144A1 COUPLING UNIT

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1. GENERAL

1.01 The 144A1 coupling unit is a demountable electronic device that serves to interconnect the send and receive legs of a line repeater or a polar relay loop repeater and a send and receive electronic hub circuit which operates on voltages of +60 mark and -30 space. This form of hub operation is employed in the No. 2 and No. 9B telegraph service boards and in testboard offices using electronic regeneration. The coupling unit is capable of half or full-duplex operation under external control and may be used with or without regeneration. The 143A2 regenerative repeater is connected between the send and receive hubs when regeneration is required.

1.02 The coupling unit contains a duplex control feature. In half-duplex circuits, this feature prevents the reflection of spacing signal elements towards the facility sending to the hub. When a "double-space" condition occurs on the hub, the duplex control feature is released to permit the transmission of a space signal outward through the coupling unit while a space also may be incoming through the unit from the facility.

1.03 In the case of full-duplex services, the duplex control feature is released at all times to permit simultaneous transmission of signals in both directions.

1.04 The coupling unit also includes a circuit element for actuating hit indicating devices at the service board.

1.05 The coupling unit is arranged for bench testing by means of a 165B1 test set.

2. PRINCIPLES OF OPERATION

Half-Duplex Hub Operation

2.01 Fig. 1 shows two 144A1 coupling units one of which is assigned to a 90C1 loop repeater and the other is assigned to a line repeater. In the idle or marking condition, the hub potentiometer holds the receive hub voltage at +60. At this time, each line or loop facility connects a +130V battery to the R lead which connects to the inward transmission circuit of the coupling unit (see Fig. 2). The inward transmission circuit includes a series varistor chain which is poled to prevent current flow toward the receive hub and hence the +130-volt marking battery of each leg is isolated from the hub during the marking or idle condition. The marking voltage on the receive hub is applied to the send hub through a hub link or a regenerative repeater which in turn applies a marking potential to the send hub to cause the transmission of a mark to the SL lead of each coupling unit. Lead SL connects to the outward transmission circuit of the coupling unit (see Fig. 2). This circuit includes a twin triode vacuum tube, the triodes of which are operated in parallel. The triodes are made to conduct by the application of marking (positive) grid voltage so that

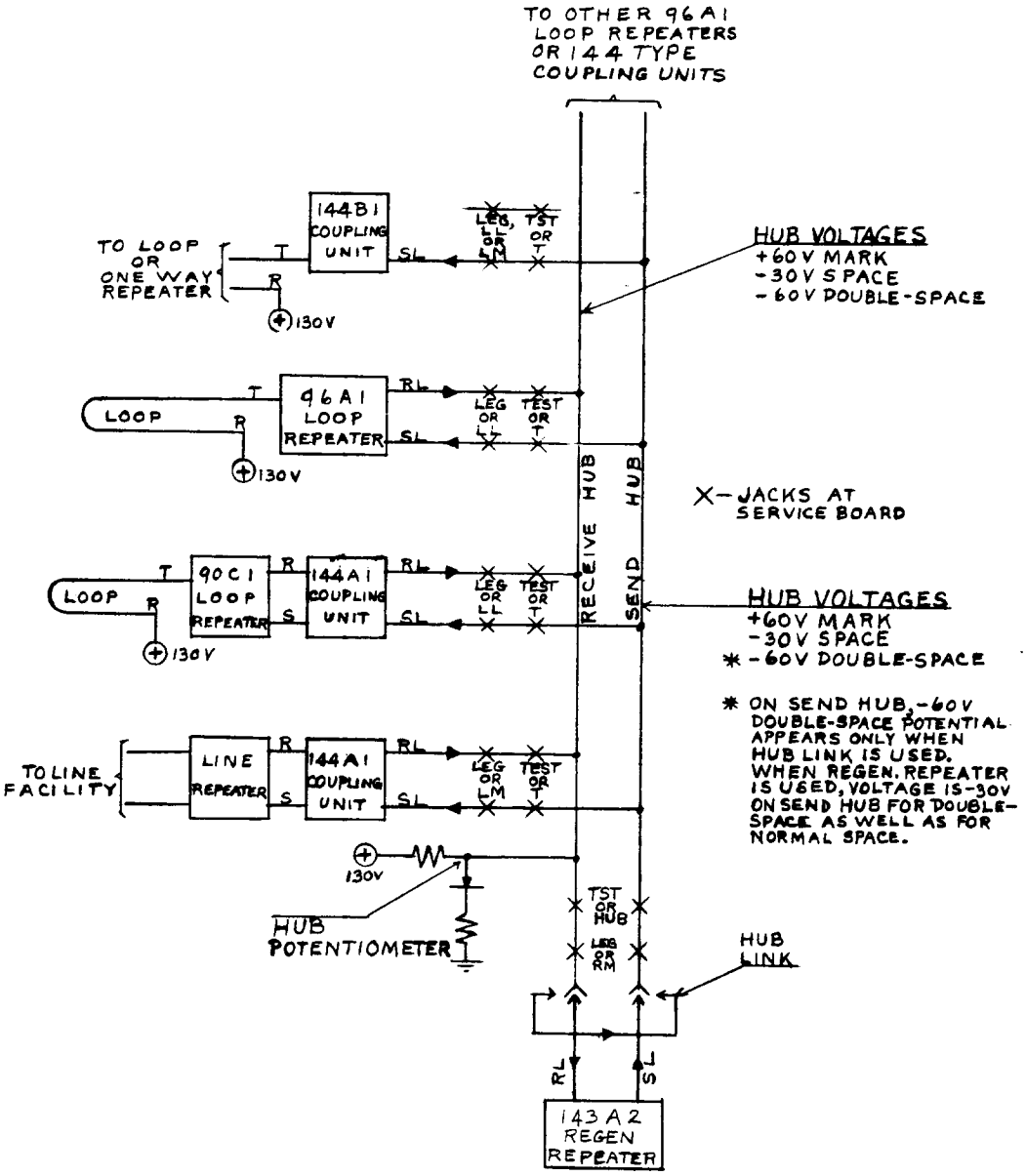
TO OTHER 96A1 LOOP REPEATERS OR 144 TYPE COUPLING UNITS
144B1 COUPLING UNIT
TO LOOP OR ONE WAY REPEATER
T
R
+130V
SL
LEG OR LL OR LM
TST OR T
HUB VOLTAGES
+60V MARK
-30V SPACE
-60V DOUBLE-SPACE
96A1 LOOP REPEATER
LOOP
RL
LEG OR LL
TEST OR T
X-JACKS AT SERVICE BOARD
RECEIVE HUB
SEND HUB
90C1 LOOP REPEATER
144A1 COUPLING UNIT
S
HUB VOLTAGES
+60V MARK
-30V SPACE
*-60V DOUBLE-SPACE
* ON SEND HUB, -60V DOUBLE-SPACE POTENTIAL APPEARS ONLY WHEN HUB LINK IS USED. WHEN REGEN. REPEATER IS USED, VOLTAGE IS -30V ON SEND HUB FOR DOUBLE-SPACE AS WELL AS FOR NORMAL SPACE.
TO LINE FACILITY
LINE REPEATER
144A1 COUPLING UNIT
LEG OR LM
TST OR T
130V
HUB POTENTIOMETER
TST OR HUB
LEG OR RM
HUB LINK
RL
SL
143A2 REGEN REPEATER

Fig. 1

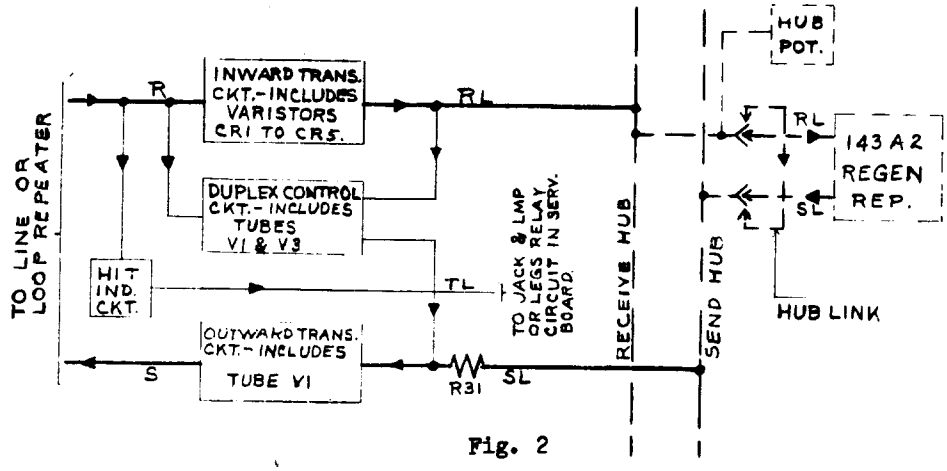
HUB POT.
TO LINE OR LOOP REPEATER
R
INWARD TRANS. CKT.-INCLUDES VARISTORS CR1 TO CR5.
RL
DUPLEX CONTROL CKT.-INCLUDES TUBES V1 & V3
HIT IND. CKT.
TL
TO JACK & LMP OR LEGS RELAY CIRCUIT IN SERV. BOARD
OUTWARD TRANS. CKT.-INCLUDES TUBE V1
S
R31
SL
RECEIVE HUB
SEND HUB
143A2 REGEN REP.
HUB LINK

Fig. 2

plate current (cathode drive) flows through the windings of the send relay of the repeater in a marking direction. For an incoming space, the repeater connects -130-volt battery to the R lead and causes a 30-mil current to flow from the receive hub through the varistor chain of the inward transmission circuit in a conducting direction. The impedance of the hub potentiometer is such that the receive hub voltage is lowered to -30 by this flow of spacing current. The spacing potential reaches the send hub via a hub link or the same voltage is applied by a regenerative repeater to the SL lead of each interconnected coupling unit. Application of the negative (spacing) potential to the outward transmission circuit of the coupling unit causes the twin triode tube to be cut off unless a space is incoming from the line or loop facility associated with the unit. In the latter case, outward passage of the space is blocked by the duplex control feature (see Fig. 2) in the coupling unit which is receiving the incoming space. Thus the twin triode tube is prevented from being cut off and the associated S relay in the repeater remains marking. In those coupling units where the outgoing space is permitted to cut off the twin triode tube, the send relay of the associated line or loop repeater is operated to spacing by a steady biasing current which flows through the relay windings in series to ground in a spacing direction. If two legs send spaces toward the receive hub simultaneously, the voltage of the hub will become -60. This voltage is known as the "double-space" potential and is sufficiently negative to cause a spacing pulse to be transmitted outward over each leg including those through which spaces are incoming.

Full-Duplex Hub Operation

2.02 Fig. 3 is a block diagram showing two 144A1 coupling units interconnected for full duplex through operation. In this case, one-half of a 144C1 coupling unit is connected between the RL lead of one 144A1 coupling unit and the SL lead of another 144A1 coupling unit as shown in the figure. A full-duplex potentiometer is connected to the RL lead of each 144A1 coupling unit in order to provide hub potentials of -10-volt marking and -60-volt spacing. These negative voltages maintain the duplex control feature of the 144A1 coupling units in a released condition so that spaces may pass through each unit simultaneously in both directions at all times. Signals on each RL lead are repeated by the 144C1 coupling unit to the SL lead of the other 144A1 unit. A hub potentiometer is connected to each SL lead so that the operating potentials will be +60-volt mark and -30-volt space on the output of each half of the 144C1 coupling unit for driving the associated 144A1 coupling unit.

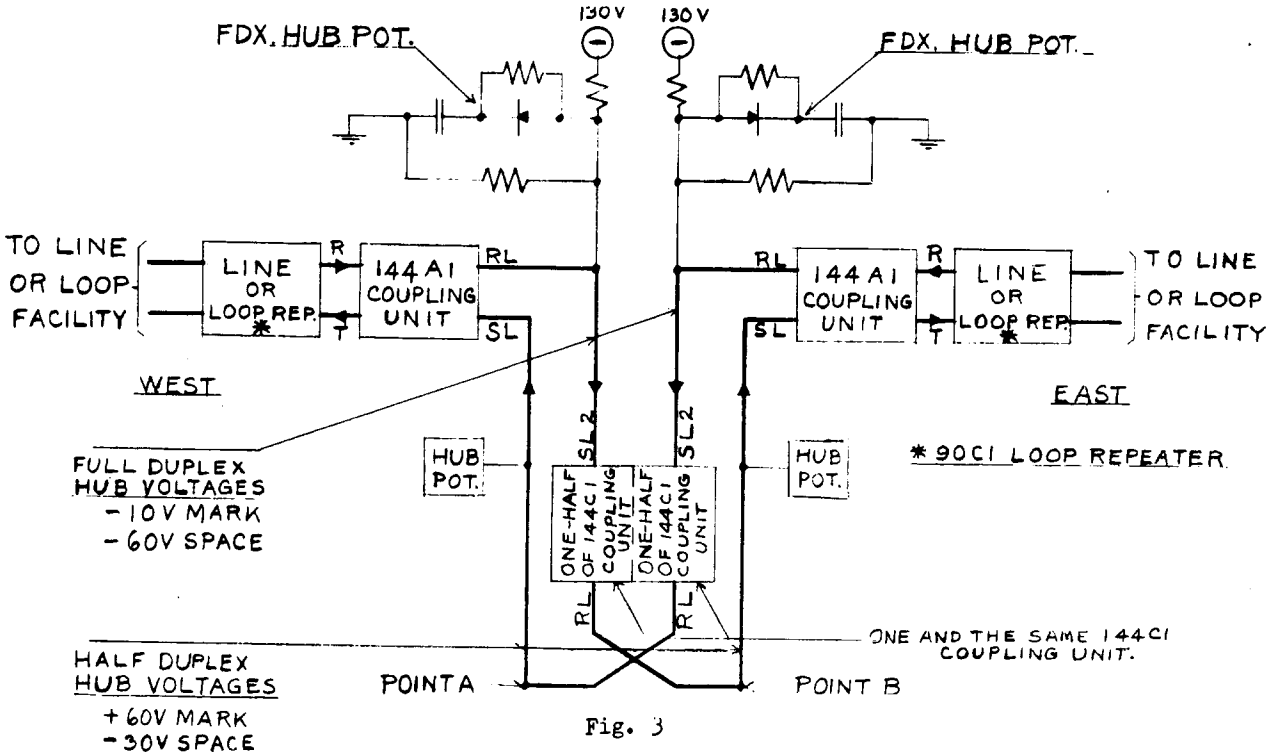

Fig. 3

2.03 Duplex Control Feature

(a) Normal Operation: Fig. 2 is a block diagram showing the internal circuit elements of the coupling unit and their interconnections. The duplex control feature performs only in conjunction with half-duplex operation and its principal purpose is to prevent a space signal which reaches the receive hub from being transmitted back toward the facility from which it has been received or to hold the S relay marking in a repeater which is receiving a space from the line. To perform this function the duplex control circuit observes and compares the voltage on the receive hub with that received from the R relay of the associated repeater. If the receive hub voltage is -30 when the R relay voltage is -130, the duplex control circuit connects a positive potential to the SL lead and thereby prevents a -30-volt (spacing) hub potential from passing through the outward transmission circuit of the coupling unit and operating the send relay of the associated repeater to spacing. This condition, which will be referred to herein, as the "operated" condition of the duplex control circuit, exists when transmission is toward the receive hub (inward). If on the other hand the duplex control circuit observes that the receive hub voltage is -30 when the R relay voltage is +130, it does not interfere with transmission over the outward transmission circuit. This condition will be referred to herein as the "released" condition of the duplex control circuit. When operation is full duplex the duplex control circuit is held released at all times.

(b) "Double-Space" Operation: When the repeater transmits a space through the coupling unit to the receive hub at the same time another leg sends a space to the receive hub, the voltage of the hub will be -60 which is the "double-space" potential. In this case, the duplex control circuit releases and permits the negative hub potential to send a space through the outward transmission circuit and operate the send relay of the associated line facility to spacing. The appearance of a double-space voltage on the receive hub, therefore, causes a space to be sent outward over every leg including the two from which spaces are being received. This feature expedites the passage of a break signal through the electronic hub circuit and gives immediate indication of simultaneous sending on complicated half-duplex networks. If three or more legs send spaces simultaneously to the receive hub, the hub voltage will reach higher negative potentials than -60 volts and the duplex control circuits of all interconnected coupling units will be released in the same manner as for two simultaneous spaces.

Hit Indications

2.04 The 144A1 coupling unit converts the +130-volt marking and -130-volt spacing potentials which it receives from the R relay of a repeater to -50 volts and -125 volts, respectively, for application to the TL lead. This lead extends to the concentration jack circuit appearance of the facility in the service board. A cold cathode tube, one side of which is connected to negative 24-volt battery at the service board, lights in response to spacing pulses (-125 volts). At a No. 2 service board, the hit indicator lamps appear in the jack field but in the No. 9B service board, each lamp is mounted in a plug which is inserted in the jack associated with the leg under observation.

3. DESCRIPTION OF OPERATION

(A) Transmission

General

3.01 The transmission circuits through which signals pass in going to and from the receive and send hubs in the case of half-duplex operation are indicated by the heavy lines in Fig. 4. The upper part of the figure shows the inward path of signals through the coupling unit and the lower part shows the outward transmission circuit through the same unit. The elements of the duplex control circuit are shown in the central part of the figure.

3.02 Inward Transmission

(a) Mark Pulse: When the repeater sends a mark toward the receive hub its R relay connects +130-volt battery through a resistance to lead R. The potentiometer circuit which includes resistors R1, R2, R3 and R29 reduces the voltage to a value of +65 volts on point A. Assuming the receive hub is at the idle or marking potential of +60 volts at this time, the varistor chain consisting of varistors CR1 to CR5, inclusive, will cause point A which is at the higher potential of 65 volts to be isolated from the receive hub. Current will thus be prevented from flowing between the R relay of the repeater and the receive hub, and the marking hub voltage of +60 which is supplied by the hub potentiometer, will remain unchanged.

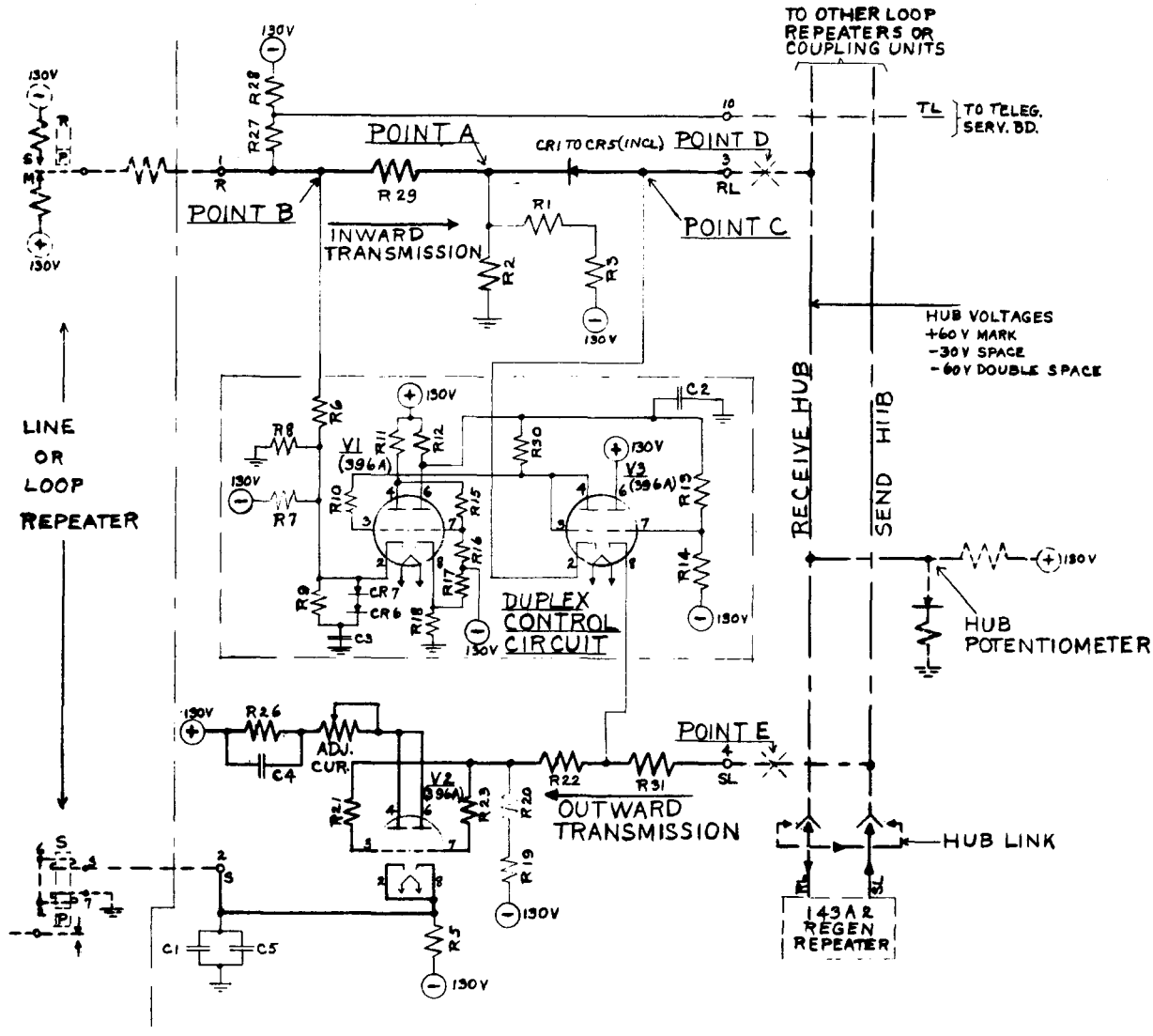

Fig. 4

(b) Space Pulse: For an incoming space, the repeater connects -130-volt battery through a resistance to the R lead. The voltage at point A will now be negative with respect to that on the receive hub and a 30-mil current will flow from the hub through the varistor chain to the R relay. This current flow from the receive hub will cause the hub voltage to fall to -30 volts.

(c) "Double-Space": If the inward transmission circuits of two coupling units send spaces to the receive hub simultaneously, the current in each RL lead will be 18 mils and the receive hub potential will become -60 volts which is known as the "double-space" potential. The receive hub is connected to the send hub either directly through a hub link or via a 143A2 regenerative repeater. The potential of the receive hub therefore will appear on the send hub although when a regenerative repeater is used, the transitions will lag behind those on the receive hub by approximately one-half pulse length and the double-space potential will not be repeated by the regenerative repeater. In Paragraph 3.07, it will be shown that if the double-space potential appears on the receive hub, it is necessary only that a normal spacing potential of -30 volts appear on the send hub in order to cause the double space to be transmitted outward to all associated legs.

3.03 Outward Transmission

(a) Mark Pulse: When the send hub is in the marking condition, it will apply +60 volts to the SL leads of all associated coupling units (see Fig. 1). Referring to Fig. 4, this voltage will be applied to the potentiometer consisting of resistors R31, R22, R20 and R19 with the result that a +50-volt potential will be applied to the grids of tube V2 through resistors R21 and R23. As the cathodes of V2 are at ground or slightly negative potential, the positive grid potential will cause both triodes to conduct and plate current will flow. The circuit may be traced from +130-volt battery through resistor R26, potentiometer ADJ CUR, the plate circuits of both triodes of tube V2 in parallel, and the windings of relay S of the repeater to ground. This current, which is in a marking direction, is adjusted to 14 mils by means of series potentiometer ADJ CUR. The S relay of the repeater receives bias (spacing) current continuously from -130-volt battery through series resistor R5. As the spacing bias current has a value of 7 mils, operation of the S relay is polar with 7 mils effective current in each direction. Parallel condensers C1 and C5 are shunted around the windings of relay S and serve to prevent the voltage transients developed across the relay windings from becoming large enough to interfere with the grid control of tube V2.

(b) Space Pulse: When the send hub is in the spacing condition, it will apply -30 volts to the SL lead of the coupling unit. Assuming that the space on the send hub is caused by reception of a space from another leg, this voltage will be applied through resistors R31, R22, R20 and R19 to -130-volt battery. In this case, the potential applied to the grids of tube V2 through resistors R21 and R23 is -35 volts which serves to cut off both triodes of this tube thereby interrupting the flow of marking current through the windings of relay S. Relay S is operated to spacing by the bias current from -130-volt battery through the 18,000-ohm resistor R5.

(B) Duplex Control Feature

General

3.04 It is important that spacing pulses transmitted to the receive hub through the coupling unit do not operate the S relay of the associated repeater to spacing as this would interrupt the half-duplex facility which is sending inward. The reflection of spacing pulses is prevented by the use of the duplex control circuit which is shown schematically in Fig. 4 in association with the inward and outward transmission circuits of the coupling unit. There is one case, however, when the duplex control circuit is prevented from functioning in this manner in half-duplex operation. This occurs when two coupling units transmit spaces simultaneously to the receive hub. In this case, the duplex control circuit recognizes the double-space condition and permits spaces to be sent towards all interconnected facilities including those from which the spaces are being received.

3.05 Inward Transmission

(a) General: The duplex control circuit which includes tubes V1 and V3 (Fig. 4) observes the voltages at points B and C of the inward transmission circuit and makes continuous comparison of them. The voltage at point B indicates whether the repeater is marking or spacing, and that at point C indicates whether the receive hub is at the half-duplex marking (+60 volts), half-duplex spacing (-30 volts) or double-space potential (-60 volts). In the case of full-duplex operation, the voltage at point C will be -10 for marking and -60 for spacing. The voltage at point B is applied to cathode 2 of tube V1 by a potentiometer which includes resistors R6, R7 and R8. The marking and spacing voltages of +130 and -130, respectively, at point B are converted by means of the potentiometer to +20 volts and -45 volts, respectively, at cathode 2 of tube V1. The voltage at point C appears at cathode 2 of tube V3, the left triode of which is connected as a diode. When the left triode of V1 is conducting, which is the condition normally existing when transmission of signals is inward, the left triode of V3 conducts for all three voltages appearing at point C since the potential of grid 3, tube V3 is approximately +120 volts. As the plate circuit impedance of this triode is relatively low, the voltage at point C (+60, -30 or -60) is applied to grid 3 of tube V1 via resistor R10.

(b) Space Pulse: When a space is received from the repeater and all other legs are marking toward the hub, cathode 2 of tube V1 will be at -45 volts and grid 3 will be at -30 volts. The left triode of tube V1 will, therefore, conduct and remain in this condition as long as transmission is inward. The circuit of tube V1 is arranged as a so-called "flip-flop"

circuit and the grid of each tube triode is connected through resistance coupling to the plate of the opposite triode. Thus, when the left triode of V1 is conducting, the right triode is made to cut off and vice versa. The incoming space will cause the receive hub potential to change from +60 volts to -30 volts and the send hub potential will also be -30 volts. With the right triode of V1 cut off, the potential of plate 6 thus will be approximately +122 volts and a potential of +20 volts will be applied to grid 7 of tube V3 from the junction of resistors R13 and R14. The right triode of V3 will now conduct if its cathode is more negative than approximately +25 volts and in the conducting condition, it will maintain the potential of this cathode at approximately +25 volts. This serves to prevent the -30-volt (spacing) potential on the send hub from lowering the potential of the grids of tube V2 sufficiently to cut off this tube. The S relay of the repeater is thereby held in a marking condition.

(c) Mark Pulse: When the R relay sends a marking pulse, the left triode of V1 will continue to conduct as its cathode will be at +20 volts and its grid at +60 volts. The receive and send hubs will assume potentials of +60 volts which will be sufficiently positive to maintain tube V2 conducting regardless of the condition of the right triode of tube V3. Table I indicates the way in which tube V1 will conduct for each of the four combinations of signal potentials appearing on the R relay and receive hub for the condition where the left triode of V1 is initially conducting.

3.06 Outward Transmission

(a) Space Pulse: If the R relay of the facility in Fig. 4 remains in the marking condition while another unit transmits a space to the receive hub, both hubs will assume a potential of -30 volts. Cathode 2 and grid 3 of tube V1 will assume potentials of +20 volts and -30 volts, respectively, and the left triode will be cut off. With the right triode of tube V1 conducting, the grid and plate of the left triode of tube V3 will be at zero potential or slightly negative. This has the effect of making the left triode of tube V3 non-conducting when a +60 volt (marking) potential appears at point C. It also causes the potentiometer which includes resistances R13 and R14 to apply a -50-volt potential to grid 7 of tube V3 thereby making the right triode non-conducting. Thus outward transmission of signals is made independent of the duplex control circuit and outgoing spaces will cause tube V2 to be cut off thereby operating the S relay to spacing.

(b) Mark Pulse: A mark pulse incoming from the transmitting leg will raise the receive hub potential to +60 volts but this will not be applied to grid 3 of V1 as the left triode of V3 is non-conducting for any cathode potential more positive than approximately 0 volt. Grid 3 of V1 will be at approximately zero potential and with cathode 2 at +20 volts, the left triode will remain non-conducting after the outgoing signal has changed from a space to a mark. The purpose of this holdover or sustaining feature of the duplex control circuit will be explained in Paragraph 3.08. For the outgoing mark, the

TABLE I

LEFT TRIODE OF TUBE V1 INITIALLY CONDUCTING

Item	R Relay	R Hub	Voltage Point B*	Voltage Point C*	Voltage Cathode 2	Voltage Grid 3	Conducting Triode
1	M	M	+130	+60	+20	+60	Left
2	M	S	+130	-30	+20	-30	Right
3	S	M	-130	-30	-45	-30	Left
4	S	S	-130	-60	-45	-60	Right

* Points B and C are indicated in Fig. 4

right triode of V1 will remain conducting, the right triode of V3 will be non-conducting and the mark will pass outward through the transmission circuit with no interference from the duplex control circuit. Table II indicates the way in which tube V1 will conduct for each of the four combinations of signal potentials appearing on the R relay and receive hub for the condition where the right triode of tube V1 is initially conducting.

"Double-Space" Condition

3.07 If two of the legs associated with a receive hub send spaces simultaneously to the hub, the hub voltage will change from +60 to -60. In each of the two legs that are spacing, potentials of -60 and -45 volts will appear on grid 3 and cathode 2, respectively, of tube V1 of the duplex control circuit. The right triode of V1 will conduct, therefore, and cause the right triode of V3 to be non-conducting. The duplex control circuit will assume the released condition and the appearance on the send hub of the "double-space" voltage (-60) or the normal -30-volt spacing potential in case a regenerative repeater is used, will serve to cut off tube V2 and send a space outward. The appearance of a double-space voltage (-60) on the send hub will tend to cause the right triode of tube V3 to conduct (approximately -50 volts on grid, -60 volts on cathode) and this will prevent the cathode from becoming more negative than approximately -40 volts. The double-space condition is shown in Item 4, Tables I and II.

Sustaining Feature

3.08 When a regenerative repeater is used in connection with a half-duplex hub circuit, the voltages on the send hub will lag behind those of the receive hub by approximately one-half pulse length. In view of this, it is necessary that for inward transmission, the duplex control feature remain operated to prevent spaces from being transmitted toward the sending station after the R relay has returned to mark. It is also important that for outward transmission the duplex control circuit remain released to permit a space to pass outward after the receive hub voltage has changed to marking (+60 volts). The sustaining feature is performed by the right triode of tube V1. Following inward transmission, the left triode of tube V1 is held conducting by the positive potential (approximately +122 volts) existing on plate 6 of V1 which makes the left triode of tube V3 conducting for any hub voltage and permits the marking receive hub potential (+60 volts) to be applied to grid 3 of V1. The left triode of tube V1 will remain conducting (+20 volts on cathode 2, +60 volts on grid 3) and a spacing pulse making its delayed appearance on the send hub following regeneration will be prevented from proceeding back toward the sending station after the R relay has returned to marking. Following outward transmission, the right triode of tube V1 is conducting and the resulting potential of approximately 0 volt on plate 6 of this tube prevents the left triode of tube V3 from conducting (0 volt on grid 3, +60 volts on cathode 2) and the 0-volt potential is applied to grid 3 of tube V1 holding it nonconducting. The duplex control circuit is, therefore, sustained in the condition which it normally assumes for outward transmission and permits a spacing pulse, delayed by transmission through a regenerative repeater to be sent outward after the receive hub potential has returned to marking. The sustaining functions are indicated as Item 1 in Tables I and II.

Operation in Full-Duplex Circuits

3.09 In full-duplex applications (Fig. 3) it is necessary to maintain the duplex control feature released at all times so that signals may pass through the coupling unit in

TABLE II

RIGHT TRIODE OF TUBE V1 INITIALLY CONDUCTING

Item	R Relay	R Hub	Voltage Point B*	Voltage Point C*	Voltage Cathode 2	Voltage Grid 3	Conducting Triode
1	M	M	+130	+60	+20	0	Right
2	M	S	+130	-30	+20	-30	Right
3	S	M	-130	-30	-45	-30	Left
4	S	S	-130	-60	-45	-60	Right

* Points B and C are indicated in Fig. 4

both directions independently. This is accomplished by connecting a full-duplex potentiometer to the RL lead which serves as the receive hub. This potentiometer maintains the receive hub potential at -10-volt marking and at -60-volt spacing. With this arrangement, when the R relay is marking, grid 3 and cathode 2 of tube V1 are at -10 volts and +20 volts, respectively, and the duplex control circuit will be arranged with the right triode of V1 conducting so as to permit spaces to pass outward in the opposite direction. When the R relay is spacing, grid 3 and cathode 2 of tube V1 are at -60 and -45 volts, respectively, and the duplex control unit again permits spaces to pass outward in the opposite direction as the right triode of tube V1 is conducting. Thus, the duplex control circuit is held in position to permit signals to pass outward continuously without interruption when arranged for full-duplex operation. As the marking and spacing voltages of -10 and -60 which appear on the receive hub can not be transmitted outward through the associated 144A1 coupling unit, it is necessary to convert these pulses to the conventional hub voltages of +60 mark and -30 space. This is accomplished by the use of a 144C1 coupling unit, one-half of which is used for each direction of transmission. The 144C1 unit receives -10 and -60-volt signals and repeats them to the SL lead of the other 144A1 coupling unit which is equipped with a hub potentiometer. In this case, the SL lead of each 144A1 coupling unit serves as the send hub.

3.10 Wave Shaping

(a) Condenser C2 (Fig. 4) is provided to make the duplex control circuit less sensitive to the effects of transient voltages and thereby reduce the possibility for it to flip inadvertently.

(b) The network consisting of condenser C3, varistors CR6 and CR7 and resistance R9 is connected between cathode 2 of tube V1 and ground in Fig. 4. This network is provided to make the space-to-mark voltage transition of the cathode slower than the mark-to-space transition for half-duplex operation. This is necessary in the case of hubs which have a large capacity to ground due to the interconnection of a number of legs having high capacity (long cabling in the office). Such a hub applies a voltage wave to grid 3 of tube V1 similar to that shown in the upper (light line) curve of Fig. 5A. It is the function of the network to round the space-to-mark transition of the lower (heavy line) curve (Fig. 5A) so that this curve will remain below the upper curve at all times. This insures that the duplex control feature will remain operated at all times for inward transmission.

(c) Condensers C1 and C5 (Fig. 4) are connected in parallel with the windings of relay S of the repeater for the purpose of lowering the impedance of the relay windings to the higher frequencies and to prevent high voltage transients from the relay windings from interfering with the grid control of tube V2.

(d) The manner in which the duplex control feature is held in the released condition for full-duplex service was described in Paragraph 3.09. In that case the RL lead or receive hub operates at negative marking and spacing voltages in order to maintain the duplex control circuit released at all times. This is accomplished by holding the potential of grid 3, tube V1 negative with respect to that of cathode 2 at all times. The manner in which the space-to-mark transition of cathode 2, tube V1 is slowed to allow for half-duplex hub capacity was described in Paragraph (b) above. The voltage curve for cathode 2, tube V1 (lower, heavy line curve in Fig. 5A) is reproduced in Fig. 5B as the upper, heavy line curve. Owing to the

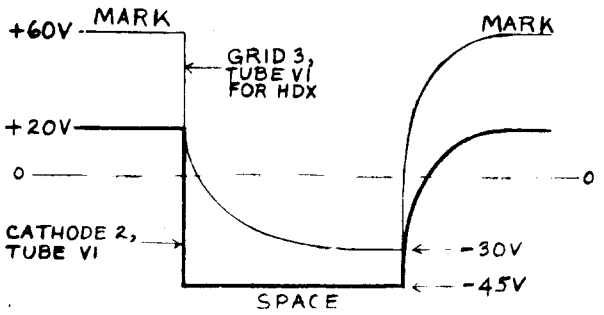

Fig. 5A

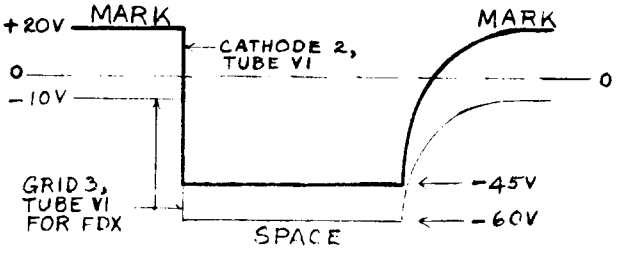

Fig. 5B

small number of interconnected legs in the case of full-duplex operation, the hub capacity to ground is usually comparatively low and there may be a tendency for the voltage curve of grid 3, tube V1 to become more positive and thereby go above that of cathode 2 during the space-to-mark transition. To avoid this difficulty, the space-to-mark transition of the grid 3 voltage curve has been rounded as shown in Fig. 5B (lower, light line curve) by the introduction of wave shaping in the full-duplex potentiometer circuit.

Release of Facility from Hub Circuit

3.11 When a coupling unit is released from the hub circuit at the service board, the RL and SL leads are disconnected at points D and E of Fig. 4, respectively. At this time, one of the following conditions will apply:

(a) R relay marking and duplex control circuit operated.

(b) R relay marking and duplex control circuit released.

(c) R relay spacing and duplex control circuit operated.

(d) R relay spacing and duplex control circuit released.

For conditions (b) and (d) above in which the duplex control circuit is released, a steady space will be transmitted outward over the released facility to serve as an indication to the distant attendant that the facility has been released. The SL lead is open and -130-volt battery is connected to the grids of tube V2 via resistances R19, R20, R21 and R23. This serves to cut off tube V2 and operate the S relay to spacing. Condition (c) is an unstable condition which will immediately change to condition (d). This change occurs because the negative potential from the R relay will make the potential at point C, Fig. 4 sufficiently negative that it will resemble a double-space voltage. This will cause the left triode of tube V1 to be cut off. In condition (a) the unit will send a steady mark outward over the facility. This mark can not be converted to a space by connecting a negative potential to the SL lead. A steady space may be sent outward, however, by flipping the duplex control circuit to the released condition which converts it to condition (b) above. The duplex control circuit may be flipped in this manner by connecting ground to the RL lead of the coupling unit. However, this would prevent the duplex control circuit from flipping from condition (c) to condition (d) in the event condition (c) existed at the time of release as grid 3 of tube V1 would be held more positive (0 volt) than cathode 2 (-45 volts). Connection of -48-volt battery through 470,000 ohms (No. 9B service board) or through 680,000 ohms (No. 2 service board) to lead RL of the unit produces a -48-volt (condition (a)) or -125-volt (condition (c)) potential on lead RL and permits the duplex control circuit to flip from condition (a) to condition (b) or from condition (c) to condition (d). This -48-volt connection has been adopted and is made at the jack circuit appearance at the service board where the facility is released.

4. CIRCUIT APPLICATIONS

(A) Half-Duplex Private Line Service

4.01 The application of 144A1 coupling units to a half-duplex hub circuit is shown in Fig. 1. This form of operation was described in detail in Part 3.

(B) Full-Duplex Private Line Service

4.02 The application of 144A1 coupling units to full duplex, through circuits is shown in Fig. 3. This form of operation was also described in detail in Part 3. When it is desirable to add one-way sending and receiving legs at a through point, these facilities may be connected at points A and B of Fig. 3. A one-way leg transmitting toward the west or one receiving from the east is connected at A. A one-way leg transmitting toward the east or one receiving from the west is connected at B.

(C) Full-Duplex Automatic Signaling Trunk Circuits for TWX Line Concentrating Units (Typical Application)

4.03 A 144A1 coupling unit is used to interconnect a line facility and the loop repeater of a full-duplex automatic signaling trunk circuit such as that shown in Fig. 6 which is for an operator office trunk located in a line concentrating unit. In this case, the TL and R relays of the loop repeater are driven from the RL lead. A current of approximately 19 mils flows through the upper windings of the relays for the spacing condition and there is no current for marking. The relays are operated to marking by currents which flow continuously in their lower windings. The transmitter branch of the loop repeater in the trunk circuit is arranged to connect +60 volts to the SL lead for mark and -30 volts for space. Transmission is on a full-duplex

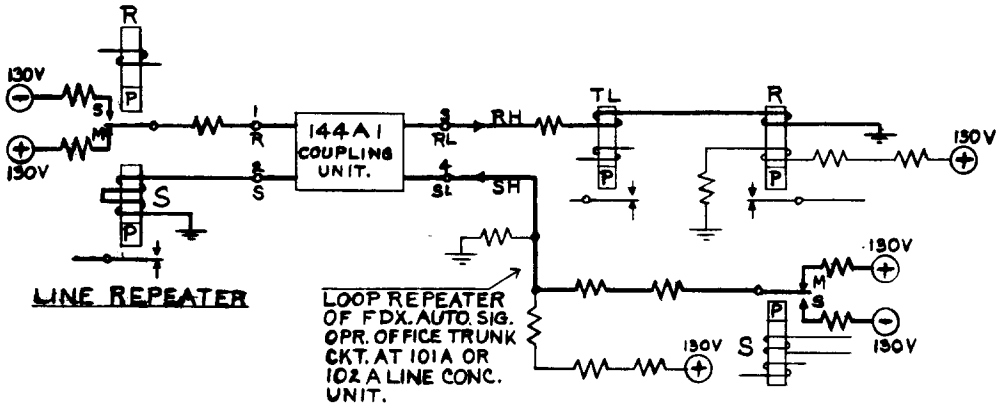

Fig. 6

basis and the duplex control circuit of the coupling unit is held released for an incoming space as the voltage on the RL lead at this time approximates the -60-volt "double-space" potential. A 144A1 coupling unit is also direct-connected to automatic signaling trunks at operator offices and to multi-section toll subscriber lines at switchboard and intermediate offices.

(D) TWX Ringdown Intertoll Trunk Circuits

4.04 Fig. 7 shows the manner in which the 144A1 coupling unit is used in conjunction with a 10G1 or 10F2 loop repeater to interconnect a line facility to a TWX ringdown intertoll trunk circuit. The S relay of the loop repeater is driven from the RL lead of the coupling unit and when a mark is received no current flows through the upper winding of relay S. This relay is operated to mark by an 18-mil current which flows from +130-volt battery through its lower winding. When a space is received from the coupling unit an 18-mil current flows in the upper winding of relay S but the circuit is so arranged that the potential at the apex is approximately zero and no perceptible current flows in the lower winding. The S relay is thus effectively driven by an 18-mil polar current. The transmitter branch of the loop repeater is arranged to connect approximately +60-volt marking and -30-volt spacing potentials to the SL lead of the coupling unit. When the coupling unit operates the S relay of the loop repeater to spacing the circuit is arranged to release the duplex control circuit and thus permit a break to pass from the loop repeater to the line repeater. In this case, the potential on the RL lead is approximately the same as the "double-space" potential.

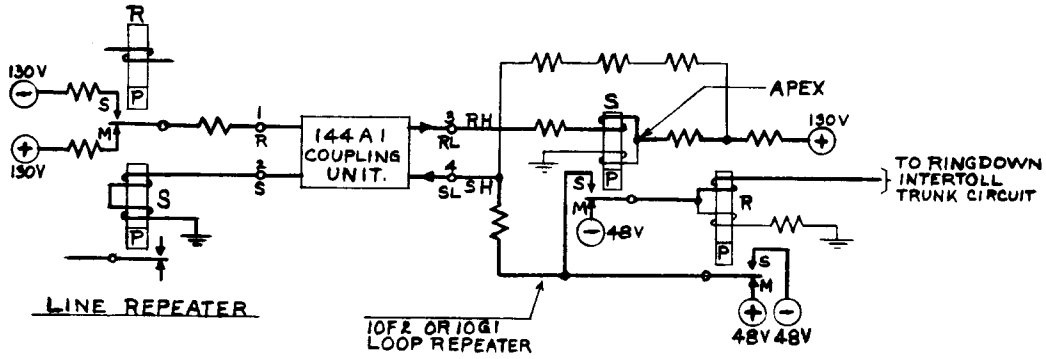

Fig. 7

(E) TWX Switchboard Regeneration

4.05 Fig. 8 shows the manner in which a 143A2 regenerative repeater may be used in combination with 144A1 coupling units and 10G1 loop repeaters for regeneration at a TWX switchboard. In this case, operation of each 144A1 coupling unit is identical with other half-duplex applications and connection to a 10G1 repeater is the same as for a line or 90C1 loop repeater.

5. DESCRIPTION OF EQUIPMENT

5.01 The 144A1 coupling unit is a plug-in-type unit arranged to mount on a shelf-type mounting plate equipped with a receptacle through which external connections are made. The plug-in feature permits rapid removal and replacement of units for maintenance. The unit is 5-3/32" high, 2-25/32" wide and 6-3/4" deep over-all with vacuum tubes inserted. It consists of an aluminum chassis, open at top and bottom for ventilation, with vacuum tubes and operating controls on the front, and other apparatus components inside. Capacitors and varistors which are particularly sensitive to temperature rise, are located on a standoff fibre panel on the rear of the chassis. A plug located on the rear provides for mounting and making external connections.

5.02 Five coupling units, occupying the space of three 1-3/4" by 19" mounting plates, are arranged to mount side by side on a shelf-type mounting plate. Due to the high heat dissipation per unit, a maximum of 60 coupling units together with a filament supply panel and bay fuse panel may be located in an 11'-6" bay. The coupling units and associated filament supply and fuse panels should be located in the upper portion of the bay and the lower portion used for equipment having low heat dissipation. The filament supply and fuse panels should be located above the coupling units. In installations where only a few coupling units are required the common filament supply panel may be omitted and an individual filament adjusting resistance provided for each coupling unit.

6. REFERENCE INFORMATION

6.01 The following is a record of the specifications and drawings for the 144A1 coupling unit and associated equipments.

144A1 Coupling Unit

Equipment Specification	J70102
Circuit	SD-70531-01
Unit Equipment	ED-71023-01
Bay Equipment	ED-70816-01

Filament Supply

Equipment Specification	J70092
Circuit	SD-70626-01
Supply Panel Equipment	ED-70814-01
Filament Adjusting Resistance Equipment	ED-70815-01

165B1 Test Set

Equipment Specification	J70098
Circuit	SD-70635-01
Equipment Assembly	ED-71028-01

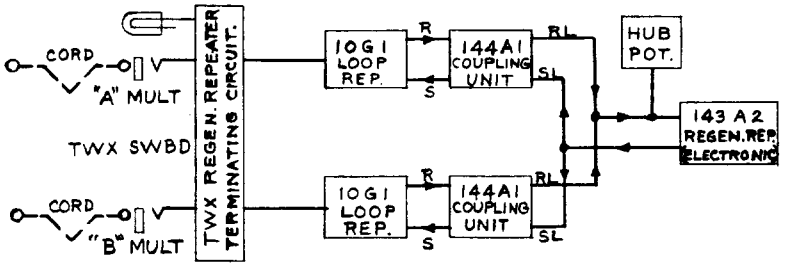

Fig. 8