MEASUREMENTS OF IMPEDANCE UNBALANCES

1. GENERAL

1.01 This section of practices describes methods of making impedance unbalance measurements on open wire and toll cable circuits (except program transmission circuits). The methods described herein apply to the 50-A impedance unbalance bridge, the portable type 1-B impedance bridge, or the 1-B impedance bridge associated with the 7-B transmission testboard.

1.02 The reason for the new issue is to cover the testing arrangements for the 1-B impedance bridge associated with the 7-B transmission testboard having the latest modifications. These modifications consist of the addition of an output transformer in the oscillator circuit, the addition of a repeating coil which makes possible the use of an amplifier in connection with the bridge and the addition of jacks in the impedance bridge bay which facilitates the testing procedures. Information is also included in this section showing the arrangements using one-half of a 44-A-1 repeater as an amplifier in connection with the bridges for the purpose of making them more sensitive. For those cases where the modifications referred to above have not been made, testing arrangements are also given for the previous standard arrangement of the 7-B transmission testboard.

1.03 As distinguished from those which cause an unbalanced condition between the line and its balancing network, the impedance unbalances referred to in this section are of the type which cause crosstalk and may result in noise.

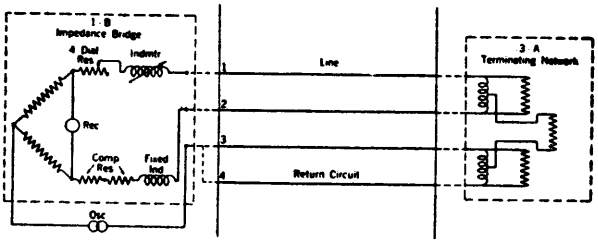
1.04 In measurements of impedance unbalances the accuracy of the results obtained depends to a considerable extent upon the magnitude of the oscillator current. If loose connections exist on a circuit and excess testing power is used, the potential across a high resistance joint may be sufficient to temporarily break it down. Hence, in general, the oscillator current should be adjusted to a small value, keeping in mind, however, the necessity of having enough oscillator current to obtain a sharp balance point.

1.05 The sensitivity of the receiver used in connection with the bridge for impedance unbalance measurements plays an important part in the accuracy of the results obtained. A visual inspection should be made of the receiver used in order to be sure that it is in good working condition.

1.06 It frequently happens, in connection with measurements of impedance unbalances on cable circuits, that the unbalance is of small magnitude and distant from the testing point, and many times it is almost impossible to obtain an unbalance curve suitable for analysis purposes. The addition of an amplifier such as one-half of a 44-A-1 repeater on the circuit, as shown in Figures 4, 8 and 12, reduces the attenuation between the bridge and the unbalance by the amount of gain which is inserted in the circuit. This results in a direct increase in the measured unbalance, thereby giving an unbalance curve with well-defined peaks of greater magnitude. The repeater arrangment may be used with any of the different types of bridges although it is particularly applicable in the case of the portable 1-B impedance bridge or the 1-B impedance bridge associated with the 7-B transmission testboard, since with this type of bridge, readings can only be made to the nearest ohm or to the nearest milhenry, while in the case of the 50-A impedance unbalance bridge, readings may be made to the nearest tenth of an ohm or to the nearest tenth of a milhenry.

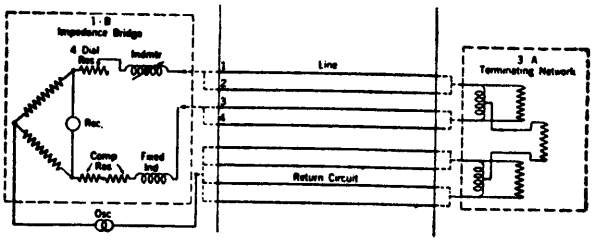
2. CONNECTING APPARATUS FOR TEST

2.01 Figures 1 and 2 are schematic circuits showing the general circuit arrangement employed in making impedance unbalance measurements. A cable side circuit and a cable phantom circuit have been used for the purpose of illustration. As indicated by Figures 1 and 2, the oscillator current is sent out on wires 1 and 2 in the case of Figure 1 and wires 1, 2, 3 and 4 in the



Schematic showing Typical Arrangement used in making Impedance Unbalance Run on Cable Side Circuit

Fig. 1



Schematic showing Typical Arrangement used in making Impedance Unbalance Run on Cable Phantom Circuit

Fig. 2

case of Figure 2. When this current reaches an unbalance, a voltage is set up at the unbalance which causes an unbalance current to be returned to the bridge. The amount of resistance and inductance which must be inserted in the bridge by means of the four-dial resistance and the inductometer to compensate for the unbalance current, is a measure of the magnitude of the unbalance.

2.02 As indicated by the figures below, where tests are made on a cable or open wire side circuit the other side of the quad or phantom group should be used as a return circuit. Where tests are made on an open wire physical or non-phantomed pair an adjacent similar physical or non-phantomed pair should be used as a return circuit. In making tests on a cable phantom circuit or an open wire phantom circuit, a neighboring phantom circuit of the same type should be used as a return circuit.

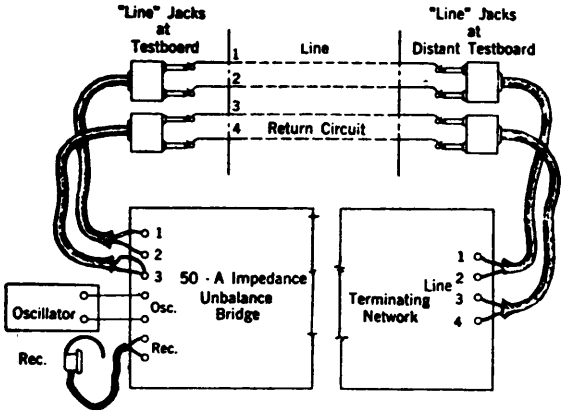
50-A Impedance Unbalance Bridge (See Figures 3, 4, 5, and 6)

2.03 In all of the measurements made with the 50-A impedance unbalance bridge, the No. 157 or No. 525 receiver and the 13-A, 8-A or similar type variable frequency oscillator will be required in addition to the apparatus listed below.

Cable or Open Wire Side Circuit Physical or Non-Phantomed Pair (See Figure 3)

2.04 Apparatus

3-A terminating network (when testing cable circuit).
2-A terminating network (when testing open wire circuit).
4 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.



Arrangement for Testing Side Circuit, Physical or Non-Phantomed Pair

Fig. 3

Cable Side Circuit Using Amplifier to Increase Sensitivity (See Figure 4)

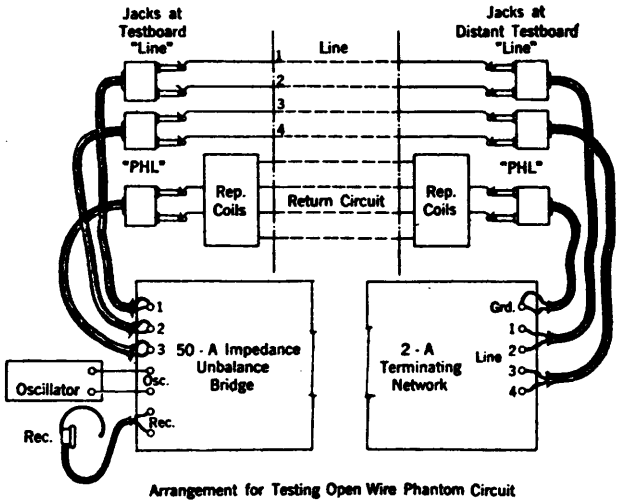
2.05 Apparatus

3-A terminating network.
One-half of a 44-A-1 repeater.
1 93-H repeating coil.
3 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.
4 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.

Open Wire Phantom Circuit (See Figure 5)

2.06 Apparatus

2-A terminating network.
6 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.



Arrangement for Testing Open Wire Phantom Circuit

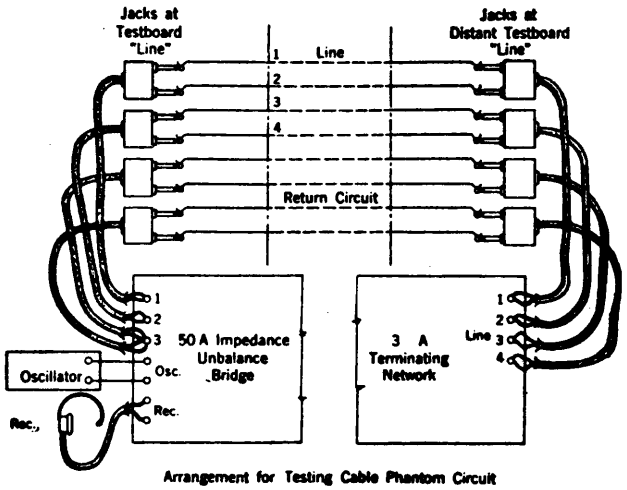
Fig. 5

2.07 Where the "PHL" jacks are not available an open wire phantom circuit may be connected to the testing apparatus as indicated in Figure 6.

Cable Phantom Circuit (See Figure 6)

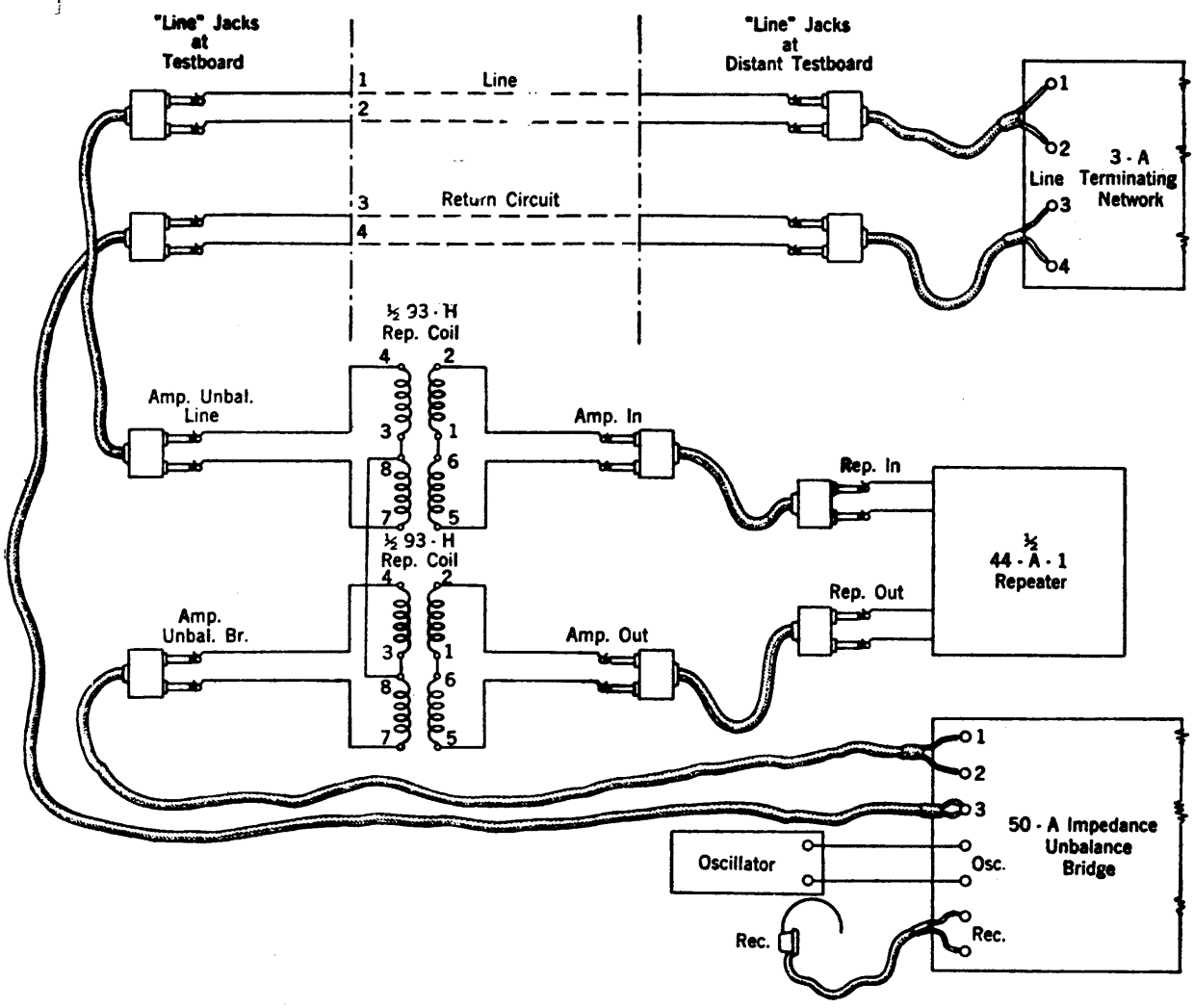
2.08 Apparatus

3-A terminating network.
8 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.



Arrangement for Testing Cable Phantom Circuit

Fig. 6



Arrangement for Testing Cable Side Circuit Using Amplifier to Increase Sensitivity

Fig. 4

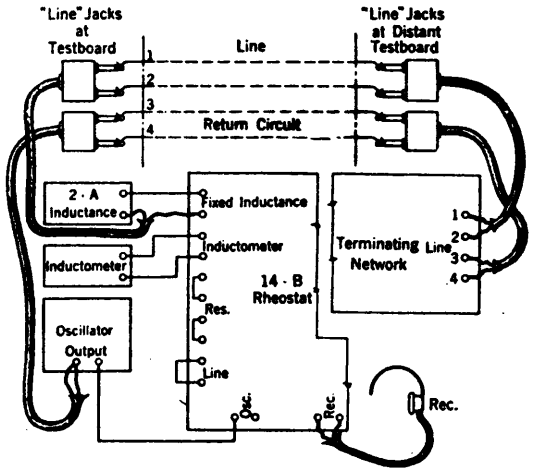
Portable 1-B Impedance Bridge (See Figures 7, 8, 9, and 10)

2.09 In all of the measurements made with the 1-B impedance bridge, the No. 157 or No. 525 receiver and a 13-A, 8-A or similar type variable frequency oscillator will be required in addition to the apparatus listed below.

Cable or Open Wire Side Circuit Physical or Non-Phantomed Pair (See Figure 7)

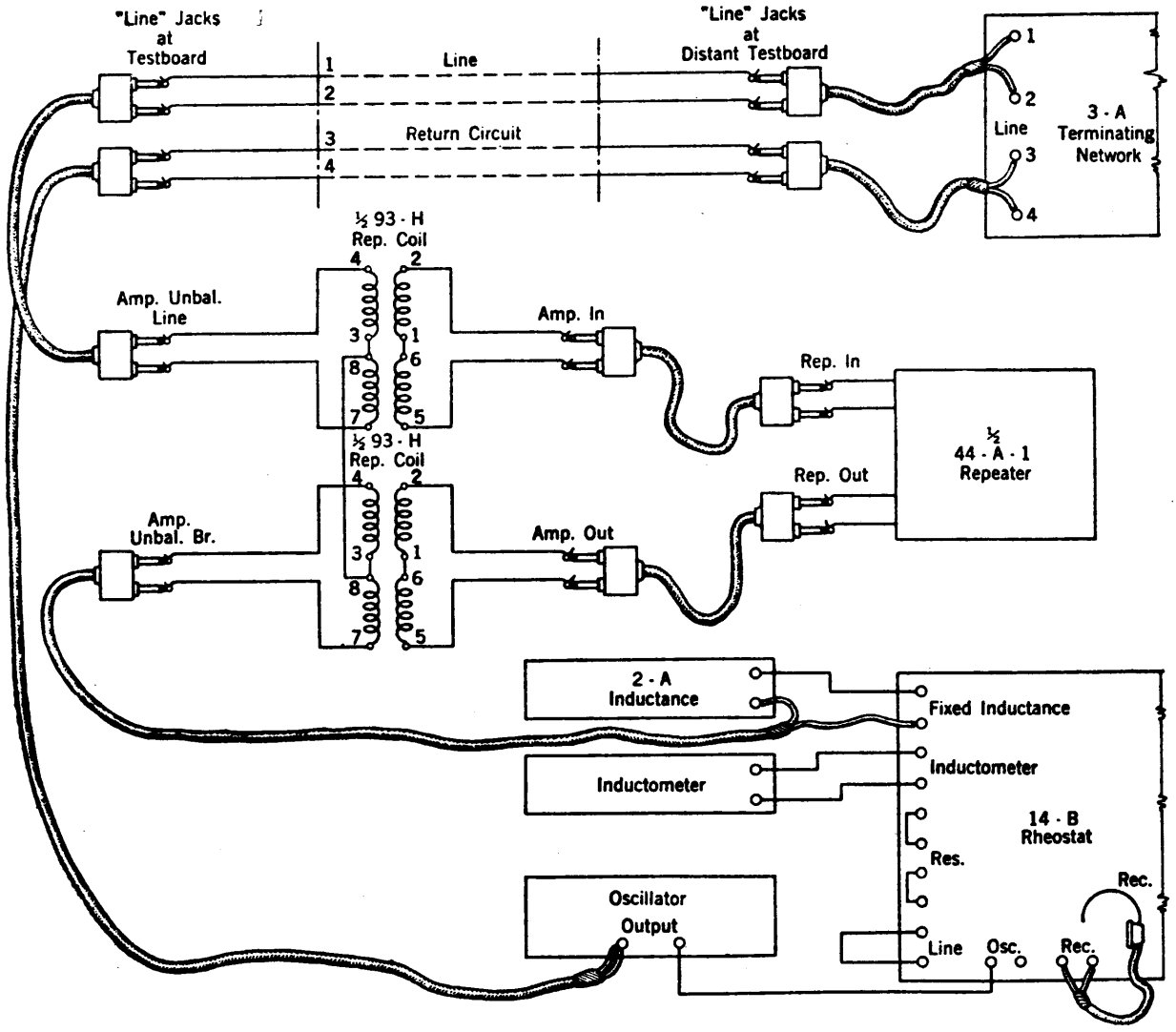
2.10 Apparatus

3-A terminating network (when testing cable circuit).
2-A terminating network (when testing open wire circuit).
4 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.



Arrangement for Testing Side Circuit, Physical or Non Phantomed Pair

Fig. 7



Arrangement for Testing Cable Side Circuit Using Amplifier to Increase Sensitivity

Fig. 8

Cable Side Circuit Using Amplifier to Increase Sensitivity (See Figure 8)

2.11 Apparatus

3-A terminating network.
One-half of a 44-A-1 repeater.
1 93-H repeating coil.
3 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.
4 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.

Open Wire Phantom Circuit (See Figure 9)

2.12 Apparatus

2-A terminating network.
6 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.

2.13 Where the "PHL" jacks are not available an open wire phantom circuit may be connected to the testing apparatus as indicated in Figure 10.

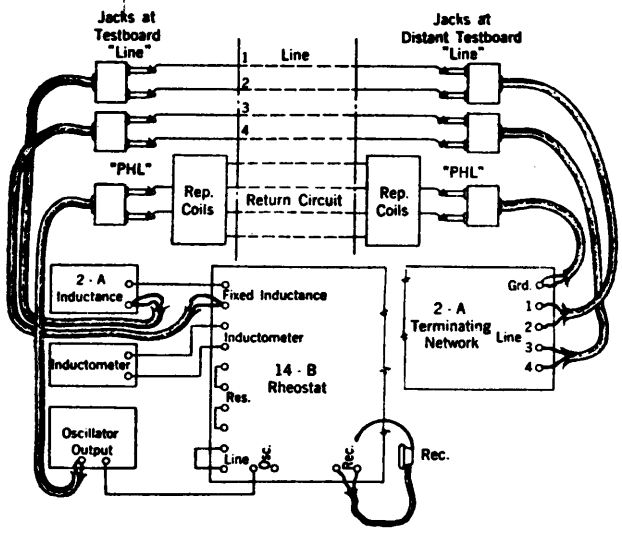
Cable Phantom Circuit (See Figure 10)

2.14 Apparatus

3-A terminating network.
8 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.

No. 7-B Transmission Testboard (See Figures 11, 12, 13, and 14)

2.15 The No. 7-B transmission testboard with the latest modifications, as indicated in paragraph 1.02, will be required in all measurements in addition to the apparatus listed below.



Arrangement for Testing Open Wire Phantom Circuit

Fig. 9

Cable or Open Wire Side Circuit, Physical or Non-Phantomed Pair (See Figure 11)

2.16 Apparatus

3-A terminating network (when testing cable circuit).

2-A terminating network (when testing open wire circuit).

5 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.

2 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.

Cable Side Circuit Using Amplifier to Increase Sensitivity (See Figure 12)

2.17 Apparatus

3-A terminating network.

One-half of a 44-A-1 repeater.

10 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.

2 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.

Open Wire Phantom Circuit (See Figure 13)

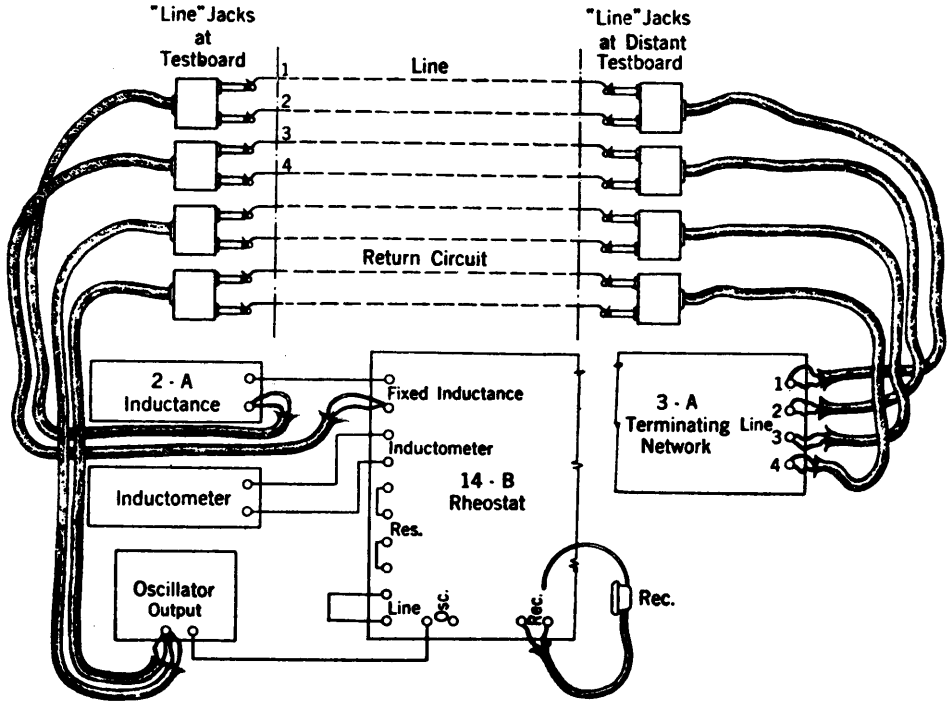
2.18 Apparatus

2-A terminating network.

6 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.

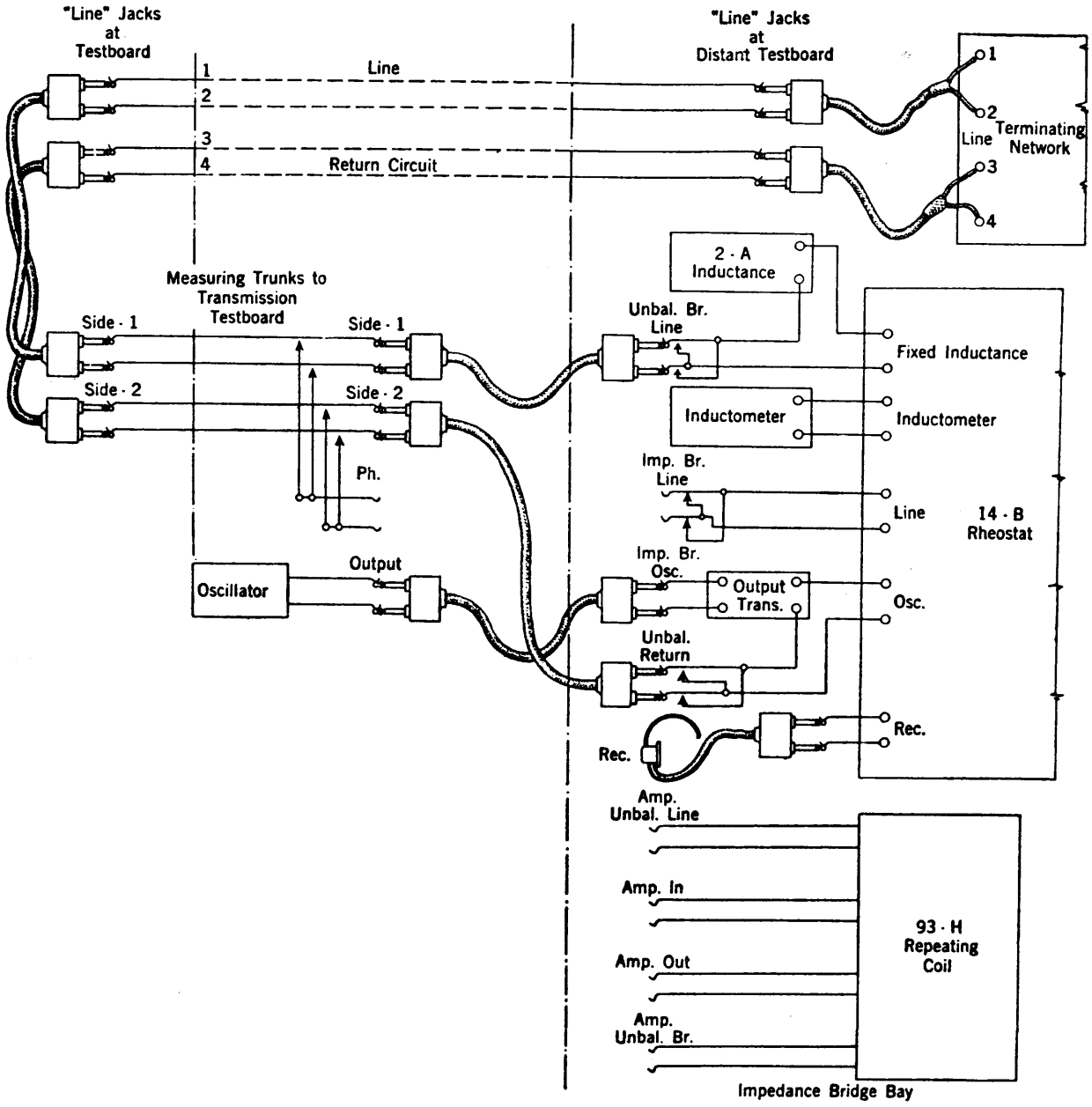
3 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.

2.19 Where the "PHL" jacks are not available an open wire phantom circuit may be connected to the testing apparatus, as indicated in Figure 14.



Arrangement for Testing Cable Phantom Circuit

Fig. 10



Arrangement for Testing Side Circuit, Physical or Non - Phantomed Pair with 7 - B Transmission Testboard

Fig. 11

Cable Phantom Circuit (See Figure 14)

2.20 Apparatus

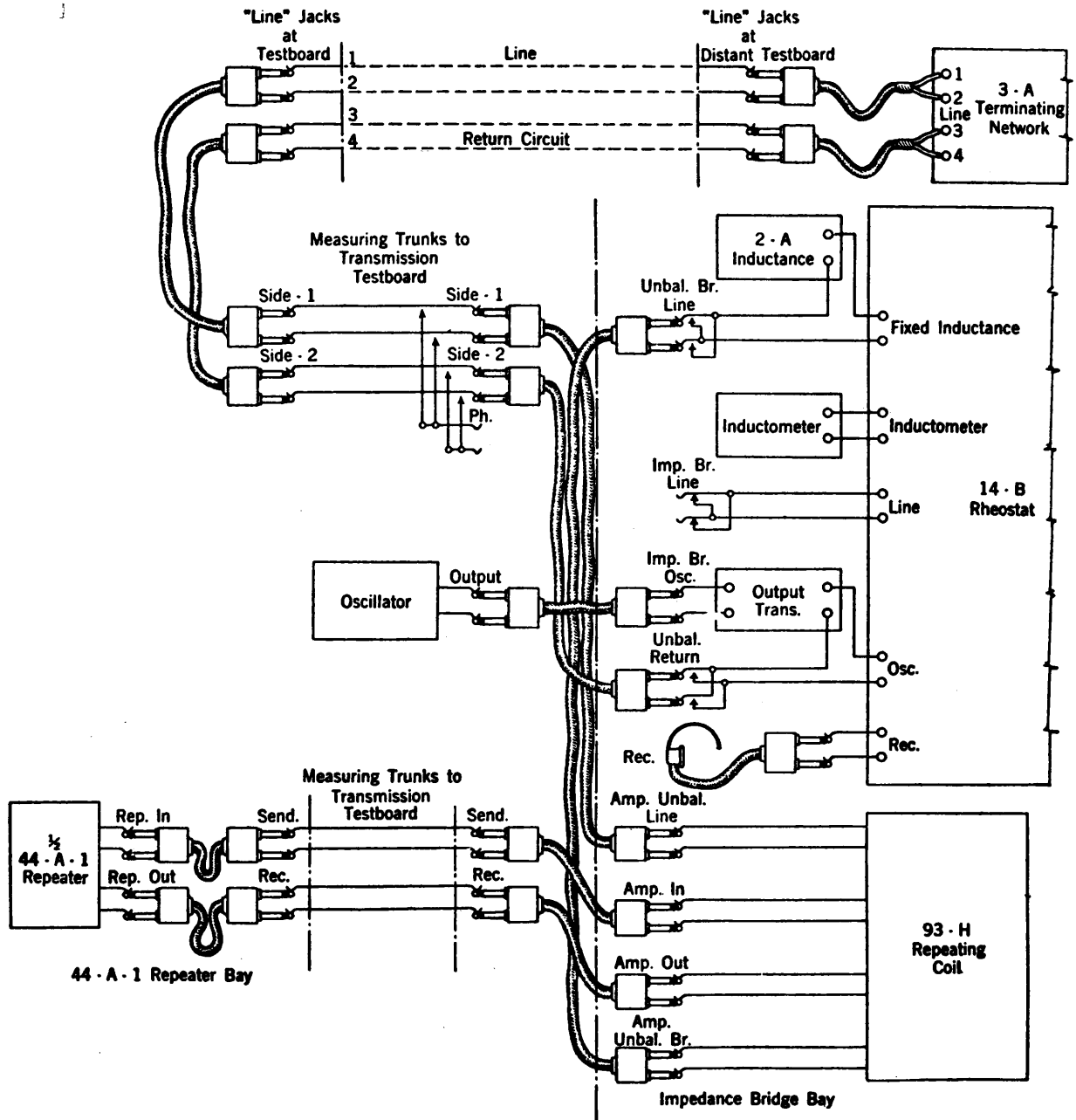
3-A terminating network.

8 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.

4 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.

No. 7-B Transmission Testboard (See Figures 15, 16, and 17)

2.21 As indicated in the latter part of paragraph 1.02, testing arrangements are shown in Figures 15, 16, and 17 below for the 7-B transmission testboard not having the latest modifications mentioned in paragraph 1.02. This arrangement does not permit the use of an amplifier in connection with the 1-B impedance bridge. The No. 7-B transmission testboard of this type will be required



Arrangement for Testing Cable Side Circuit using Amplifier to Increase Sensitivity of 7 - B Transmission Testboard

Fig. 12

in all measurements in addition to the apparatus listed below.

Cable or Open Wire Side Circuit, Physical or Non-Phantomed Pair (See Figure 15)

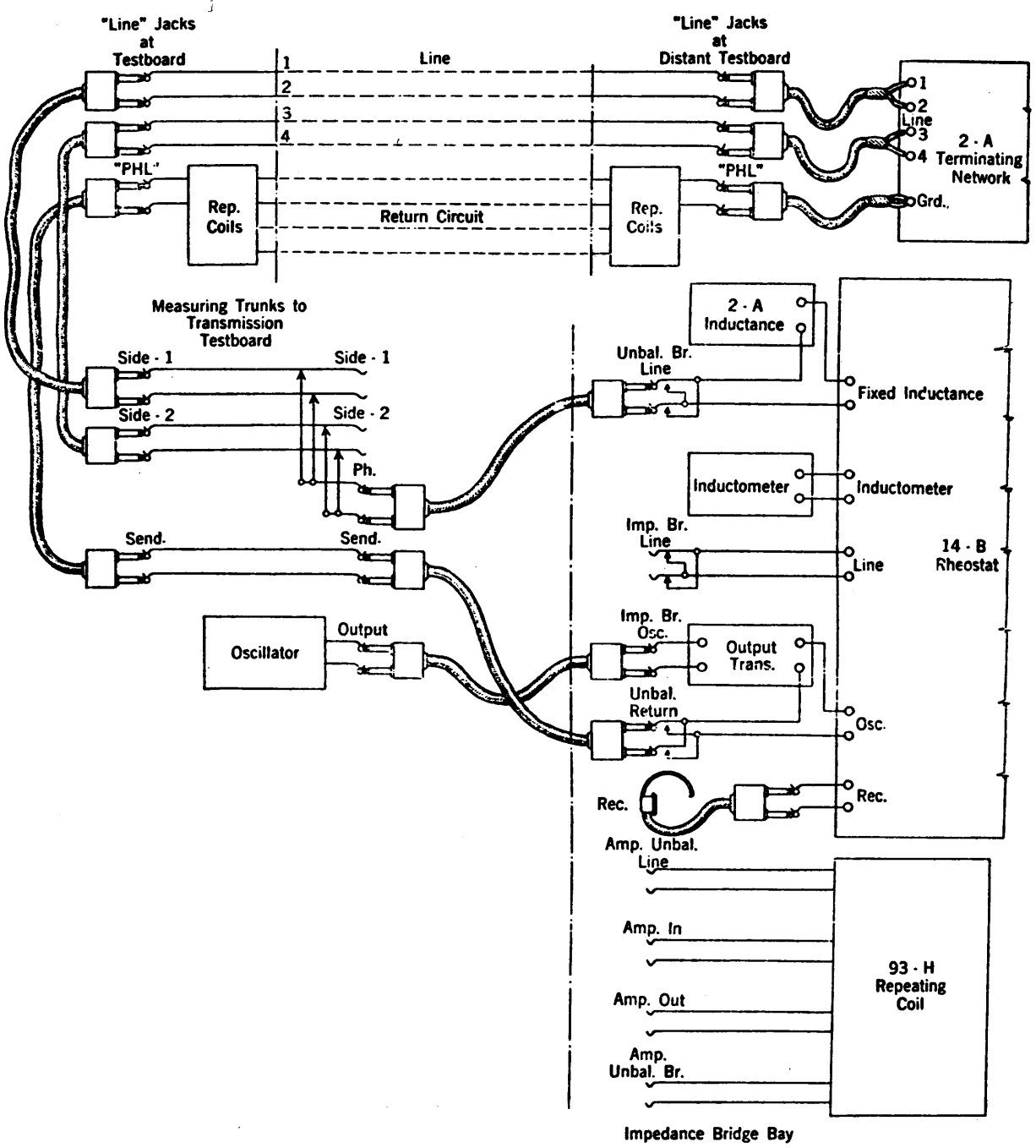
2.22 Apparatus

3-A terminating network (when testing cable circuit).
2-A terminating network (when testing open wire circuit).
3 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.
2 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.
2 One-conductor cords, P1-A type, each equipped with a No. 116 plug at each end.
1 No. 241-C plug.

Open Wire Phantom Circuit (See Figure 16)

2.23 Apparatus

2-A terminating network.



Arrangement for Testing Open Wire Phantom Circuit with 7 - B Transmission Testboard

Fig. 13

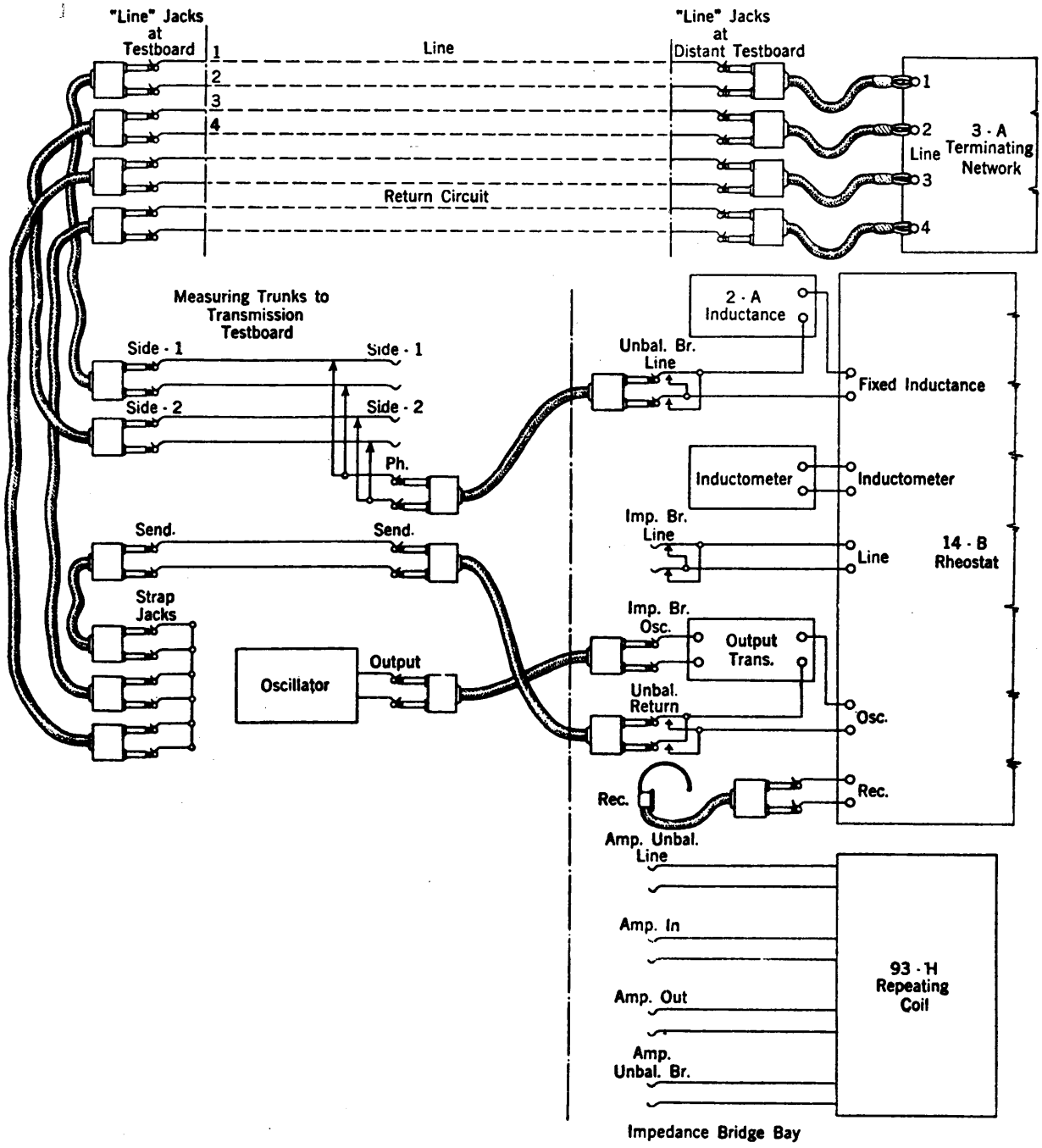
3 two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.
4 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.
3 One-conductor cords, P1-A type, each equipped at both ends with a No. 116 plug.
1 No. 241-C plug.

2.24 Where the "PHL" jacks are not available an open wire phantom circuit may be connected to the testing apparatus, as indicated in Figure 17.

Cable Phantom Circuit (See Figure 17)

2.25 Apparatus

3-A terminating network.



Arrangement for Testing Cable Phantom Circuit with
7 - B Transmission Testboard
Fig. 14

4 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at one end and spade tips at the other.

5 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.

3 One-conductor cords, P1-A type, each equipped with a No. 116 plug at each end.

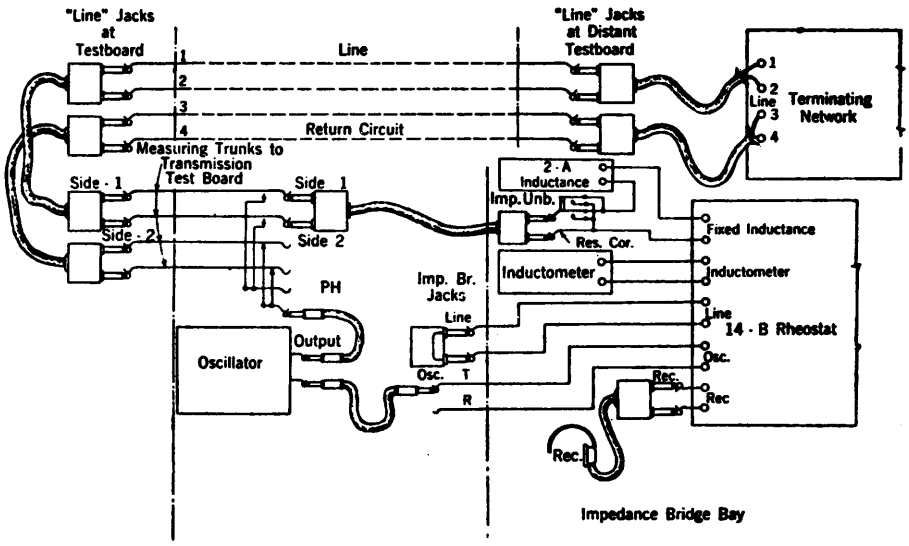
1 No. 241-C plug.

Resistance Correction Measurements (See Figures 18, 19, and 20)

Portable 1-B Impedance Bridge (See Figure 18)

2.26 Apparatus

1-B impedance bridge.
13-A or similar type variable frequency oscillator.
No. 157 or No. 525 receiver.
Miscellaneous wire.



Arrangement for Testing Side Circuit, Physical or Non-Phantomed Pair

Fig. 15

7-B Transmission Testboard (Figure 19, with latest Modifications, See Paragraph 1.02)

2.27 Apparatus

7-B transmission testboard.

2 Two-conductor cords, P2-AA type, each equipped with a No. 241-A plug at each end.

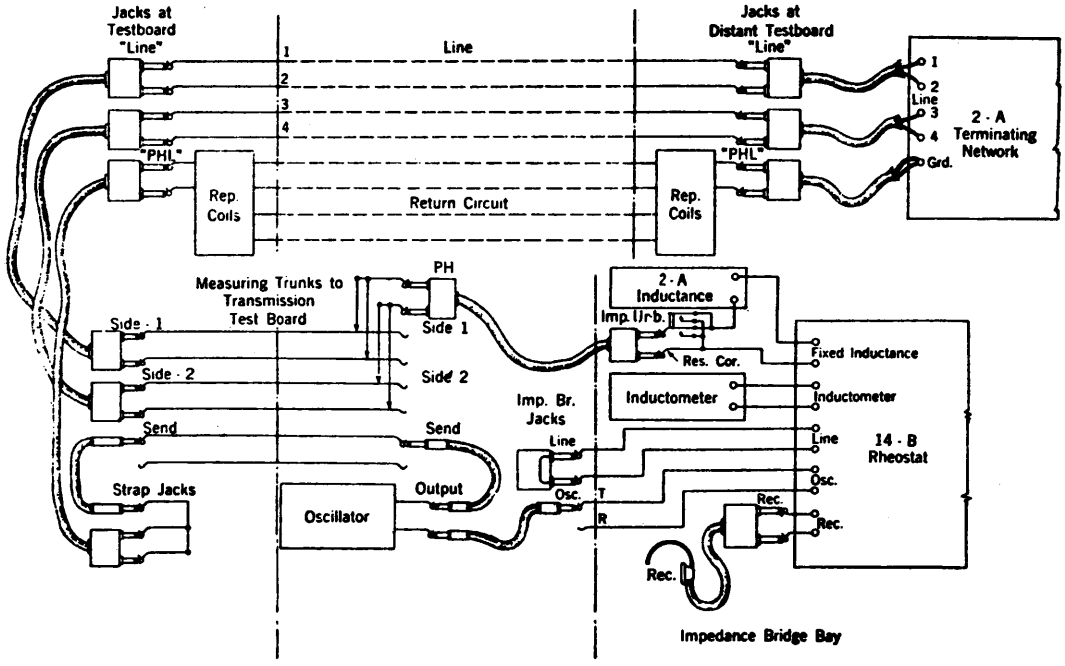
7-B Transmission Testboard (Figure 20, not having latest Modifications, See latter part of Paragraph 1.02)

2.28 Apparatus

7-B transmission testboard.

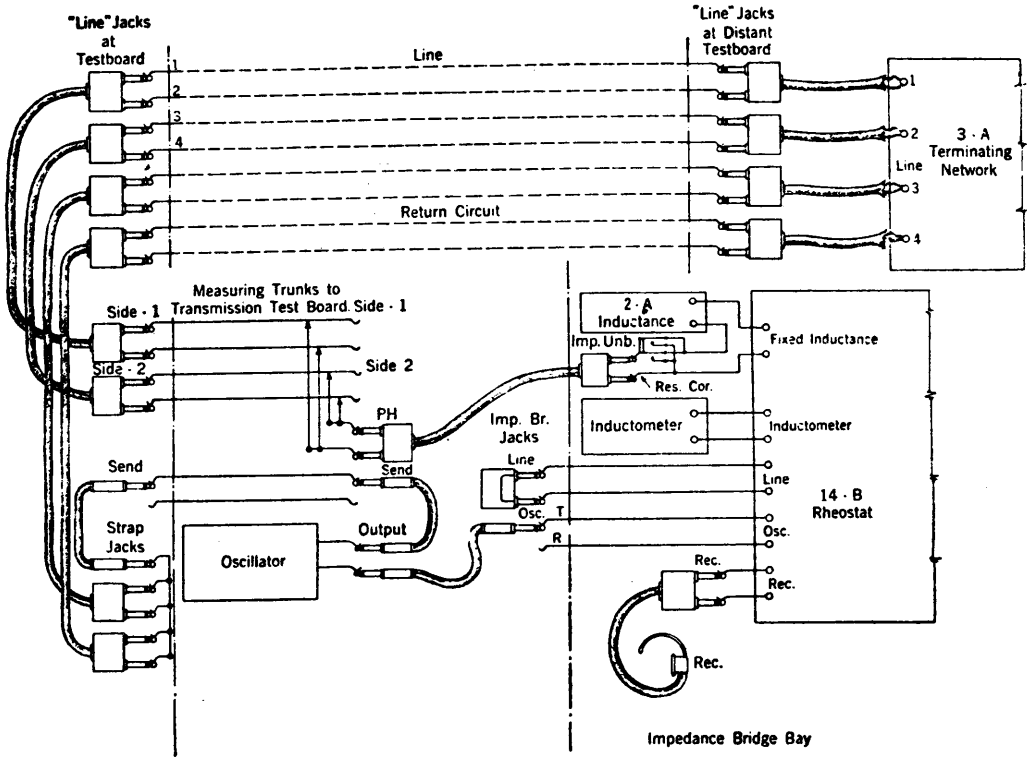
2 One-conductor cords, P1-A type, equipped at both ends with a No. 116 plug.

1 241-C plug.



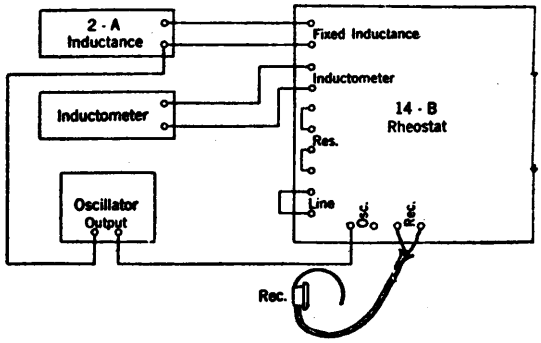
Arrangement for Testing Open Wire Phantom Circuit

Fig. 16



Arrangement for Testing Cable Phantom Circuit

Fig. 17



Arrangement for Obtaining Resistance Correction for 1 - B Impedance Bridge Portable Apparatus

Fig. 18

3. OPERATION OF APPARATUS

Terminating Networks

3.01 As indicated by the figures of part 2, it is necessary to terminate the circuits under test at the distant end. This is accomplished by means of the 2-A terminating network in the case of open wire circuits and the 3-A terminating network in the case of cable circuits. The proper key positions when testing various types of circuits are given in paragraphs 3.02-3.05, inclusive.

2-A Terminating Network

3.02 **Open Wire Side Physical or Non-Phantomed Pair:** Operate key 1 to "Network," keys 2 and 3 to "Non-Loaded Sides" and key 4 to "N.L. Phan." Key 5 should be normal.

3.03 **Open Wire Phantom Circuit:** Operate key 1 to "Network," key 4 to "Non-Loaded Phantom" and key 5 to "Phan. Ground Term." Keys 2 and 3 should be normal.

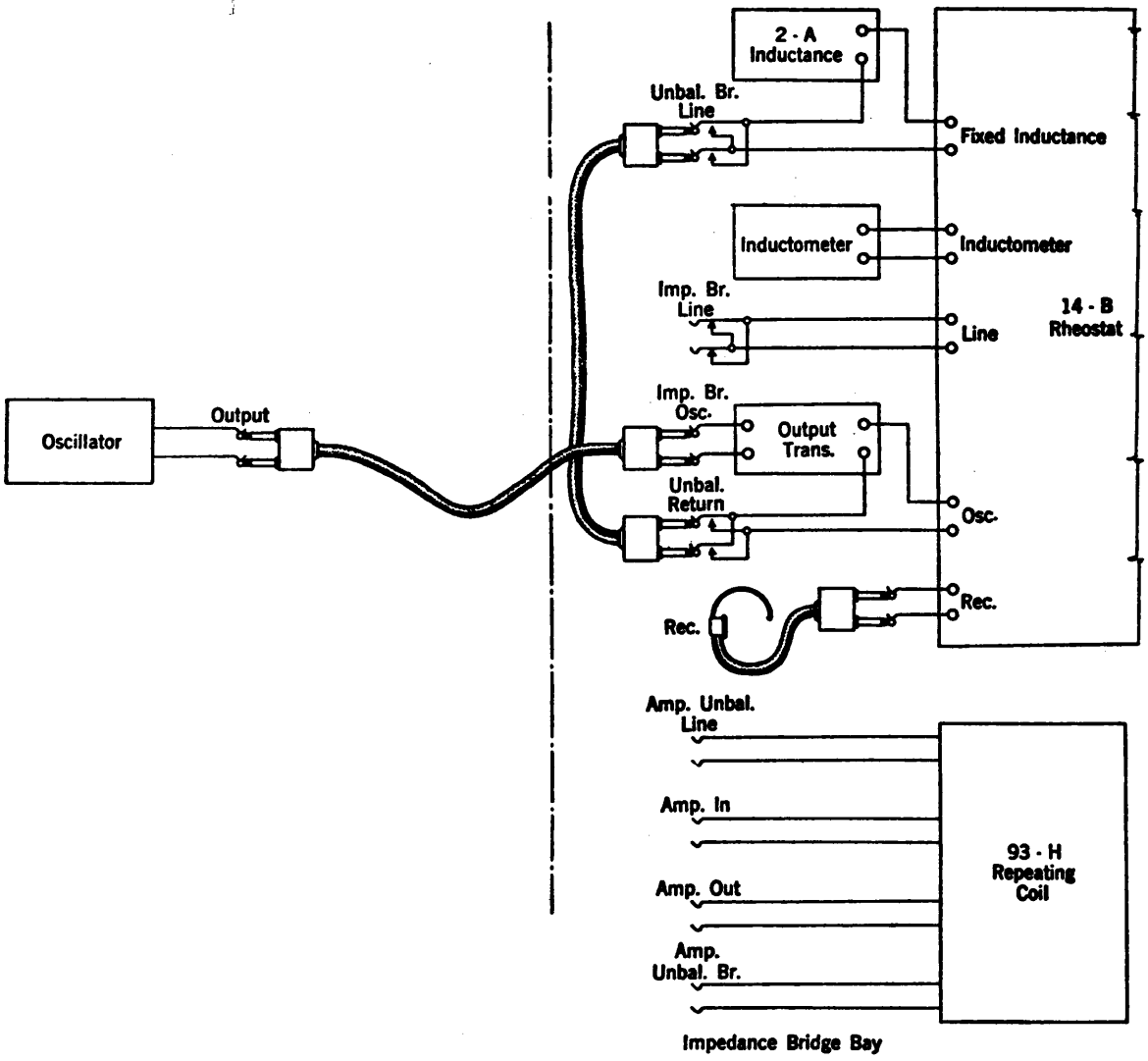
3-A Terminating Network

3.04 **Cable Side Circuit:** Set "Loading" key to H-174-106, H-174-63 or H-44-25, depending upon the impedance of the circuits connected to the line terminals. Set "B. O. Cond." key to "Off." Set keys 1, 2 and 3 to "Term."

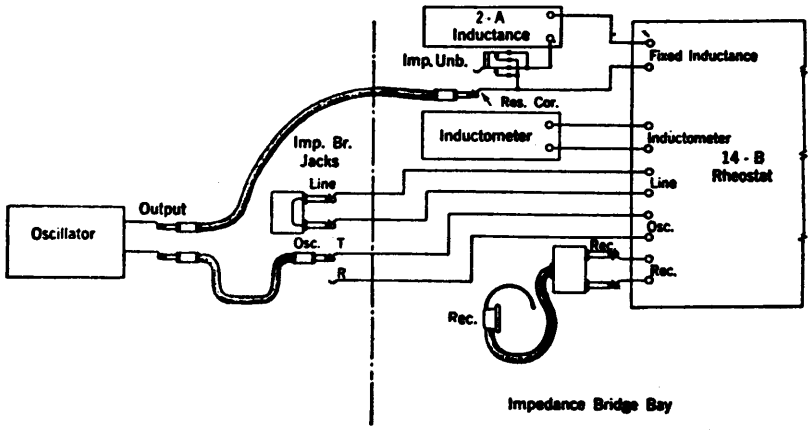
3.05 **Cable Phantom Circuit:** Set "Loading" key to H-174-106, H-174-63 or H-44-25, depending upon the impedance of the circuits connected to the line terminals. Set "B. O. Cond." key to "Off." Set keys 1, 2 and 3 to "Term."

50-A Impedance Unbalance Bridge (Without Amplifier, see Figures 3, 5 and 6)

3.06 Adjust the variable frequency oscillator to the desired frequency. Adjust the four-dial variable resistance and the inductometer until a



Arrangement for Obtaining Resistance Correction for 1 - B Impedance Bridge
7 - B Transmission Testboard
Fig. 19



Arrangement for Obtaining Resistance Correction for 1 - B Impedance Bridge-
7 - B Transmission Testboard
Fig. 20

minimum volume of tone is heard in the receiver. It will probably be found that the most convenient method for doing this will be to adjust first the inductometer to an approximate balance point then the variable resistance, then readjust each in turn until a balance has been obtained. When a balance has been reached correct the reading in ohms as shown on the four-dial resistance by subtractnig 100 ohms.

50-A Impedance Unbalance Bridge with Amplifier (see Figure 4)

3.07 Before connecting the apparatus as indicated in Figure 4 adjust the gain of the repeater at 1000 cycles for 20 db. Make a gain frequency calibration on the repeater throughout the frequency range that is to be employed in making the unbalance run. In case an approximately flat gain frequency characteristic is not obtained, that is in case the maximum variation from the 1000 cycle value for any particular frequency in excess of 1000 cycles exceeds 0.4 db, the equalizer should be adjusted until this requirement has been met.

3.08 Make the connections as indicated in Figure 4. Adjust the gain of the repeater so that the variations between the maximum and minimum measured resistance values made as indicated in paragraph 3.06 are large enough to give well defined humps. This will ordinarily have to be done by a cut and try method for a few representative frequencies throughout the frequency range. It will usually be found desirable to start with a gain of 20 db. In no case should a gain in excess of 30 db be used because of the probability of crosstalk from other conductors in the cable.

3.09 Having determined the proper repeater gain to be used proceed as outlined in paragraph 3.06.

Portable 1-B Impedance Bridge and 7-B Transmission Testboard

Impedance Unbalance Measurements (Without Amplifier, See Figures 7, 9, 10, 11, 13, 14, 15, 16 and 17)

3.10 With the 2-A inductance connected to line wire 1 in the case of side circuits and line wires 1 and 2 in the case of phantom circuits, the inductance unbalance range of the 1-B impedance bridge is from about — 50 to + 360 milhenries and the resistance unbalance range is from about — 60 ohms to + 11,000 ohms. With line wires 1 or 1 and 2, as referred to above, connected to the fixed inductance terminal of the 14-B rheostat the range is from about + 50 to — 360 milhenries and + 60 to — 11,000 ohms. It may be necessary in certain cases during the process of making an unbalance run to interchange the connections to the circuit under test in the manner just indicated in order to make a reading with the impedance bridge. In such cases all that is necessary is to record the reading as indicated, giving it the opposite sign from that which was recorded for the final reading just previous to the interchange of connections.

3.11 Adjust the variable frequency oscillator to the desired frequency. Place the keys of the 14-B rheostat on "+" and "ADD." Adjust the variable resistance and the inductometer until a minimum volume of tone is heard in the receiver. When a balance has been reached correct the resistance reading by subtracting the values obtained as outlined in paragraph 3.13. In general it is only necessary to record the resistance values in making unbalance runs. Where it is desired to know the inductance values the reading shown on the inductometer should be corrected by subtracting 100 milhenries.

Impedance Unbalance Measurements—Amplifier with Bridge (See Figures 8 and 12)

3.12 Where an amplifier is used in connection with the portable 1-B impedance bridge or the 1-B impedance bridge associated with the 7-B transmission testboard the gain frequency characteristic of the repeater should first be obtained as outlined in paragraph 3.07. Next the connections should be made as indicated in Figures 8 and 12 and the gain of the repeater should be adjusted in a manner similar to that outlined in paragraph 3.08. The procedure from this point on is the same as outlined in paragraph 3.10 and 3.11. As indicated in paragraph 3.11 the resistance values should be corrected by subtracting the values obtained as outlined in paragraph 3.13 and where inductance readings are desired the readings shown on the inductometer should be corrected by subtracting 100 milhenries.

Resistance Correction Measurements (See Figures 18, 19 and 20)

3.13 Make the measurements in the manner indicated in paragraph 3.11. The reading of the four-dial resistance is the resistance correction value for the particular frequency being used. As indicated in paragraph 3.11 this value of resistance should be subtracted from the four-dial resistance measurement made in paragraph 3.11 or paragraph 3.12 in order to give the actual resistance unbalance.