph thump is expected to be objectionable.

32. Telegraph binding posts.— The CXT and CXR terminal strips are arranged so that the d-c circuits can be carried through to the midpoints of the windings on the 4-wire sides of the repeating coil hybrid. These circuits are then carried to Telephone Terminal CF-1-A and Repeater CF-3-A on the simplex of the conductors connecting the carrier equipment to the hybrid unit. As a result of this, usually no connections are required to binding posts TLG 1 and TLG 2, or to terminals F of the CXT and CXR terminal strips. The binding posts are available, however, in case special arrangements of the telegraph circuits are desired. When making connections to these binding posts, be sure to take into consideration the reversal of the d-c circuits from one terminal strip to the other at each Carrier Hybrid CF-7 unit along the line, as mentioned in paragraph 30 *b*.

33. Hybrid arrangement.— *a.* Two repeating coils A and B, shown in figure 10, connected to form a hybrid arrangement are used for separating the two directions of transmission. Briefly, the functioning of the two repeating coils is as follows: Energy from the incoming 2-wire line produces equal voltages in the line windings of both the A and B repeating coils. Because of the reverse poling of the network windings of the one coil with respect to those of the other coil, the resulting voltage across the network is zero and the energy is equally divided between the TRSG and REC circuits. The energy transmitted to the TRSG circuit is useful energy, whereas the energy delivered to the REC circuit is blocked at the output of the adjacent Repeater CF-3-A or Telephone Terminal CF-1-A. Incoming energy from the REC circuit induces equal voltages in the line and network windings of the B repeating coil (assuming that the line and network impedances are equal). The resulting voltages of the corresponding windings of the A coil are also equal. However, due to the reverse poling of the network windings, no voltage is induced in the winding connected to the TRSG circuit and the energy is equally divided between the 2-wire line and the network. The midpoint of the line winding of repeating coil B is grounded, either directly or through the phantom repeating coil, to reduce noise which might result from any shunt unbalance in the composite set.

b. The voltages produced in the TRSG winding of repeating coil A, due to the incoming current from the REC circuit, will be equal and opposite only if the impedance of the line is exactly equal to the impedance of the network. If these impedances are not equal, the voltages induced in the TRSG winding will not be equal and some of the incoming energy from the carrier equipment will return to it through the TRSG circuit. Such a condition may produce singing. It is desirable, therefore, that the impedance of the network be as close to that of the line as possible. The balance between the line and network is a measure of the relationship between these impedances. A high balance indicates that they are nearly equal; a low balance indicates considerable inequality. It is apparent, therefore, that to prevent circulating currents and singing, as high a balance as is possible is desirable. This is obtained by adjusting the network in the manner outlined in the detailed procedures.

34. Low-pass filter.— The low-pass filter, also shown in figure 10, is included to insert loss in the transmitting branch of the circuits at frequencies above about 12 kc. The cutting off of the higher frequencies is desirable to reduce the possibility of singing outside of the useful band. Singing outside of the band may be encountered occasionally, but in most cases the filter will be sufficient to prevent this. The filter consists of an 11-millihenry retardation coil F and two capacitors designated FA and FB, respectively, and introduces less than 2 db loss in the useful frequency band.

35. Balancing network.— *a.* The balancing network covers a number of types of facilities including moderate lengths of nonloaded entrance cable. It is provided with dial controls and contact strips for making adjustments, so that the best network condition can be obtained for a given line. A detailed circuit of the network and the various controls is given in figure 4.

b. The network consists essentially of three components. One of these is composed of capacitor N and retardation coil NCX, which together serve to balance the composite set regardless of whether or not the noise filters are used.

c. A second component of the network is the low-frequency corrector which consists of a combination of resistors and capacitors. The combination appropriate to a particular facility is selected by means of the LF CORR dial. The six steps on this switch are for the various line facilities indicated in table VII. The gradation of the steps is such that when turning the LF CORR dial from step 1 toward step 6 the resistance and negative reactance are progressively decreased at low frequencies.

d. A third component of the network is a resistance connected in series with the low-frequency corrector. This series resistance is adjustable and is divided into two parts which are connected in series.

The first part consists of 25-, 50-, 100-, 200-, and 400-ohm resistors which are brought out to contacts on the BAL RES contact strip. By manipulating the several screw contacts properly, resistance values from 0 to 775 ohms may be obtained in 25-ohm steps. The second part consists of seven 10-ohm resistors which are wired to contacts

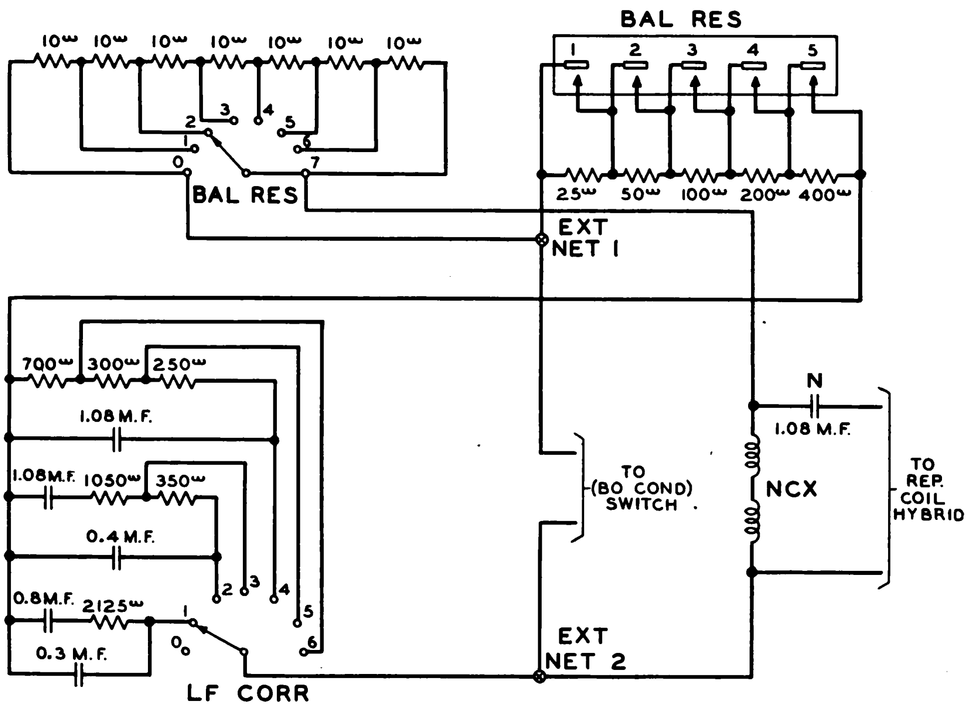

Figure 4.— Schematic diagram of balancing network.

of the BAL RES switch. This arrangement affords a convenient and fine control of the resistance for making final adjustments of the network.

36. Building-out condenser unit.— *a.* The building-out condenser unit designated BO is a multi-unit capacitor which can be adjusted to obtain capacitance from 0 to 0.085 microfarad in small steps. Leads from the various capacitors making up the unit are brought out to two contact strips marked BO COND, and the desired capacitance is obtained by adjusting the several screw contact posts associated with these contact strips.

b. The building-out condenser unit is wired to the BO COND switch which permits the unit to be connected in parallel with other components of the network or in parallel with the 2-wire line. An open position of the switch also is provided which disconnects the unit entirely from the circuit. The arrangement of the building-out unit, the BO COND contact strips, and the BO COND switch is shown in detail in figure 5.

c. The value of each capacitance associated with the unit is indicated on the face of the panel and is also shown in figure 5. This value is the nominal capacitance. The actual value may differ somewhat from that indicated.

d. The principal function of the building-out condenser unit is to control the reactance of the network or line at high frequencies. If the reactance of the line is more negative than that of the low-frequency corrector, the deficiency in the network can be made up by associating the building-out condenser unit with the network. If the reactance of the line is less negative than that of the network, the deficiency can be made up by connecting the condenser unit across the line.

e. The building-out condenser unit must be used when there is a length of entrance cable between the hybrid unit and the terminals of the open-wire line. Short lengths of cable can be balanced very accurately but some inaccuracy of balance is unavoidable if the cable lengths approach the limiting values given in table I.

37. Protectors.— The protector blocks connected across the 2-wire and 4-wire line terminals, as shown in figure 10, protect the equipment against excessive external potentials. Such potentials may be caused by lightning or effects from power lines. The protector blocks connected across the 2-wire line have a drainage coil D connected in series with them to reduce the effect of protector breakdown on voice-frequency telegraph transmission. The protector blocks connected across the 4-wire lines are not provided with drainage. However, protectors are provided at these points to protect the equipment when the hybrid unit and carrier equipment are at separate points. Such a situation is not expected to be a normal arrangement and drainage coils are omitted to save size and weight of the unit.

38. Transmission performance.— *a. Loss.*— (1) The transmission loss through Carrier Hybrid CF-7 is approximately 4 db, making the available gain 4 db less at a terminal and 8 db less at a repeater (if provided on both sides of the repeater) than the normal gains of a Telephone Terminal CF-1-A or a Repeater CF-3-A. The lower available gain is not an important limitation except for very long

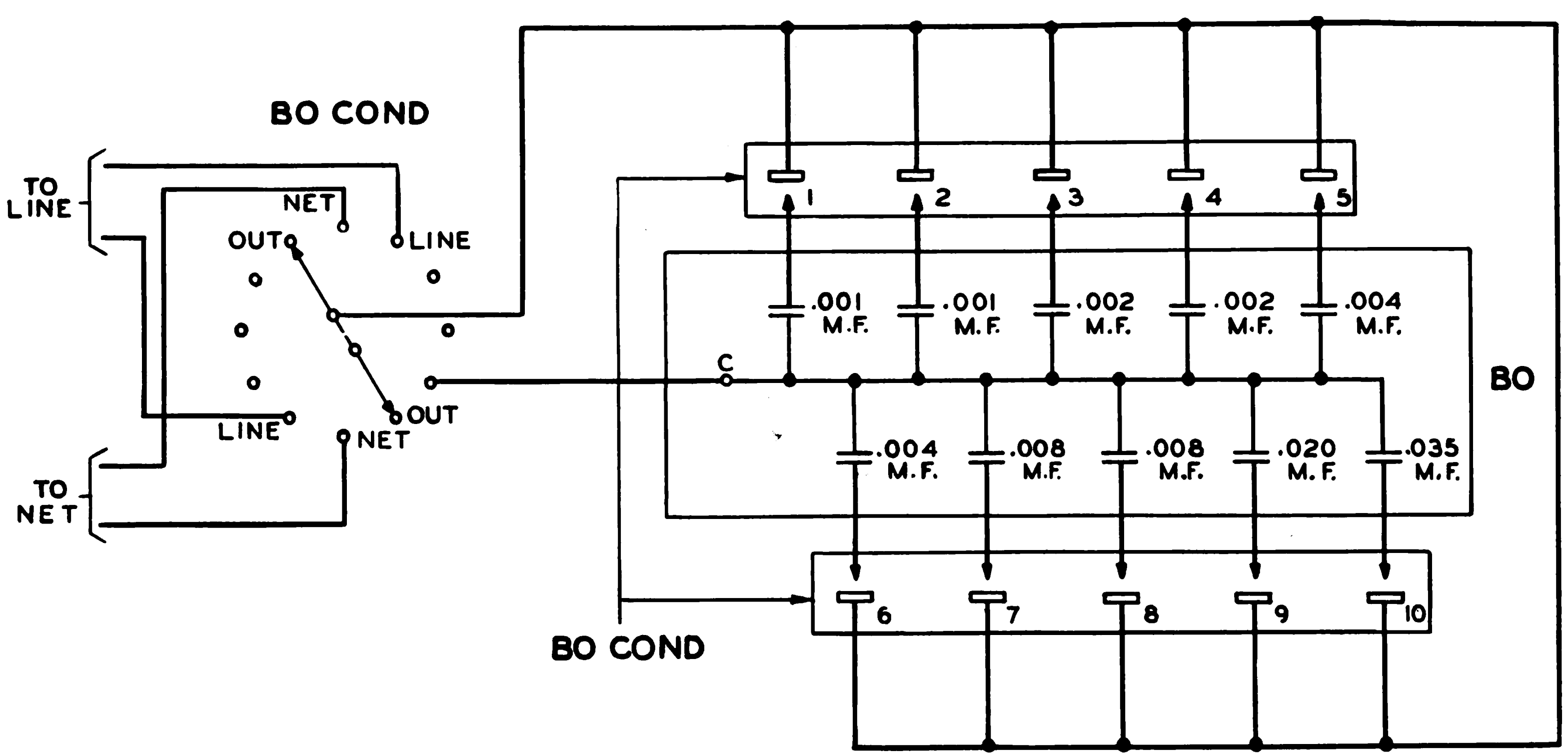

Figure 5.— Arrangement of building-out condenser unit.

single-section systems. The loss introduced by the hybrid unit is substantially independent of frequency for the 200 to 12,000 cycle range of the CF-1-A and CF-3-A systems.

(2) The maximum gain of a Repeater CF-3-A equipped with two hybrid units, when measured between 600-ohm resistances, is approximately 16.5 db at 1,000 cycles and 29.5 db at 10.8 kilocycles. The maximum gain at a Telephone Terminal CF-1-A is such that the measuring meter will read 0 dbm at the output of the receiving amplifier when the input to the 2-wire line of the hybrid unit is approximately —20 dbm at 1,000 cycles and —33.5 dbm at 10.8 kilocycles. In both cases the MILES dial is assumed to be on 0 and EQL dials 1, 4 and 2 on steps 30, 14 and 4, respectively.

b. Impedance.— The impedance looking into the 2W-LINE terminals of Carrier Hybrid CF-7 with the TRSG and REC terminals connected to the carrier equipment is approximately 600 ohms over the transmitted frequency band.

39. Explanation of 21 test.— *a.* As explained in paragraph 33, if the hybrid arrangement is to function satisfactorily, the impedance of the balancing network must be approximately equal to that of the line at all frequencies in the transmitted band. Otherwise, the usable gain of the carrier equipment may be limited because of singing at frequencies where impedance mismatch exists. The balance between the line and its associated network is an indication of how close the impedance of the line is to that of the network. The balance is expressed in db and is defined in terms of a singing test. It is equal to the sum of the net gains at a reference frequency, in this case 10.8 kc, in the AB and BA directions of a Telephone Terminal CF-1-A or a Repeater CF-3-A when the gains are adjusted to cause singing on a 21 test.

b. In making a 21 test on line A, for example, at a Repeater CF-3-A and its associated Carrier Hybrid CF-7 unit, terminals AB OUT of the repeater are connected to terminals BA IN. Thus, a possible singing path, as shown in figure 6, is formed from amplifier AB, through equalizer BA and amplifier BA, across the carrier hybrid and back through equalizer AB to amplifier AB. The repeater gains are then increased until singing around this path just occurs. Under this condition, the sum of the two gains at the singing frequency is equal to the loss across the hybrid at the singing frequency. The sum of the net gains at 10.8 kc plus a correction for hybrid coil loss is the balance.

It will be recognized that the actual repeater gains at the singing frequency may be different from the gains at 10.8 kc but the balance is defined in terms of the 10.8 kc gains for simplicity.

c. Before making this test at a repeater, the gains at the adjacent terminal or repeater (terminal A in the example) are reduced as far as possible to provide a termination for the line without a possible singing path through this termination. Also, the equalizer dials on the repeater under test are adjusted to have their normal settings in the direction of transmission coming from the line under test.

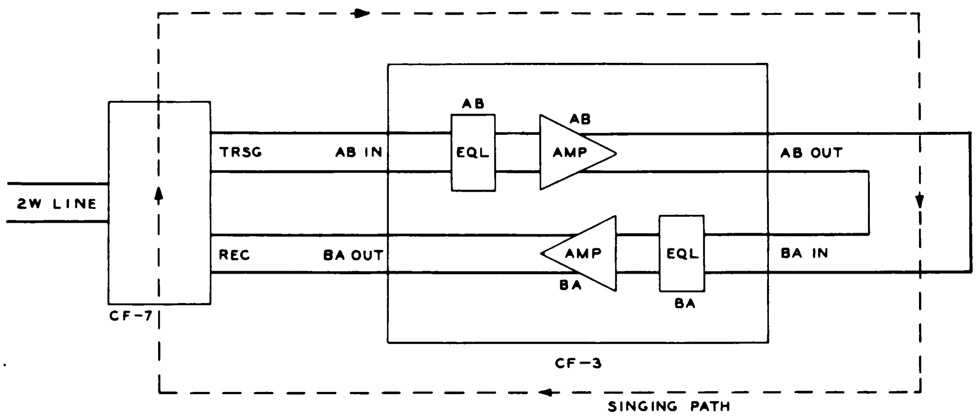

Figure 6.— Illustration of 21 test.

This insures a normal transmission frequency characteristic in that direction of transmission. In the opposite direction of transmission the equalizer dials are adjusted so that the same gain is obtained at all frequencies in order not to introduce an abnormal slope into the singing path.

d. Since at a repeater the frequencies for channels 2, 3 and 4 cannot be monitored conveniently, the best way to observe singing is by means of the measuring meter. This is arranged to be responsive to each of four representative frequencies in the useful band. Thus, to obtain the balance over the entire frequency band of 12 kc, it is necessary to determine the loss across the hybrid when singing just occurs for all four positions of the switch on the MEAS panel. Furthermore, the phase relationships of the circulating currents around the singing path are very important and change from time to time, because of temperature changes, battery changes, etc. Consequently, it is necessary to make measurements to disclose the worst phase relationship. This is done by repeating the test for each position of the switch with the connections at the AB IN terminals of the repeater reversed, which changes the phase relationships. This reversing of the wiring is termed reversing the poling. The sum of the two gains at the reference frequency (10.8 kc) for whichever poling (change of phase) gives the lowest sum is called the balance for the particular switch position. The minimum balance for the four switch positions is the balance between the line and network under test over the useful frequency band.

e. A 21 test is made at a terminal in a manner similar to that indicated in paragraphs *b, c,* and *d* above except that the singing path is formed by removing the terminations across the 2-wire voice-frequency terminals of each channel instead of looping the transmitting and receiving circuits together as is done at a repeater. Removal of the terminations unbalances the voice-frequency hybrid coil of each channel, which results in a low loss across the hybrid. In addition, the gains and losses introduced by the voice amplifiers and other channel equipment are included in computing the balance. In the case of a terminal, singing is observed by monitoring on the individual channels instead of using the measuring meter as at a repeater.

40. Explanation of 22 test.— The purpose of a 22 test, which is illustrated in figure 7, is to determine the singing margin for a Telephone Terminal CF-1-A or a Repeater CF-3-A with associated Carrier Hybrid CF-7 after the operating adjustments for the equipment have been made. Both equalizers are set on their normal settings and the connections on each side of the equipment are left normal

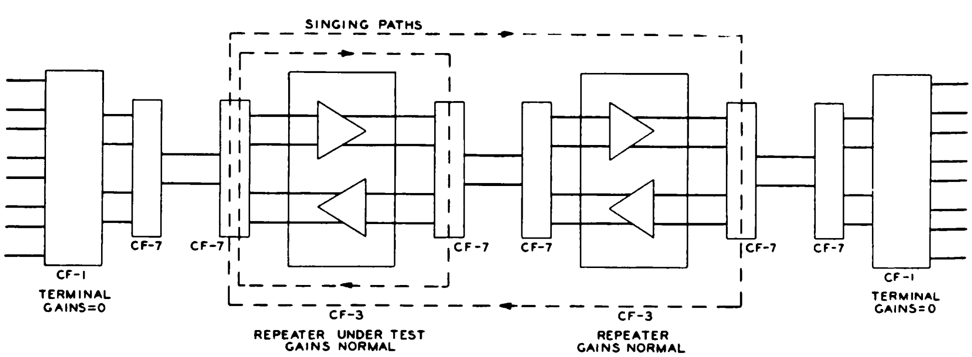

Figure 7.— Illustration of 22 test.

so that the singing path includes the loss across both hybrids. In addition, the gains of all other repeaters on the circuit are made normal to include the additional singing paths formed through the hybrids on the far side of these repeaters. However, the gains at the two terminals (or the distant terminal if a terminal rather than a repeater is under test) are reduced to a minimum since it is not desirable to include the singing paths through these equipments when making the test. Under these conditions, the change in the repeater (or terminal) gains from their normal gains to those necessary to cause singing is the singing margin. A 22 test differs from a 21 test in that a 22 test depends upon the change in gain from normal gain to the gain required to produce singing, whereas a 21 test depends only upon the absolute value of the gain required to cause singing.

SECTION IV

MAINTENANCE

41. General maintenance.— Ordinarily, no maintenance procedures other than occasional servicing of the protector blocks should be required for Carrier Hybrid CF-7.

42. Location of trouble.— *a. General.*— A unit which develops trouble that cannot be corrected by visual inspection or simple tests should be returned to a designated location where suitable testing facilities are available. Before returning the equipment for servicing, be sure that the trouble is not due to some obvious defect of the equipment or its associated line circuits, or to the use of the equipment in a manner or for a purpose for which it was not designed. Be sure to attach a tag describing the operating difficulty.

b. Testing equipment.— (1) A telephone receiver and volt-ohmmeter will be sufficient for most of the tests required. Volt-ohmmeter I-166 will be satisfactory as will also volt-ohmmeters contained in Test Sets I-56-A or I-56-C.

(2) Transmission measuring equipment for 600-ohm circuits occasionally may be found useful for checking the over-all loss through the equipment.

c. Diagrams.— A schematic circuit and wiring diagram is attached to the inside of the lid of the case. A copy of this drawing also is included in this manual as figure 9. The lines on this drawing indicate the individual wires. Each is marked with the color of the wire. The letter P indicates that the wires are paired.

d. Precaution.— This equipment contains coils which may be injured permanently if the cores are magnetized by direct or excessive alternating current flowing through their wirings. Consequently, do not use ordinary direct-current buzzers and similar equipment for making continuity tests. The volt-ohmmeters referred to under paragraph *b* above are satisfactory, provided they are used on the highest resistance scale (highest multiplier).

e. Resistors and coils.—Resistors suspected of being in trouble may be measured with a volt-ohmmeter. The instrument may also be used to check a coil winding.

f. Capacitors.— Check for a broken-down capacitor may be made with a telephone receiver and flashlight cell if no volt-ohmmeter is available. Before making such a test be sure that no direct-current path exists across the capacitor in question. If one does, or if there is doubt, remove the wiring from the capacitor. Connect the receiver and battery in series and connect and disconnect the combination repeatedly across the terminals of the capacitor. In this test a good capacitor will cause a click in the receiver when contact is first made, but almost inaudible subsequent clicks when repeated contacts are made. A broken-down capacitor will cause a uniform intensity of click each time contact is made.

g. Over-all loss.— (1) Measurement of the over-all loss between the 2-wire and 4-wire terminals of the equipment will provide a quick check as to whether the equipment is functioning properly from the standpoint of transmission between the 2-wire and 4-wire circuits. Loss measurements should be made between the 2W-LINE binding posts and the TRSG and REC binding posts, respectively.

(2) To measure the loss between the 2W-LINE binding posts and the TRSG binding posts, proceed as follows, using 600-ohm transmission measuring equipment.

(*a*) Connect the SEND side of the measuring equipment to the 2W-LINE binding posts.

(*b*) Connect the REC side of the measuring equipment to the TRSG binding posts.

(*c*) Connect a 600-ohm resistor to the REC binding posts.

(*d*) Adjust the balancing network controls for 165, 12-inch, open-wire copper line, according to table VII.

(*e*) Measure the loss of the equipment for the following frequencies: 500, 1,000, 5,000, 11,000 and 13,500 cycles. The loss should not exceed 5.0 db up to and including 11,000 cycles and should be at least 6.0 db at 13,500 cycles.

(3) To measure the loss between the 2W-LINE and REC binding posts, proceed as follows:

(*a*) Connect the SEND side of the measuring equipment to the 2W-LINE binding posts.

(*b*) Connect the REC side of the measuring equipment to the REC binding posts.

(*c*) Connect a 600-ohm resistor to the TRSG binding posts.

(*d*) Adjust the balancing network controls for 165, 12-inch, open-wire copper lines, according to table VII.

(*e*) Measure the loss of the equipment for the following frequencies: 500, 1,000, 5,000, and 11,000 cycles. The loss at any of these frequencies should not exceed 5.0 db.

SECTION V

SUPPLEMENTARY DATA

43. Table of replaceable parts, Carrier Hybrid CF-7.— The reference designations shown in the following list correspond to designations shown on the schematic diagrams. These designations are stamped on the equipment or on the adjacent mounting. The resistor value and manufacturer's part number are stamped on each resistor.

43. Table of replaceable parts, Carrier Hybrid CF-7.

Reference designation	Sig. C. stock no.	Name of part and description	Function	Manu-facturer	Manufacturer's part no.
—	4B1467	CARRIER HYBRID CF-7: Consists essentially of a repeating coil hybrid arrangement and associated balancing network contained in a plywood case approximately 1'–6⅜" long, 9½" wide and 7⅜" deep. Weight 48 pounds. Moisture-resistant.	For use in a 4-channel carrier system to permit operation on a 2-wire basis. Designed to connect between a 2-wire line and either Telephone Terminal CF-1-A (Carrier) or Repeater CF-3-A (Carrier), both of which normally operate on a 4-wire basis.	W. E. Co.	X-66107
—	4B1467/C1	ASSEMBLY, CARRYING CASE: 1'–6$\frac{5}{16}$" x 9½" x 7$\frac{11}{32}$" high plywood case, exterior hinge at rear, three draw-bolts at front and carrying strap attached at each end. Reinforced corners. Unequipped except for two Airloc stud assemblies attached to inside bottom which fit into chassis assembly EP-265166.	Carrying case.	W. E. Co.	ES-807998,G1
—	—	ASSEMBLY, STUD: Airloc, for use in plywood. Consists of a flat-head metal stud with a pin diametrically through it and a washer between pin and stud head. End of stud opposite head is rounded. Head *(continued)*	Holds chassis in carrying case.	United-Carr	99888-4-.370

43. Table of replaceable parts, Carrier Hybrid CF-7 (continued).

Reference designation	Sig. C. stock no.	Name of part and description	Function	Manu-facturer	Manufacturer's part no.
—	—	(ASSEMBLY, STUD, *continued*) — has a screwdriver slot and under side is bevelled to form 120° angle in cross-section. A round washer fits over stud and is formed to follow bevel of stud head and has six curved prongs at right angles spaced evenly around edge for securing assembly to wood. Pin is diametrically placed through stud near rounded end. Dimensions, center of pin to outside of stud head, 0.577″; washer is $\frac{15}{16}$″ diameter and has $\frac{7}{32}$″ long prongs. Fits in ⅝″ diameter hole in wood.	Holds chassis in carrying case.	United-Carr	99888-4-.370
—	4E926	BLOCK, PROTECTOR: Hard carbon block 1¼″ x ⅜″ x $\frac{5}{32}$″ which with no. 27 block forms open space cut-out without the use of a separator.	Part of protector.	W. E. Co.	26
—	4E927	BLOCK, PROTECTOR: Grooved porcelain frame block with a carbon insert depressed below the surface of the porcelain and held in place by means of fusible cement. Block dimensions 1¼″ x ⅜″ x $\frac{5}{16}$″. With no. 26 block forms open space cut-out without use of a separator.	Part of protector.	W. E. Co.	27

A	3DA300-3	CAPACITOR: 0.3 μf ±3%, 400v d-c w-v at —40°F to +185°F ambient temperature. Paper-wound, impregnated in mineral oil, 2⅜" x 1½" x 1" rectangular metal case, hermetically-sealed, two rubber-insulated wire terminals approximately ⅞" long at top of case on 1⅛" centers, 0.164"-32 mounting studs ½" long on 1" centers on same end as terminals.	Part of balancing network.	W. E. Co.	D-164642
B	3DA800-4	CAPACITOR: 0.8 μf ±3%, 400v d-c w-v at —40°F to +185°F ambient temperature. Paper-wound, impregnated in mineral oil, 3½" x 1½" x 1" rectangular metal case, hermetically-sealed, two rubber-insulated wire terminals approximately $\frac{15}{16}$" long at top of case on 1⅛" centers, 0.164"-32 mounting studs ½" long on 1" centers on same end as terminals.	Part of balancing network.	W. E. Co.	D-166931
C	3DA400-21	CAPACITOR: 0.4 μf ±3%, 400v d-c w-v at —40°F to +185°F ambient temperature. Paper-wound, impregnated in mineral oil, 2⅜" x 1½" x 1" rectangular metal case, hermetically-sealed, two rubber-insulated wire terminals approximately ⅞" long at top of case on 1⅛" centers, 0.164"-32 mounting studs ½" long on 1" centers on same end as terminals.	Part of balancing network.	W. E. Co.	D-166932

43. Table of replaceable parts, Carrier Hybrid CF-7 (continued).

Reference designation	Sig. C. stock no.	Name of part and description	Function	Manufacturer	Manufacturer's part no.
D E N	3DB1.930	CAPACITOR: Precision type, 1.08 µf ±5%, 400v d-c w-v at —50°F to +185°F ambient temperature. Wound-paper, oil-impregnated, 4½" x 1½" x 1" rectangular metal case, hermetically-sealed, two rubber-insulated terminals extending approximately ⅞" above top of case on 1⅛" centers, 0.164"-32 mounting studs ½" long on 1" centers on same end as terminals.	Part of balancing network.	W. E. Co.	D-166930
R T	3DEB2A16	CAPACITOR: Precision type, two units, each unit 2.16 µf ±5%, 600v d-c w-v at +32°F to +150°F ambient temperature. Units do not vary more than 0.043 µf. Paper dielectric, wax-filled, 4¾" x 4⅞" x 1 19/32", two D-164539 capacitors assembled on a 4¾" x 1 17/32" x ⅜" strap. Each capacitor is hermetically-sealed and each has two rubber-insulated wire terminals 27/32" long at the top of the case on ⅞" centers and 0.190"-24 mounting studs ½" long on 1¾" centers on same end as terminals.	Part of d-c telegraph composite set.	W. E. Co.	D-166929

BO	3DEA35-1	CAPACITOR: Ten units, one 0.035 μf ±13%, one 0.020 μf ±15%, two 0.008 μf ±15%, two 0.004 μf ±15%, two 0.002 μf ±15%, two 0.001 μf ±15%, 600v d-c w-v at +32°F to +150°F ambient temperature. Paper-wound wax-impregnated, 3½" x $2\frac{13}{32}$" x $1\frac{15}{32}$" rectangular metal case, hermetically-sealed, ten units connected to a common terminal, eleven rubber-insulated wire terminals ⅝" long at top of case, top marked to show capacity of individual units, 0.164"-32 mounting studs ½" long on 1¾" centers on same end as terminals.	Building-out condenser unit.	W. E. Co.	D-166050
FA	3DA40-13	CAPACITOR: 0.040 μf ±3%, 400v, d-c w-v at —40°F to +185°F ambient temperature. Paper-wound, impregnated in mineral oil, $2\frac{7}{16}$" x 1½" x $\frac{37}{64}$" rectangular metal case, hermetically-sealed, two rubber-insulated wire terminals $\frac{15}{16}$" long at top of case on 1⅛" centers, 0.164"-32 mounting stud ½" long in center on same end as terminal.	Part of low-pass filter.	W. E. Co.	D-166934
FB	3DA30-22	CAPACITOR: 0.030 μf ±3%, 400v d-c w-v at —40°F to +185°F ambient temperature. Paper-wound, impregnated in mineral oil, $2\frac{7}{16}$" x 1½" x $\frac{37}{64}$" rectangular metal case, hermetically-sealed, two rubber-insulated wire terminals $\frac{15}{16}$" long at top of case on 1⅛" centers, 0.164"-32 mounting stud ½" long in center and on same end as terminals.	Part of low-pass filter.	W. E. Co.	D-166933

43. Table of replaceable parts, Carrier Hybrid CF-7 (continued).

Reference designation	Sig. C. stock no.	Name of part and description	Function	Manufacturer	Manufacturer's part no.
RA1	3DB1.930	CAPACITOR: Precision type, 1.08 µf ±5%, 400v d-c w-v at —50°F to +185°F ambient temperature. Wound-paper, oil-impregnated, 4½" x 1½" x 1" rectangular metal case, hermetically-sealed, two rubber-insulated terminals extending approximately ⅞" above top of case on 1⅛" centers, 0.164"-32 mounting studs ½" long on 1" centers on same end as terminals.	Part of d-c telegraph composite set.	W. E. Co.	D-166930
RA2	3DB5E5	CAPACITOR: 5.5 µf ±3%, 400v d-c w-v at +32°F to +150°F ambient temperature. Rectangular metal case, $4\frac{23}{32}$" x $1\frac{15}{32}$" x $2\frac{13}{32}$" hermetically-sealed, rubber-insulated terminals ⅞" long, paper dielectric, two mounting studs on 1.64" centers, studs and terminals on same end of case.	Part of d-c telegraph composite set.	W. E. Co.	D-162717
RB	3DB7E5	CAPACITOR: 7.5 µ ±10%, 400v d-c w-v at —40°F to +185°F ambient temperature. Paper dielectric, Aroclor-impregnated, $4\frac{23}{32}$" x $2\frac{13}{32}$" x $1\frac{15}{32}$" rectangular metal case, hermetically-sealed, two 0.164"-32 terminals insulated with phenol plastic on ¾" centers extending ⅞" above top of case, four 0.164"-32 mounting studs ½" long on 1¾" x ¾" centers on same end as terminals.	Part of telegraph noise filter	W. E. Co.	D-166989

TA1	3DB1.930	CAPACITOR: Same as RA1.	Part of d-c telegraph composite set.	W. E. Co.	D-166930
TA2	3DB5E5	CAPACITOR: Same as RA2.	Part of d-c telegraph composite set.	W. E. Co.	D-162717
TB	3DB7E5	CAPACITOR: Same as RB.	Part of telegraph noise filter	W. E. Co.	D-166989
A B	3C1337A	COIL, REPEATING: D-c resistance of windings (3–4), (7–8), (9–10), (11–12), 9$^{\omega}$ each. Resistance of windings (1–2), (5–6), 18$^{\omega}$. Impedance ratio between windings (4–3), (8–7), (2–1), (6–5); and (10–9), (12–11), (2–1), (6–5) is 2 to 1. Shell-type, potted in elliptical-shaped metal case, $1\frac{23}{32}$" x $3\frac{1}{8}$" x $4\frac{15}{32}$" excluding mounting studs and terminals. Two $\frac{9}{16}$" long mounting studs $\frac{7}{16}$" in from side, $2\frac{1}{4}$" between centers, and twelve $\frac{11}{16}$" long terminals projecting from same end of case. Moisture-resistant W. E. Co. 173A.	Part of hybrid arrangement.	W. E. Co.	D-162037A
D	3C1987-41	COIL, RETARDATION: Two windings, d-c resistance of each winding, 3.8$^{\omega}$. Rectangular metal case $3\frac{9}{32}$" x $1\frac{11}{16}$" x $3\frac{7}{16}$", four $\frac{3}{4}$" long terminals, two $\frac{9}{16}$" long mounting studs on $2\frac{1}{4}$" centers, studs and terminals on same $3\frac{9}{32}$" x $1\frac{11}{16}$" side, toroidal-type coil with permalloy core.	Protector drainage coil.	W. E. Co.	D-163041

43. Table of replaceable parts, Carrier Hybrid CF-7 (continued).

Reference designation	Sig. C. stock no.	Name of part and description	Function	Manu-facturer	Manufacturer's part no.
F	3C1987-27	COIL, RETARDATION: Inductance 0.01111 henry maximum, 0.01089 henry minimum, with 0.001 ampere at 12,000 cps, effective resistance 8.35$^{\omega}$ maximum with 0.001 ampere at 12,000 cps. Allowable inductance unbalance 1%. D-c resistance at 68°F, 2.0$^{\omega}$ maximum. Toroidal-type coil having a molybdenum permalloy core, potted in a 1" x 1½" x 2⅜" hermetically-sealed, rectangular case. Two 8-32 x ½" mounting studs on 1" centers and four ⅞" terminals on same end of case.	Part of low-pass filter.	W. E. Co.	D-166027
CXA CXB	3C1987-39E	COIL, RETARDATION: Two windings d-c resistance 44$^{\omega}$ each, series-aiding inductance 20 cps 0.005 ampere 6.6 henrys minimum, 8.0 henrys maximum, 900 cps, 3v, 4.3 henrys minimum. Inductance between windings balanced to 1%. Shell-type, silicon steel core, 3⅛" x 1$\frac{11}{16}$" x 4$\frac{7}{16}$" metal case, two 8-32 x $\frac{9}{16}$" mounting studs on 2¼" centers and four $\frac{11}{16}$" terminals on same end of case.	Part of d-c telegraph composite set.	W. E. Co.	D-162039E
CXR CXT	3C1987-39E	COIL, RETARDATION: Same as CXA.	Part of telegraph noise filter		
NCX	3C1987-39E	COIL, RETARDATION: Same as CXA.	Part of balancing network.		

EXT NET 1 EXT NET 2	3Z737-10	POST, BINDING: Metal binding post with nonremovable top, tumble nickel finish, cap diameter $\frac{3}{8}''$, height open $\frac{21}{32}''$, height closed $\frac{9}{16}''$, slot size $\frac{3}{32}''$ x $\frac{1}{8}''$, 6-32 threaded stem $\frac{3}{8}''$ long, base heavily knurled.	External connections.	Eby	12
GRD PH REC R REC T TLG 1 TLG 2 TRSG R TRSG T 2W LINE R 2W LINE T	3Z286	POST, BINDING: Brass, tumble nickel finish with molded rubber cap approximately $\frac{5}{8}''$ diameter x $\frac{3}{8}''$ high. Bottom of base knurled to prevent turning. Slot $\frac{1}{8}''$ x $\frac{5}{32}''$, 8-32 solid stem $\frac{3}{4}''$ long, $\frac{5}{8}''$ x $1\frac{3}{4}''$ over-all.	External connections.	Eby	TM 186
—	—	RECEPTACLE: Airloc, flat metal piece with hole in center, each end extended and has a 0.130″ diameter plain hole for mounting with centers 1″ apart. Sides are doubled over to form wings in which pin of stud assembly is secured. Dimensions $1\frac{9}{32}''$ long, $\frac{3}{4}''$ wide, 0.270″ high. For $\frac{5}{8}''$ diameter hole in plywood.	Holds chassis in carrying case.	United-Carr	99833-P.130

43. Table of replaceable parts, Carrier Hybrid CF-7 (continued).

Reference designation	Sig. C. stock no.	Name of part and description	Function	Manufacturer	Manufacturer's part no.
A	3Z6212E5	RESISTOR: Fixed resistance 2125ω ±1%, 0.25 watt, low reactance. Wire-wound on bakelite core, 1″ x $\frac{5}{16}$″ diameter phenol fibre outer tube with 2″ axial lead at each end.	Part of balancing network.	W. E. Co.	D-164886A 2125ω
B	3Z6035-9	RESISTOR: Fixed resistance 350ω ±1%, 0.5 watt. Wire-wound on ceramic core, 1″ x $\frac{5}{16}$″ cylindrical, 2″ radial lead on each end, lacquer-coated.	Part of balancing network.	W. E. Co.	D-163158B 350ω
C	3Z6105	RESISTOR: Fixed resistance 1050ω ±1%. Otherwise same as B.	Part of balancing network.	W. E. Co.	D-163158B 1050ω
D	3Z6025-29	RESISTOR: Fixed resistance 250ω ±1%. Otherwise same as B.	Part of balancing network.	W. E. Co.	D-163158B 250ω
E	3Z6030-43	RESISTOR: Fixed resistance 300ω ±1%. Otherwise same as B.	Part of balancing network.	W. E. Co.	D-163158B 300ω
F	3Z6070-15	RESISTOR: Fixed resistance 700ω ±1%. Otherwise same as B.	Part of balancing network.	W. E. Co.	D-163158B 700ω
G	3Z6002E5-17.1	RESISTOR: Fixed resistance 25ω ±1%. Otherwise same as B.	Part of balancing network.	W. E. Co.	D-163158B 25ω
H	3Z6005-67	RESISTOR: Fixed resistance 50ω ±1%. Otherwise same as B.	Part of balancing network.	W. E. Co.	D-163158B 50ω
J	3Z6010-100	RESISTOR: Fixed resistance 100ω ±1%. Otherwise same as B.	Part of balancing network.	W. E. Co.	D-163158B 100ω

K	3Z6020-56	RESISTOR: Fixed resistance 200^{ω} $\pm 1\%$. Otherwise same as B.	Part of balancing network.	W. E. Co.	D-163158B 200^{ω}
L	3Z6040-18	RESISTOR: Fixed resistance 400^{ω} $\pm 1\%$. Otherwise same as B.	Part of balancing network.	W. E. Co.	D-163158B 400^{ω}
M, N, P, R, S, T, U	3Z6001-32	RESISTOR: Fixed resistance 10^{ω} $\pm 5\%$, 0.5 watt. Wire-wound on ceramic core, 1″ x $\frac{5}{16}$″ cylindrical, 2″ radial lead at each end, lacquer-coated.	Part of balancing network.	W. E. Co.	D-163158A 10^{ω}
RA	3Z6020-55	RESISTOR: Fixed resistance 200^{ω} $\pm 5\%$, 25 watts. Wire-wound on ceramic tube, vitreous enamel outer coating, approximately 2″ long x $\frac{25}{32}$″, one $\frac{9}{16}$″ long radial terminal at each end.	Part of telegraph noise filter.	W. E. Co.	D-166982 200^{ω}
RB	3Z6010-100	RESISTOR: Fixed resistance 100^{ω} $\pm 1\%$, 0.5 watt. Wire-wound on ceramic core, cylindrical 1″ x $\frac{5}{16}$″, lacquer-coated, 2″ radial lead at each end.	Part of telegraph noise filter.	W. E. Co.	D-163158B 100^{ω}
TA	3Z6020-55	RESISTOR: Same as RA.	Part of telegraph noise filter.	W. E. Co.	D-166982 200^{ω}
TB	3Z6010-100	RESISTOR: Same as RB.	Part of telegraph noise filter.	W. E. Co.	D-163158B 100^{ω}

43. Table of replaceable parts, Carrier Hybrid CF-7 (continued).

Reference designation	Sig. C. stock no.	Name of part and description	Function	Manufacturer	Manufacturer's part no.
—	2Z9405.19	STRIP, CONTACT: Terminal strip assembly consisting of phenol fibre strip with five screws and five terminals together with insulator, contact strips, and bushings. Phenol fibre strip $3\frac{3}{4}''$ x $\frac{5}{8}''$ x $\frac{7}{32}''$ equipped with insulator and bushings. Steel terminal screws with zinc and chromate finish and knurled and slotted heads on $\frac{9}{16}''$ centers on one side of the strip and brass terminals with solder-dip finish on other side of strip.	For BAL RES and BO COND connections.	W. E. Co.	P-265159
—	2Z9412.19	STRIP, TERMINAL: Black, hard rubber strip $5\frac{33}{64}''$ x $\frac{5}{8}''$ x $\frac{1}{4}''$ with twelve screw terminals on $\frac{5}{16}''$ centers on one side and twelve soldering terminals on other side.	For TLG–SIG CONN connections.	W. E. Co.	P-265174
BO COND	3Z9825-66.9	SWITCH, ROTARY: Two circuits, three contacts per circuit, nonshorting, $1\frac{1}{4}''$ diameter, shaft $\frac{3}{32}''$ long beyond bushing, slot in shaft $\frac{1}{16}''$ wide x $\frac{1}{16}''$ deep.	Building-out condenser unit switch.	W. E. Co.	P-263452
BAL RES	3Z9825-66.25	SWITCH, ROTARY: One circuit, seventeen contacts, shorting-type, $1\frac{11}{16}''$ diameter base, screwdriver slot shaft 0.249" diameter extending $\frac{3}{32}''$ beyond end of bushing, with adjustable stop, $\frac{3}{8}$–32 mounting bushing $\frac{3}{8}''$ long.	Balancing network series resistance switch.	W. E. Co.	P-265155
LF CORR	3Z9825-66.25	SWITCH, ROTARY: Same as BAL RES.	Balancing network low-frequency corrector switch.	W. E. Co.	P-265155

44. List of manufacturers.

Abbreviation	Manufacturer	Address
Eby	H. H. Eby, Inc.	Philadelphia, Pa.
W. E. Co.	Western Electric Co.	New York, N. Y.
United-Carr	United-Carr Fastener Corp.	Cambridge, Mass.

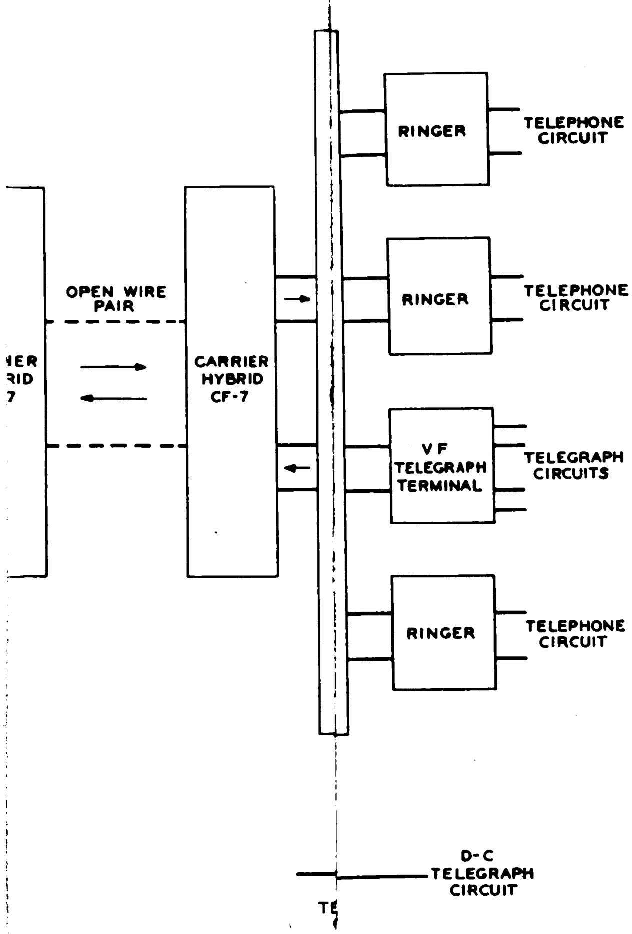

Figure 8.— Block schema

Figure 8.— Block schematic diagram. 63

Figure 9.— Carrier Hybrid CF-7 circuit label. 65

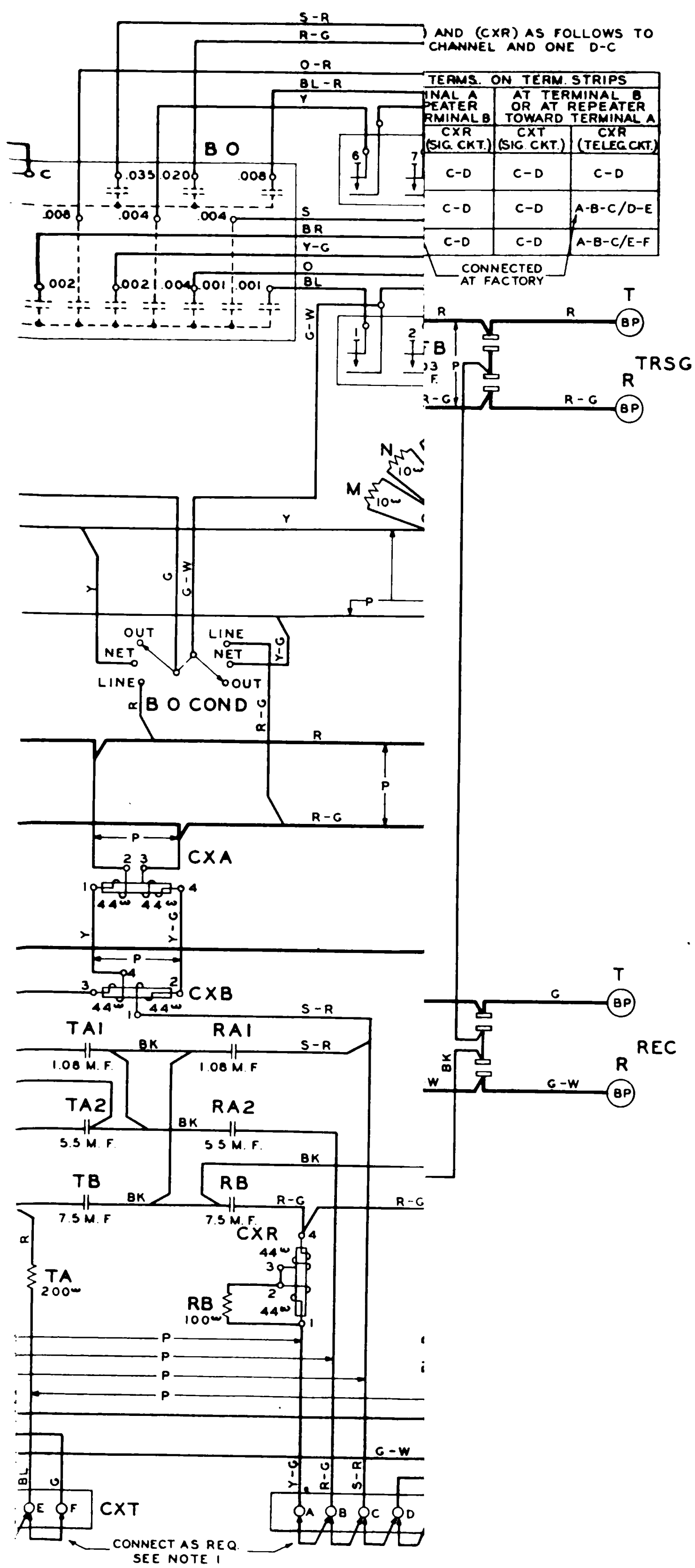

Figure 9.— Carrier Hybrid CF-7 circuit label.

Figure 9.— Carrier Hybri

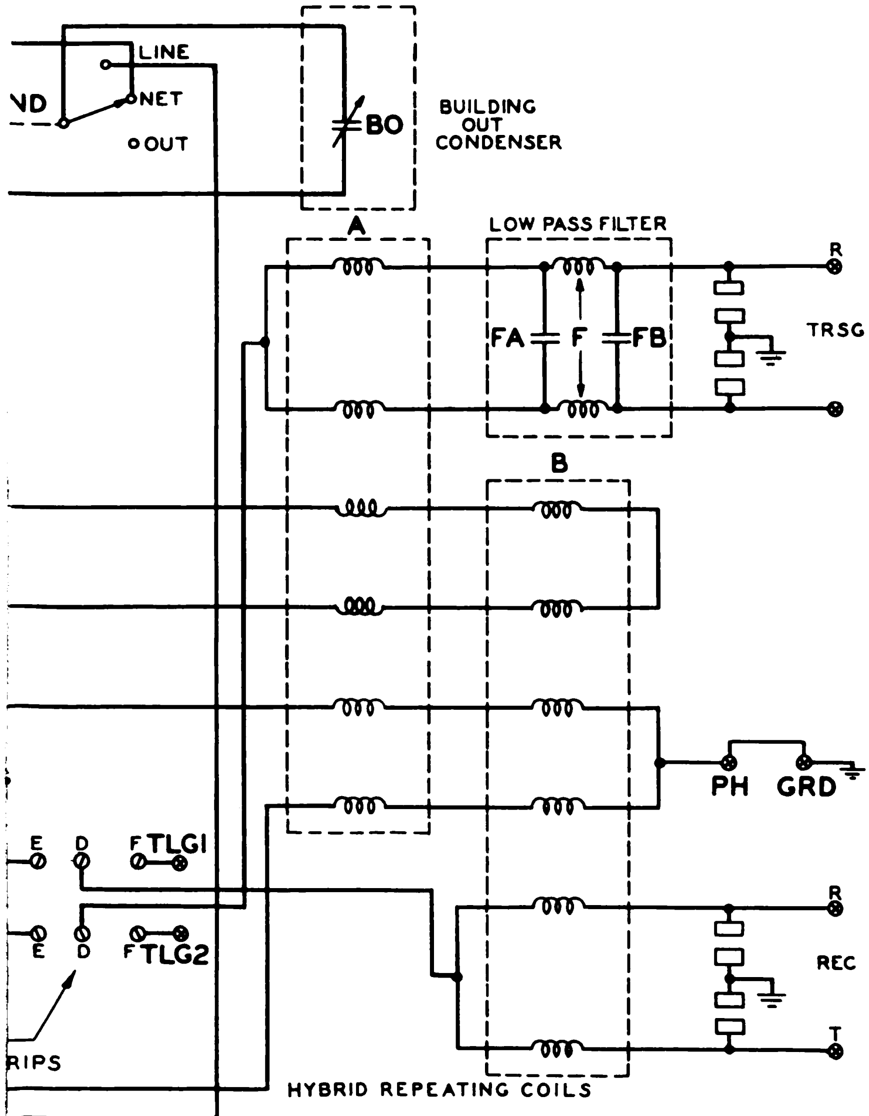

Figure 10.— Simplified circuit schematic diagram.

uit schematic diagram.

Signal Corps Order No. 35791—Phila.—43; 17600; 27 Dec. 1943.