16B1 TELEGRAPH REPEATER

CONTENTS

1. GENERAL

1.01 This section describes the 16B1 telegraph repeater which is suitable for operation either on a grounded or a metallic basis over open-wire lines and non-composited toll cable conductors. This repeater provides for the following three methods of operation:

(1) Differential duplex operation having a balance adequate for half duplex and, under certain conditions, satisfactory for full duplex operation.

(2) Polarential Type "A" employing negative and positive sending polarities at one end of the line and ground and negative at the other for marking and spacing respectively. In this case, transmission is affected very little by variations in line resistance.

(3) Polarential Type "B" employing sending polarities of negative and positive at one end of the line and ground and positive at the other for marking and spacing respectively. In this case, transmission is only slightly affected by line leakage.

1.02 When arranged for any of the above methods of operation the repeater may be operated on a grounded basis over one line circuit with or without a filter for suppressing 60-cycle interference. When facilities are available a second or neutralizing wire may be employed to minimize the effects of interference such as ground potential, cross-fire, and a-c induction. This form of two wire operation is the same as single commutation metallic over small gauge cables. The two line wires should be similar and preferably the two wires of a pair. However, the effects of ground potential interference will be greatly reduced and other types of interference may possibly be reduced even if the two wires are not of the same pair. The 60-cycle filter is not employed when operation is over two line circuits.

1.03 For differential duplex operation the 16B1 repeater will work with any other standard polar duplex repeater or a station with battery at the distant point (upset) on a ground return basis and with another 16B1 or a 128B2 set on either a single or two wire basis. As a polarential repeater it will operate with another 16B1 repeater, a modified 12 or 16A1 repeater or a 128B2 station set on a single wire basis and with another 16B1 or a 128B2 set using a neutralizing wire. When a 128B2 set is employed at the outlying point this set is operated polar receiving and applies ground to the line for marking and battery for spacing. It will also be practicable to operate directly from a 16B1 repeater to a teletypewriter on a Type "A" polarential basis. No provision is made for operating the repeater on a two-path polar basis.

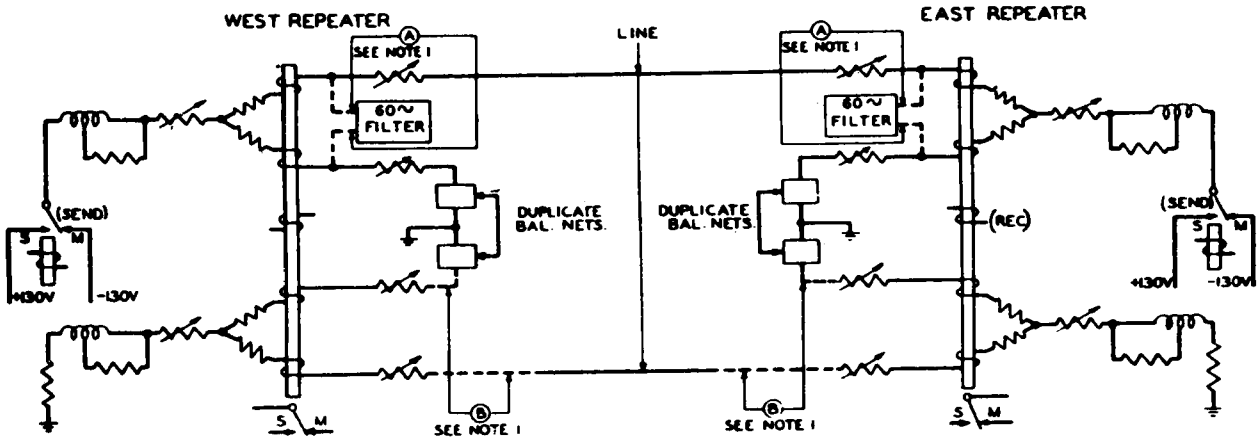
2. DESCRIPTION OF OPERATION

(A) Differential Duplex Operation

2.01 Fig. 1 shows two 16B1 repeaters arranged for differential duplex operation. As this form of operation is the same as for 12 and 16A1 repeaters which are fully described elsewhere the operating principles will not be discussed here. The upper part of Fig. 1 shows this arrangement schematically. The lower part of this figure shows the arrangement for the neutralizing wire. As in other differential duplex circuits the bias of signals will be affected by changes in line impedance due to temperature or leakage variations unless a compensating adjustment is made in the balancing networks.

2.02 Fig. 2 shows two 16B1 repeaters connected with aiding line batteries which will permit operation of intermediate subscriber stations on an upset basis. The neutralizing function in this case is effective in through transmission only and will not apply to transmission to and from the intermediate station unless special arrangements are provided for this purpose at the station.

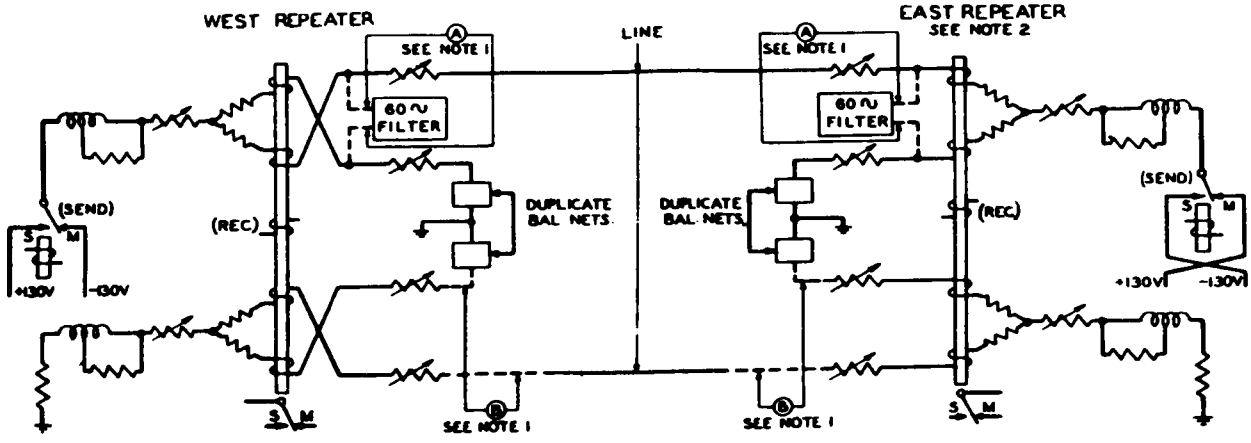
2.03 The repeater is arranged for full duplex operation on a differential duplex basis over lines on which a suitable balance can be maintained. However, the repeater is not recommended for general use on a full duplex basis.



NOTES:
1 USE EITHER (A) OR (B) OR OMIT BOTH AS REQUIRED.

DIFFERENTIAL DUPLEX - OPPOSED LINE BATTERIES

Fig. 1



NOTES:
1. USE EITHER (A) OR (B) OR OMIT BOTH AS REQ.

2. THE EAST REPEATER MAY BE REPLACED BY A SUBSCRIBER'S STA WITH LINE BATTERY.

DIFFERENTIAL DUPLEX - AIDING LINE BATTERIES

Fig. 2

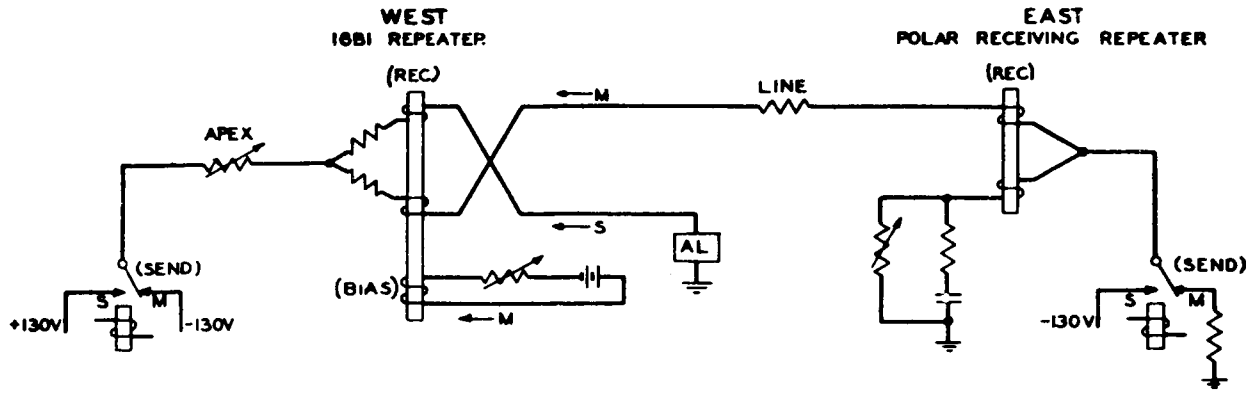
(B) Type "A" Polarential Operation

General

2.04 Reference should now be made to Fig. 3 which shows two repeaters arranged for Type "A" polarential operation and connected together over a line circuit. Although 16B1 repeaters may be used at both ends of the line, they will be arranged differently and, as shown in the figure, transmission from west to east will be polar and that from east to west will be differential. The 128B2 set has transmission circuits similar to those of the east repeater.

Operating Principles

2.05 Transmission from west to east takes place as follows. Operation of the send relay at the west repeater will apply negative and positive voltages to the line for the marking and spacing conditions, respectively. Current will pass over the line, through the receiving relay of the



TYPE "A" POLARENTIAL SYSTEM

Fig. 3

east repeater, and thence to ground. This latter relay will operate therefore on a polar basis. When the line leakage changes or, when the line resistance is changed, the amount of current received by the east repeater will be changed equally for both marking and spacing conditions and there will be no bias introduced. However, if the leakage is large enough the receiving relay will fail to operate properly because of insufficient current.

2.06 The receiving relay of the west repeater in addition to its line and balancing windings is provided with biasing windings. When the repeater is balanced the outgoing currents from the contacts of the sending relay will divide equally. Half of this current will flow over the line and the other half will pass through the artificial line to ground. Since the windings are poled oppositely, there will be no net operating ampere turns on the relay. The relay will be held to marking by a third winding which is designated (BIAS) in the figure.

2.07 Transmission from east to west takes place as follows. The sending relay of the east repeater is operated by telegraph signals and it connects the line to ground for marking and applies to the line a negative 130-volt battery for spacing. At the east repeater when the send relay is on the marking or ground contact, the receiving relay will be held to its marking contact by means of the line current in the line winding and there is very little current flowing through the artificial line winding. When the sending relay is operated to spacing the line current is reversed and current passes through the artificial line winding of the receiving relay to oppose the spacing current in the line winding so as to cause the receiving relay to stay in a marking condition.

2.08 When the sending relay at the east repeater is operated to spacing the line current reverses. The current through the line winding of the receiving relay at the west repeater will then be in a spacing direction and the current in the artificial line winding will be increased somewhat but will continue to be spacing. This increase in artificial line current is caused by the presence of apex resistance so that the spacing battery of the east repeater produces a current in the west artificial line. The net effect due to the line and artificial line currents will be the sum of these two currents and will be in a spacing direction. Assuming that the west repeater is balanced the biasing current should be adjusted so that it will have one-half of the combined effect of the line and artificial line currents when a spacing signal is received from the east repeater. Then, since the line and artificial line currents have equal and opposite effects on the relay when a marking signal is received from the east repeater, equal and opposite marking and spacing effects are produced at the receiving relay when marking and spacing signals are received.

Bias Due to Changes in Line Resistance

2.09 A Type "A" polarential system is shown in simplified form in Fig. 3. Transmission from west to east over this circuit is polar and changes in line resistance have no effect on bias. Transmission from east to west is not polar and changes in the line resistance will cause a bias unless the repeater is lined up in a particular manner. It can be shown that by adjusting the values of the resistances of the artificial line and apex branches of the west repeater so that the line currents are made equal and opposite for marking and spacing, transmission from east to west

will be made free from bias due to line resistance variations. Bias in the east to west direction of transmission is minimized in this manner due to a characteristic of the repeater circuit which causes the marking and spacing effects on the west receiving relay to be reduced equally when the series line resistance is increased. This characteristic also causes the marking and spacing effects on the receiving relay to be increased equally when the series line resistance is reduced. The required equality of marking and spacing effects will be obtained when the resistances of the apex and artificial line branches are approximately equal assuming that the battery voltages at both ends of the line are equal. It is often impracticable with single wire operation to obtain this 1:1 ratio of resistances without reducing the line operating currents below allowable limits. In the case of operation using a neutralizing wire as shown in Fig. 4 this ratio can be maintained over longer lines than for operation over one wire since a lower operating line current can be tolerated with the lower interference level which this operation affords.

2.10 The Type "A" polarential system is recommended for cable circuits where line resistance variations are the controlling factor. For such circuits, Type "A" operation is likely to be more satisfactory than either differential duplex or Type "B" polarential. The Type "A" polarential system is likely to be less immune from bias due to the effects of line leakage than a differential duplex system. It is accordingly much less satisfactory for open-wire operation than a Type "B" polarential system.

(C) Type "B" Polarential Operation

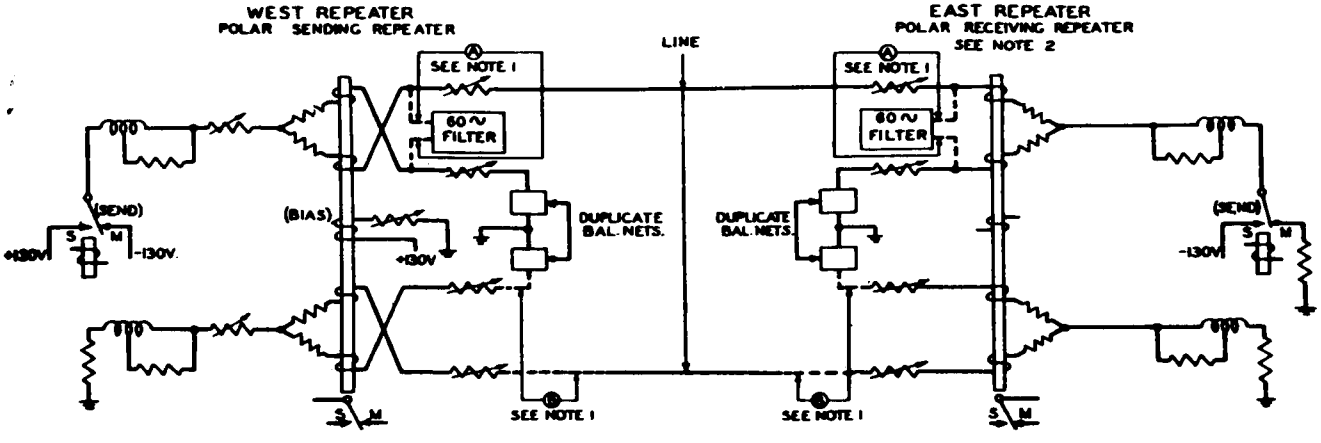
General

2.11 Reference should now be made to Fig. 5 which shows two repeaters arranged for Type "B" polarential operation and connected together over a line circuit. Although 16B1 type repeaters may be used at both ends of the line these two repeaters will be different to the extent that transmission from west to east will be polar while that from east to west will be differential. The 128B2 teletypewriter subscriber set will have transmission circuits similar to the east repeater.

Operating Principles

2.12 Transmission from west to east is similar to that for Type "A" polarential which is covered in Paragraphs 2.05 and 2.06.

2.13 Transmission from east to west takes place as follows. The sending relay of the east repeater is operated by telegraph signals and connects ground to the line for marking and applies positive 130-volt battery for spacing. The currents through the receiving relay windings of the west repeater for the marking condition are in the direction shown by the arrows. The

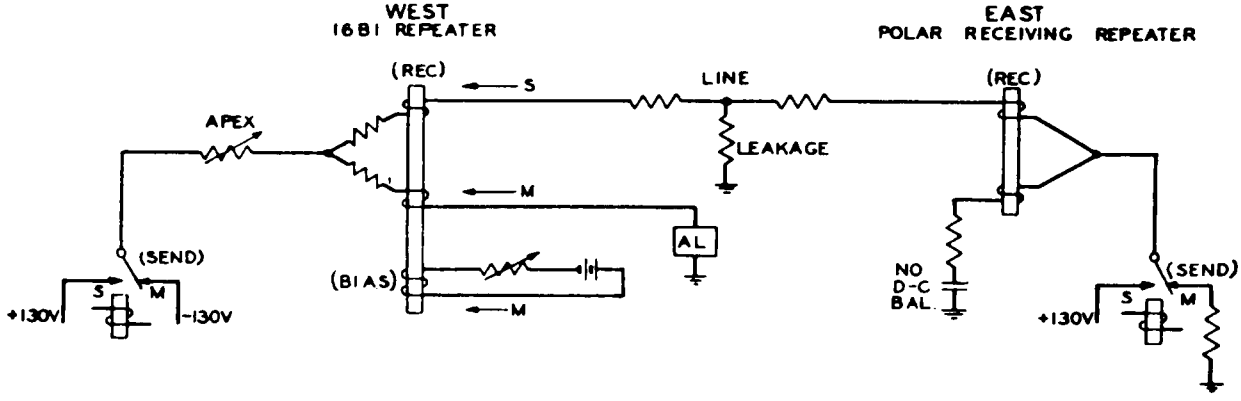


NOTES:
1 USE EITHER Ⓐ OR Ⓑ OR OMIT BOTH AS REQUIRED.

2 THE POLAR RECEIVING END MAY ALSO EMPLOY A 128 B2 SET, A 12 TYPE OR 16 A1 REPEATER, OR A SPECIAL TELETYPEWRITER WIRED FOR TYPE "A" RECEIVING.

16B1 REPEATERS ARRANGED FOR TYPE "A" POLARENTIAL OPERATION.

Fig. 4



TYPE "B" POLARENTIAL SYSTEM

Fig. 5

west receiving relay will be operated to marking by its bias current. When the east sending relay operates to spacing, current in the line will be increased to a value somewhat less than three times the current for the marking condition and will be in the same direction as this current, thus producing a spacing effect on the west receiving relay. The artificial line current will be reduced because of the presence of the common apex resistance but will continue in the marking direction. To produce unbiased signals the effect of the line current must exceed the combined effects of the bias and artificial line currents by an amount equal to the bias current.

2.14 For transmission from east to west the line currents for marking and spacing both tend to hold the receiving relay of the east repeater to marking. From this it might appear that no balancing network would be required at the east repeater. However, when the east send relay is in the spacing condition the capacity of the line and composite set is charged to a positive potential by the spacing battery. Subsequently, when the relay returns to marking the capacity discharges through the line winding of the receiving relay to ground in a direction opposite to the marking current and tends to operate the relay to spacing. This particular kick-off of the receiving relay is prevented by providing a capacity network to balance the capacity of the line, including the composite sets.

Bias Due to Changes in Line Leakage

2.15 Transmission from west to east in the simplified Type "B" polarential circuit of Fig. 5 is polar and changes in line leakage have no effect on bias. Transmission from east to west, however, is not polar and unless the system is lined up in a definite manner leakage will cause bias. This bias is minimized for a Type "B" polarential system by adjusting the apex resistance at the polar sending repeater in a certain relation with that of the line circuit. Instructions for making this adjustment are given in another section of Bell System Practices. The characteristics of the Type "B" system are such that when this adjustment is properly made the marking and spacing effects on the west receiving relay will be reduced by approximately the same amount as the leakage increases, and increased about equally as the leakage decreases.

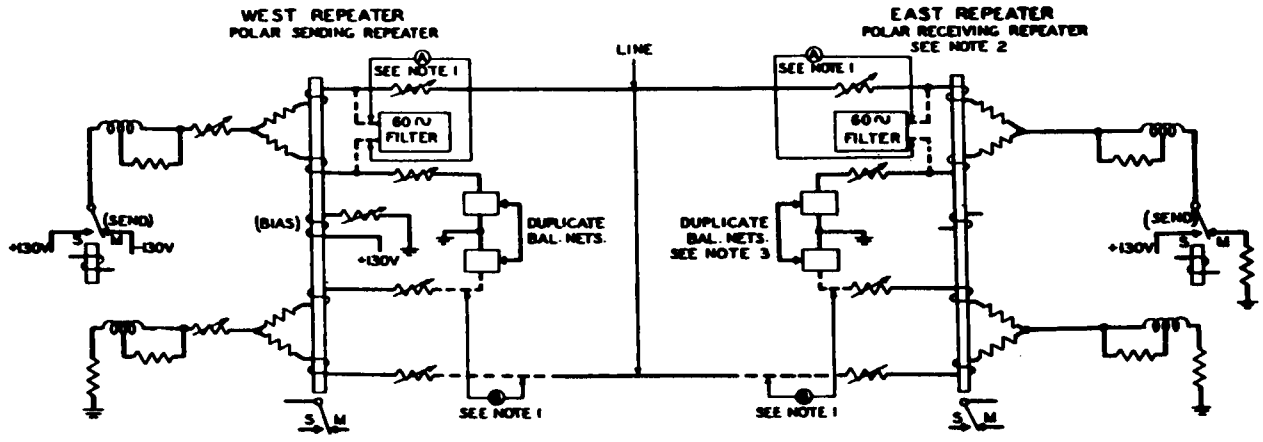
2.16 Type "B" polarential is recommended only for use over open-wire circuits and it is likely to be less satisfactory than a differential duplex or a Type "A" polarential system when operated over cable circuits, particularly when line resistance variations are a factor.

2.17 A neutralizing line wire can be employed for polarential operation in the same manner as described in Paragraph 2.01 for differential duplex as a means for minimizing the effects of interference. This neutralizing wire, together with its balancing network is shown dotted in Figs. 4 and 6 which apply to Type "A" and Type "B", respectively. For convenience the balancing networks of the regular and neutralizing circuits are adjusted by common controls, so that their impedances are the same at all times.

3. CIRCUIT ARRANGEMENTS

General

3.01 A 209FG relay is used for receiving signals from the line. One of the four balanced windings is for use in series with each line conductor and one is for use in each of the two balancing networks. The two auxiliary windings are connected in series and serve as a biasing winding for use at the polar sending end for polarential operation. Fig. 7 is a typical schematic



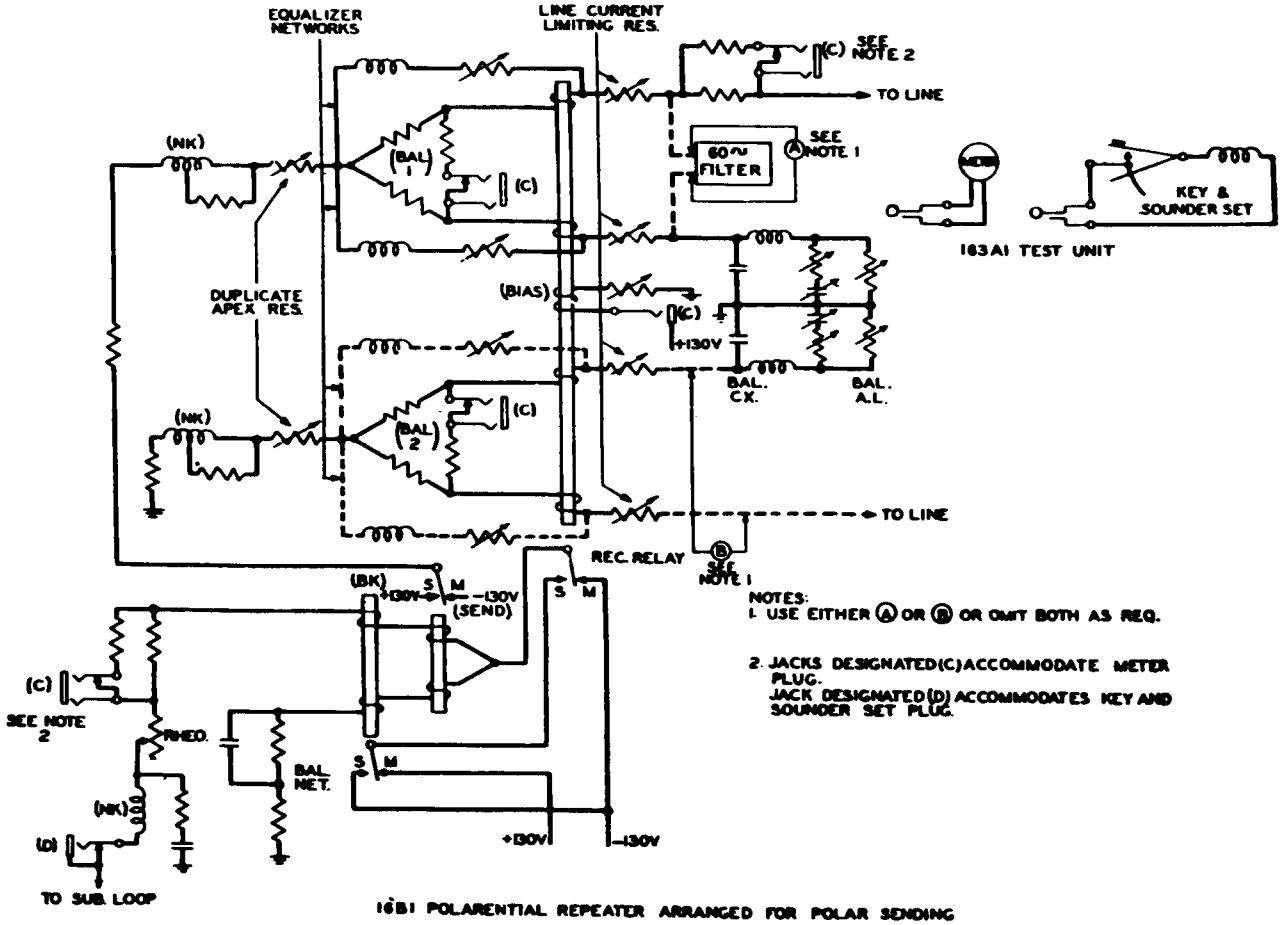
NOTES:
1. USE EITHER Ⓐ OR Ⓑ OR OMIT BOTH AS REQUIRED.

2. THE POLAR RECEIVING END MAY ALSO EMPLOY A 12 TYPE OR 16A1 REPEATER, OR A 12B82 STATION SET.

3. FOR TYPE "B" POLAR RECEIVING THE ARTIFICIAL LINE BALANCE IS A-C ONLY NO D-C BALANCE BEING REQUIRED.

16B1 REPEATERS ARRANGED FOR TYPE "B" POLARENTIAL OPERATION.

Fig. 6



NOTES:
1. USE EITHER Ⓐ OR Ⓑ OR OMIT BOTH AS REQ.

2. JACKS DESIGNATED (C) ACCOMMODATE METER PLUG.
JACK DESIGNATED (D) ACCOMMODATES KEY AND SOUNDER SET PLUG.

16B1 POLARENTIAL REPEATER ARRANGED FOR POLAR SENDING

Fig. 7

circuit of the 16B1 repeater and shows in more detail the circuit arrangements. In this case the repeater is wired for Type "B" polar sending. A complete schematic of the repeater is shown on Fig. 12.

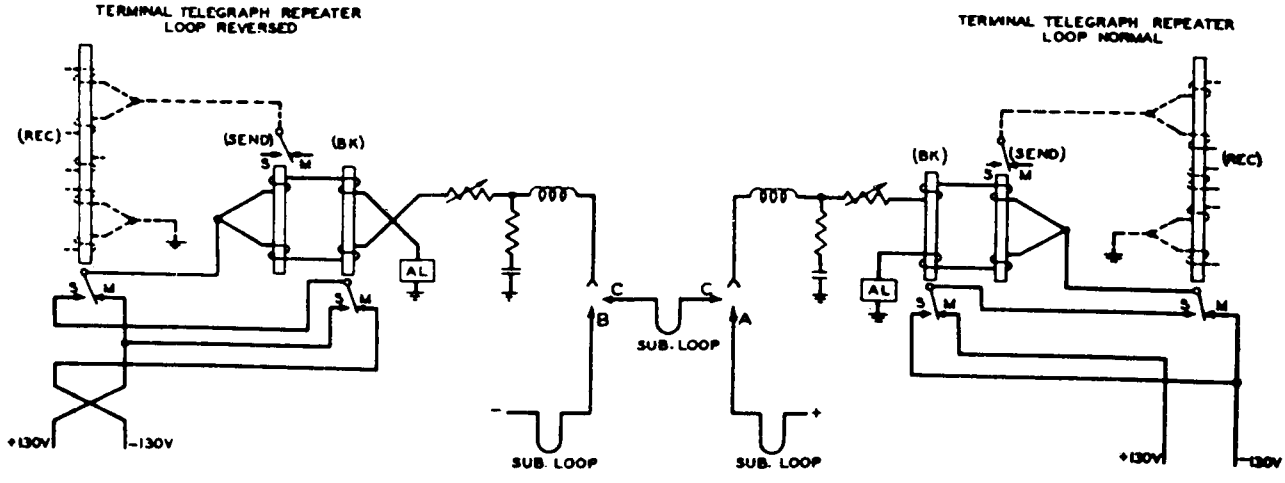
3.02 The two apex circuits are arranged so that their impedances will always be the same. This is accomplished by providing duplicate series resistances in each circuit and employing keys for adjusting the resistances of both circuits simultaneously. The resistance of each branch is adjustable from zero to 1900 ohms in 100 ohm steps. The noise killer consists of two units, one in each apex, and each employs a 149E Retard Coil and a 160 and a 2990 ohm resistance. For economy the 149E coil used in the noise killer unit of the neutralizing line circuit is also employed in the 60-cycle filter as these circuits are never used simultaneously. For convenience in transferring the 149E coil, leads from the two circuits and from the coil are brought out to a terminal strip.

3.03 Duplicate resistance units are furnished in the line and artificial line circuits to facilitate current adjustments. Each of these current limiting resistances has a 300 and 150 ohm unit which may be arranged as desired on a soldering iron basis. Rheostats are provided for the adjustment of bia current (BIAS), condenser timing resistance (TIM RES) and d-c line resistance balance (BAL RES). The capacity balance for each branch consists of condensers, adjustable in 1 mf. steps from 0 to 7 mf. by means of rotating button type keys which control the adjustment of both balancing branches simultaneously. The (TIM RES) and (BAL RES) resistances are provided as duplicate rheostats for the artificial line balance of the regular and neutralizing line circuits. These are made to give the same values by mechanical coupling between units. Provision is made for opening the (BAL RES) circuits at the terminal strips when the repeater is used for Type "B" polarential polar receiving.

3.04 Duplicate composite balancing units are provided in the artificial lines of both regular and neutralizing line wires. A 60-cycle filter is provided as optional equipment for use in suppressing 60-cycle interference when operating on a one-line basis. This filter is, of course, not employed when operating with a neutralizing circuit.

3.05 Conversion from half to full duplex operation is done on a soldering iron basis at the terminal strips. Half and full duplex loop arrangements are shown in schematic form in Figs. 8 and 9 respectively. Single service only is possible for Types "A" and "B" polarential. For full duplex operation currents of both sending and receiving loops are adjustable by means of rheostats. A balanced loop circuit is provided for half duplex operation and a break relay is employed to provide a positive break feature. The loop balancing circuit is not adjustable.

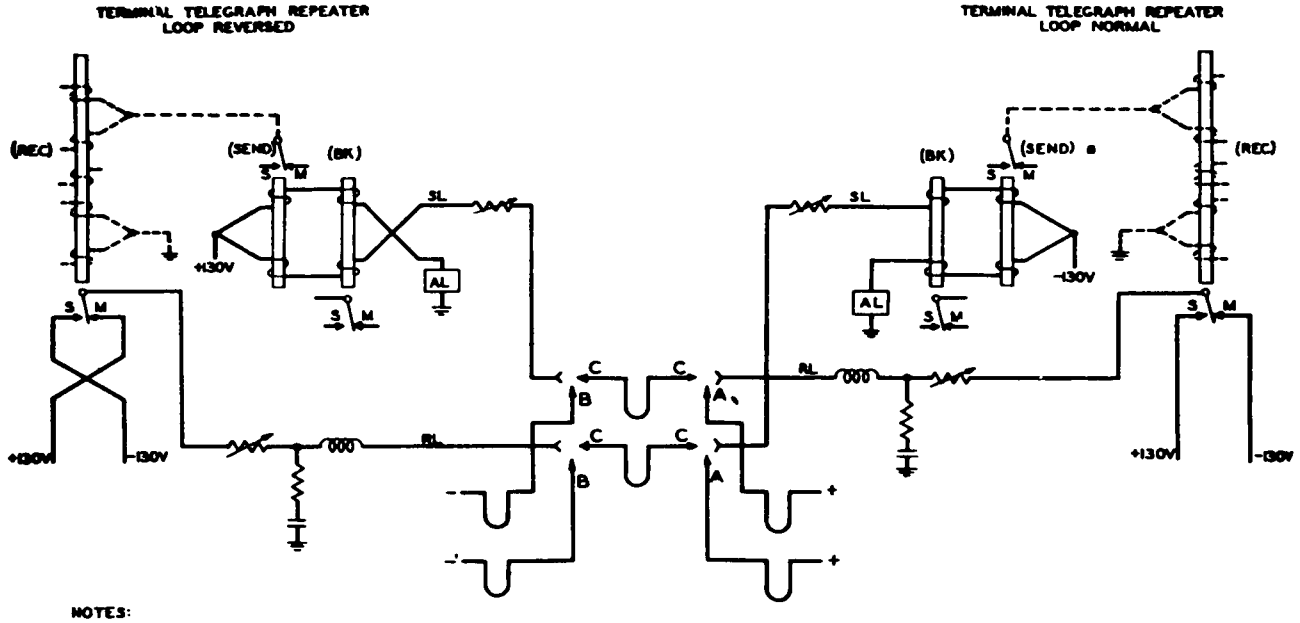
3.06 A loop noise killer is provided for connection in the (S) leg for half duplex and in the (R) leg for full duplex operation. For this purpose leads from the



NOTES
1. "A" WIRING - TERMINAL REPEATER BATTERY NORMAL.
"B" WIRING - TERMINAL REPEATER BATTERY REVERSED.
"C" WIRING - INTERMEDIATE REPEATER WITH LOOP.

LOOP ARRANGEMENTS FOR HALF DUPLEX SERVICE.

Fig. 8



LOOP ARRANGEMENTS FOR FULL DUPLEX SERVICE.

Fig. 9

(R) and (S) legs and the noise killer are brought out to a terminal strip. Telegraph battery is connected to the repeater by means of a relay which is operated locally through a key. Provision has been made for inverse neutral operation, that is, hub circuit, to the extent of bringing out leads at the terminal strip to facilitate the necessary connections if required for this purpose. This type of operation requires additional equipment in the form of an applique unit.

3.07 The repeater is equipped with a total of eight jacks, six of which are used for patching the meter of the 163A1 test unit into the various circuits of the repeater for purposes of adjustment. The circuits are arranged for use with this particular type of meter and the use of any other meter is likely to result in erroneous readings and adjustments. The meter has a 100-0-100 mil scale and 25 mils through the meter circuit produces full scale deflection.

3.08 The two additional jacks, one located in the (S) loop circuit and the other in the (R) loop circuit, are provided for connection to the key and sounder circuit of the 163A1 test unit as shown in Fig. 7. During adjustment of the artificial line balance the loop circuit is opened and closed by either the operation of the telegraph key or the insertion and removal of a dummy plug and the capacity and resistance balance adjustments are varied until sent signals have no effect on the receiving relay and cause minimum change in the meter reading.

Meter Readings

3.09 When patched in the (BAL 1) jack the meter reads the differential current in the line and artificial line. The shunt on the (BIAS) jack is such that the proper bias current is obtained when the bias meter reading is equal and opposite to the (BAL 1) jack reading, when the line is balanced and a spacing signal is received. The meter reads the true loop currents in the (S) and (R) loops.

Full Duplex Balance

3.10 The capacity and resistance of the line circuit cannot be exactly duplicated in the balancing artificial line without having many adjustable members. In the case of operation with a neutralizing wire, capacity coupling between the regular and neutralizing line circuits is not duplicated between the two balancing artificial lines, and the use of a single winding meter such as that provided with the 163A1 test unit may introduce some error in the a-c balance adjustment. In cases where a more accurate artificial line adjustment is required transmission measurements may be made and the capacity balance adjustment varied until best operation is obtained.

Equalizer Networks

3.11 The repeater is provided with equalizer networks, one of which is connected in parallel with each of the line and artificial line windings of the receiving relay. Networks are applied to the artificial line circuits for the purpose of

maintaining line balance. Each consists of a 207E coil in series with a resistance unit connected as shown in Fig. 7. The purpose of these networks is to improve transmission by applying wave shaping at the receiving relay. Equalizers can be employed for all forms of operation for which the repeater is recommended. The equalizers are adjusted by changing the value of the series resistance on a soldering iron basis and each equalizer branch should have the same adjustment when in use. For best results the equalizer resistances should be adjusted to produce the least distortion for the particular line circuit with normal interference present. In the case of differential duplex operation the use of equalizers results in improved transmission only under severe line conditions. For polarential operation the effect of the equalizer is more beneficial and this is particularly so at the polar receiving repeater.

4. DESCRIPTION OF EQUIPMENT

16B1 Repeater

4.01 The assembled repeater is shown in Fig. 10. It is mounted on six 19" mounting plates and has a total height of 14". The three upper 1-3/4" mounting plates accommodate the fixed resistances, retard coils, condensers, and the battery cutoff relay. Three 181A terminal strips are mounted on the rear of the uppermost plate. These terminal strips are provided to facilitate changes in the optional wiring arrangements. Below the three upper 1-3/4" mounting plates and separated from them by a resistance shield are two 3-1/2" mounting plates which accommodate the three polar relays, the adjustable rheostats and the remainder of the condensers.

4.02 The (TIM RES) and (BAL RES) rheostats are each twin slide wire rheostat units mounted with a common shaft. The (RL RES) and (SL RES) rheostats provided for loop current regulation are of higher wattage rating than the others because of the necessity for handling larger currents in the loop circuits. The rheostat shafts are slotted for screwdriver adjustment. The keys and jacks are mounted on the lowest mounting plate which is of 1-3/4" height. This mounting plate is furnished with a designation strip. The keys are of the rotating button type with a white line designation which is in a vertical direction when the unit is connected in the circuit and horizontal when it is not connected. An additional designation strip of new design is provided to accommodate a 3" x 5" designation card. This designation strip is mounted at the right ends of the second and third mounting plates from the top and extends over some of the resistance units. The rheostats with the exception of that controlling the biasing current, turn in a

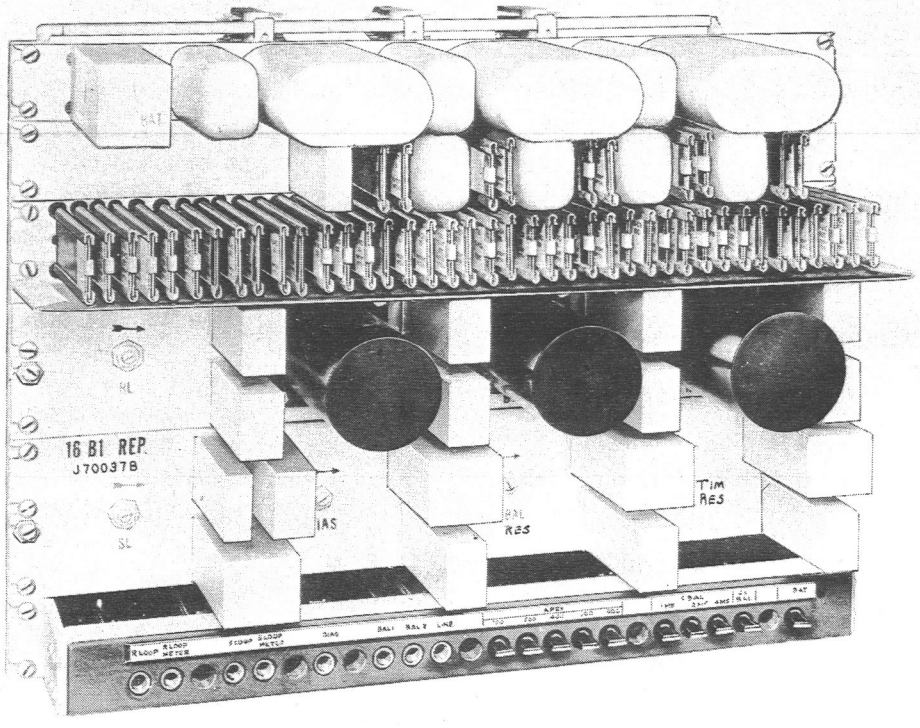


Fig. 10 - 16B1 Repeater

clockwise direction to increase the resistance. The bias rheostat is turned clockwise to increase marking bias. The direction of rotation of these rheostats is clearly indicated by markings on the repeater panel.

163A1 Test Unit

4.03 The monitoring equipment consists of a 163A1 test unit which is a portable unit consisting of a meter mounted on a bracket slotted to slip over the heads of two extended mounting plate screws. The test unit which is shown in Fig. 11 is designed to mount on the left side of the repeater unit without interference in any way with the adjustment of the repeater. The bracket is also designed to accommodate a Morse key and sounder which are provided on an optional basis. The repeater is provided with jacks in the various circuits for connection to the test unit.

4.04 Means are provided for preventing injury to the meter in case it is accidentally connected to the jacks intended for the key and sounder circuit. This is accomplished by employing two-conductor jacks for the key and sounder circuit and three-conductor jacks for the meter. The meter is wired to the tip and ring conductors of its plug and as the ring of this plug does not make contact with the sleeve of the key and sounder jack, the meter cannot be connected in series with the loop circuit. The tip and sleeve conductors of the meter plug are strapped together so that the loop circuit would not be opened if the meter circuit were accidentally plugged into the key and sounder jack.

4.05 The meter cord is a three-conductor slate colored cord, three feet in length, equipped with a three-conductor plug having a red shell. The key and sounder cord is a two-conductor green cord, three feet in length, equipped with a two-conductor plug having a black shell. The cords are of sufficient length to permit the test unit to be mounted in a bay adjacent to that on which the 16B1 repeater under test is mounted.

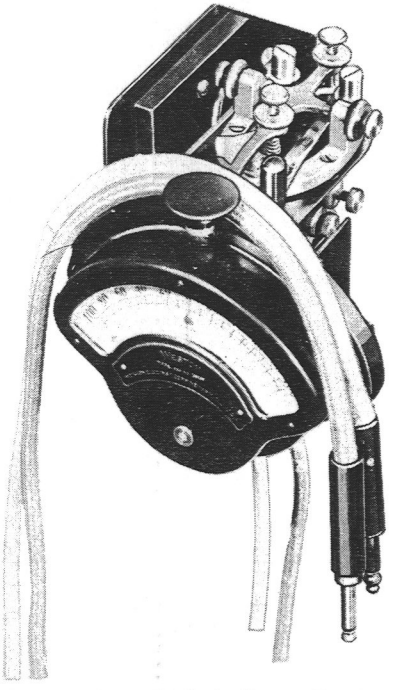


Fig. 11 - 163A1 Test Unit

5. LINE LENGTH LIMITS

5.01 The lengths of line over which good operation will be obtained under ideal conditions such as are found in the laboratory are given on the circuit drawing. It is expected that such ideal conditions will not usually be obtained in the field. Thus for practical field application the line limits which are given in the BSP section covering transmission coefficients should be consulted.

Attached:
Fig. 12.

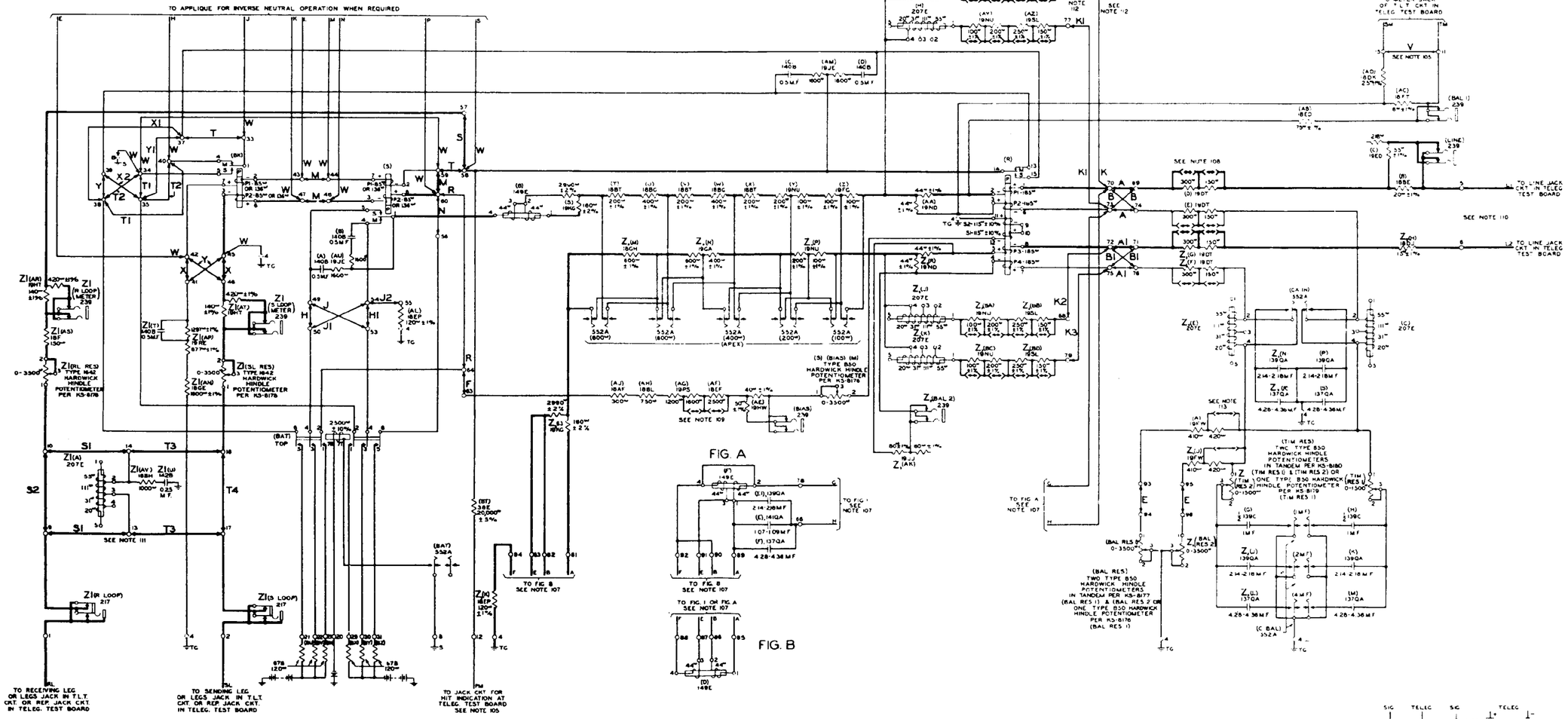


FIG. A

FIG. B

TABLE A

LINE CONDITIONS \ OPTIONAL WIRING — TERMINAL / STRAPPING	GENERAL OPTIONS (1) STRAP ITEMS CHECKED FOR PARTICULAR LINE CONDITION REQUIRED: A	B	K	KI	E	F	H	HI	J	JI	J2	V	LINE INTERFERENCE OPTIONS (2) ADD TO (1) WHEN 60~ FILTERS ARE REQ: FIGS A & B	(3) ADD TO (1) WHEN OPERATING OVER TWO LINES FOR NEUTRALIZATION OF VARIOUS LINE INTERFERENCES: A1	B1	K2	R3	FIG B
	69-73	70-74	67-73	70-77	83-95	84-96	63-89	64-90	53-87	54-88	55-91	11-13 **		66-70, 85-89, 72-76, 68-72, 75-79, 84-88, 73-78, 86-90, 75-78, 71-75, 87-91, 88-92				82-86, 83-87, 84-88
DP DUPLEX-LINE BAT NORMAL-LINE NORMAL	✓		✓	✓	✓		✓	✓		✓			✓	✓		✓	✓	✓
DP DUPLEX-LINE BAT REVERSED-LINE REVERSED		✓	✓	✓	✓		✓	✓		✓			✓		✓	✓	✓	✓
DP DUPLEX-LINE BAT NORMAL-LINE REVERSED		✓	✓	✓	✓		✓	✓	✓				✓		✓	✓	✓	✓
DP DUPLEX-LINE BAT REVERSED-LINE NORMAL	✓		✓	✓	✓		✓	✓	✓				✓	✓		✓	✓	✓
TYPE A (POLAR SENDING)		✓	✓		✓	✓	✓	✓		✓			✓		✓	✓	✓	✓
TYPE A (POLAR RECEIVING)	✓		✓		✓	✓	✓	✓		✓			✓	✓		✓	✓	✓
TYPE B (POLAR SENDING)	✓		✓	✓	✓		✓	✓		✓			✓		✓	✓	✓	✓
TYPE B (POLAR RECEIVING)	✓		✓	✓	✓		✓	✓		✓			✓	✓		✓	✓	✓

* WIRING SHALL BE PROVIDED FOR TYPE B POLAR RECEIVING ONE WIRE REPEATER WITH 60 CYCLE FILTERS
** SEE NOTE 105.

TABLE B

LOOP CONDITIONS \ OPTIONAL WIRING — TERMINAL / STRAPPING	GENERAL OPTIONS (4) STRAP ITEMS CHECKED FOR PARTICULAR LOOP CONDITION REQUIRED: M	N	R	S	T	TI	T2	W	X	XI	X2	Y	YI
	43-47, 44-48, 59-60	45-60	64-58	57-58	33-38, 34-39, 37-40	34-39	35-40	4-34, 5-35, 8-38	4-43, 5-44, 8-34, 35-48, 34-59	41-42, 37-38, 34-59	35-39, 36-40	38-39, 41-43, 42-46	35-37
HALF DUPLEX LOOP NORMAL	✓				✓	✓		✓		✓		✓	
HALF DUPLEX LOOP REVERSED	✓				✓		✓		✓		✓		✓
FULL DUPLEX LOOP NORMAL	✓	✓		✓			✓		✓	✓		✓	
FULL DUPLEX LOOP REVERSED	✓		✓		✓		✓		✓		✓		✓
INVERSE NEUTRAL (PROV)								✓		✓			

CIRCUIT NOTES

101 (A) PROVIDE 3 LEADS FROM THE +130 V TELEG BAT BUS BAR EACH EQUIPPED WITH A 7AC OR 7AE HEAT COIL PER CKT
(B) PROVIDE 3 LEADS FROM THE -130 V TELEG BAT BUS BAR EACH EQUIPPED WITH A 7AC OR 7AE HEAT COIL PER CKT

102 PROVIDE ONE LEAD FROM 24V SIG BAT BUS BAR EQUIPPED WITH A 1/8 AMP FUSE FOR EACH CIRCUIT

103 WHERE THE TELEG BAT IS EQUIPPED WITH GROUND POTENTIAL COMPENSATOR, PROVIDE A 1/8 AMP FUSE IN THE TELEG GRD LEAD FOR EACH CIRCUIT. WHERE NOT SO EQUIPPED TELEG GRD SHALL BE CONNECTED TO SIG GRD WITHOUT FUSING

104 FOR VARIOUS LINE CIRCUIT CONDITIONS FURNISH WIRING ACCORDING TO TABLE A
FOR VARIOUS LOOP CIRCUIT CONDITIONS FURNISH WIRING ACCORDING TO TABLE B

105 WHEN FULL TEST BOARD ANSWERING FACILITIES ARE REQUIRED OMIT "Y" WIRING AND CONNECT "3M" AND "TM" LEADS TO METER JACK OF "L" CKT. PROVIDE "Y" WIRING IN ALL OTHER CASES. WHEN REPEATER IS ARRANGED FOR POLAR RECEIVING TYPE B OPERATION, FULL TEST BOARD ANSWERING CANNOT BE USED. FOR LEAK TYPE HIT INDICATION CONNECT THE "PM" LEAD TO JACK CKT AS SPECIFIED

106 "Z" APPARATUS IS REQUIRED FOR TWO WIRE OPERATION AND MAY BE OMITTED FOR ALL OTHER CASES.

107 (A) FOR ONE WIRE OPERATION WITHOUT 60 CYCLE INTERFERENCE, OMIT FIGS A AND B
(B) FOR ONE WIRE OPERATION WITH 60 CYCLE INTERFERENCE, PROVIDE FIGS A AND B
(C) FOR TWO WIRE OPERATION, PROVIDE FIG B AND OMIT FIG A

108 WHEN THE REPEATER IS ARRANGED FOR POLARENTAL OPERATION OVER ONE WIRE, STRAP THE (D) AND (E) RESISTANCES AS FOLLOWS:

TOTAL LINE RESISTANCE	STRAP RESISTANCES (D) AND (E) TO BE
1200~ OR MORE	ZERO
800~-1200~	150~
400~-800~	300~
400~ OR LESS	450~

WHEN THE REPEATER IS ARRANGED FOR TWO WIRE OPERATION, THE RESISTANCES (D) (E) (F) AND (G) SHALL BE STRAPPED IN ACCORDANCE WITH THE ABOVE TABLE FOR DIFFERENTIAL DUPLEX OPERATION. THE (D) (E) (F) AND (G) RESISTANCES SHALL BE STRAPPED TO ZERO OHMS

109 THE (AF) RESISTANCE AND THE 1800~ HALF OF THE (AG) RESISTANCE SHALL BE STRAPPED AS REQUIRED TO PERMIT THE PROPER ADJUSTMENT OF THE BIAS CURRENT BY MEANS OF THE (BIAS) POTENTIOMETER

110 WHEN COMPOSITED OR NON-COMPOSITED OPEN WIRE LINES ARE USED FOR TWO WIRE OPERATION, LINES L1 AND L2 SHALL BE PAIRS OF THE SAME QUAD. WHEN OPERATING OVER SIMPLEXED OPEN WIRE OR CABLE PAIRS, LINES L1 AND L2 SHALL BE PAIRS OF THE SAME QUAD

111 (A) FOR HALF DUPLEX AND HALF DUPLEX THRU OPERATION WITH A SUBSCRIBER LOOP, PROVIDE "T3" WIRING AND OMIT "T4", "T3" AND "52" WIRING
(B) FOR HALF DUPLEX THRU OPERATION WITHOUT A SUBSCRIBER LOOP, PROVIDE "T4" WIRING AND OMIT "T3" AND "52" WIRING
(C) FOR FULL DUPLEX AND FULL DUPLEX THRU OPERATION WITH A SUBSCRIBER LOOP, PROVIDE "T4" AND "51" WIRING AND OMIT "T3" AND "52" WIRING
(D) FOR FULL DUPLEX THRU OPERATION WITHOUT A SUBSCRIBER LOOP, PROVIDE "T4" AND "52" WIRING AND OMIT "T3" AND "51" WIRING

112 THE (AW), (AX), (AY), (AZ), (BA) (BB) (BC) AND (BD) RESISTANCES SHALL BE STRAPPED TO OBTAIN THE BEST TRANSMISSION OVER THE CIRCUIT. THE STRAPPING SHALL BE THE SAME FOR EACH BRANCH WHEN THE BEST TRANSMISSION IS OBTAINED WITHOUT THE EQUALIZING NETWORK. OMIT "N1", "Y1" AND "K3" WIRING

113 HALF OF THE (A) AND (J) RES. SHALL BE STRAPPED TO PERMIT PROPER BALANCE FOR LINES HAVING A RES. OF LESS THAN 830~

114 ALL POTENTIOMETERS EXCEPT THE (BIAS) POTENTIOMETER INCREASE RESISTANCE WHEN OPERATED IN THE CLOCKWISE DIRECTION. THE (BIAS) POTENTIOMETER INCREASES CURRENT WHEN OPERATED IN THE CLOCKWISE DIRECTION

115 "Z" APPARATUS IS REQUIRED FOR ALL TYPES OF OPERATION EXCEPT INVERSE NEUTRAL

Fig. 12