96A1 ELECTRONIC LOOP REPEATER

CONTENTS PAGE

1. GENERAL

1.01 This section describes the 96A1 electronic loop repeater used to interconnect a 62.5-milliampere neutral telegraph loop, and an electronic hub circuit which operates on mark and space voltages of +60 volts and -30 volts, respectively. These hub circuits are used in the No. 2 Serviceboard, No. 9B Serviceboard, Data Observing Test Center (DOTC) Serviceboard, and for multiway electronic regeneration in testboard offices.

1.02 This section is reissued to describe the use of KS-21703 hybrid integrated networks (HINs) in place of the 396A-type electronic tube presently used in the 96A1 repeater. Since a general revision has been made, arrows generally used to indicate changes have been omitted.

2. DESCRIPTION OF EQUIPMENT

2.01 ***96A1 Loop Repeater—J70103A-4:*** The 96A1 electronic loop repeater is a plug-in unit equipped with two 396A-type electron tubes and three 429A-type electron tubes. In order to eliminate the power required for the 429A tube heaters, the 429A tube is being replaced with the 262-type switches and associated 4143-type network. These switches are solid state plug-in modules that serve as a replacement for all 429A electron tubes used in the 96A1 loop repeater. In order to eliminate the power required for the 396A tube filaments, the 396A tube is being replaced with the KS-21703 HIN. Figure 1 shows the 96A1 repeater with its physical dimensions when equipped with the 429A and 396A electron tubes. Fig. 2 shows the repeater equipped with 262-type switches and 396A electron tubes. Figure 3 shows the repeater equipped with 262-type switches and KS-21703 HINs. The repeater is open at the top and bottom to provide ventilation.

(a) The front panel of the 96A1 repeater is equipped with a duplexing switch (DX) for selecting either full- or half-duplex operation. In addition, two potentiometers, LP CUR (loop current) and BIAS are mounted on the front panel, providing easy access for their adjustment. The LP CUR potentiometer provides for adjustment of the loop current to a value of 62.5 milliamperes when the total loop resistance is 2880 ohms. The BIAS potentiometer permits adjustment of the detection threshold level of the incoming loop signal. This adjustment is needed to compensate for the marking bias generally encountered by transmission of station-generated neutral signals over cable facilities and to compensate for variations in switching thresholds of send tube V3B.

(b) An 11-pin plug is mounted on the rear panel to provide for making external connections through a receptacle located on a shelf-type mounting plate. The plug-in arrangement permits convenient removal and replacement of units for maintenance. In addition to plug P1, the Adjust Full Duplex (ADJ FDX) potentiometer is also located on the rear panel. This adjustment is provided when full-duplex operation is selected and loop current is supplied through a resistor instead of the dynamic impedance of the 262C switch and its associated 4143B network.

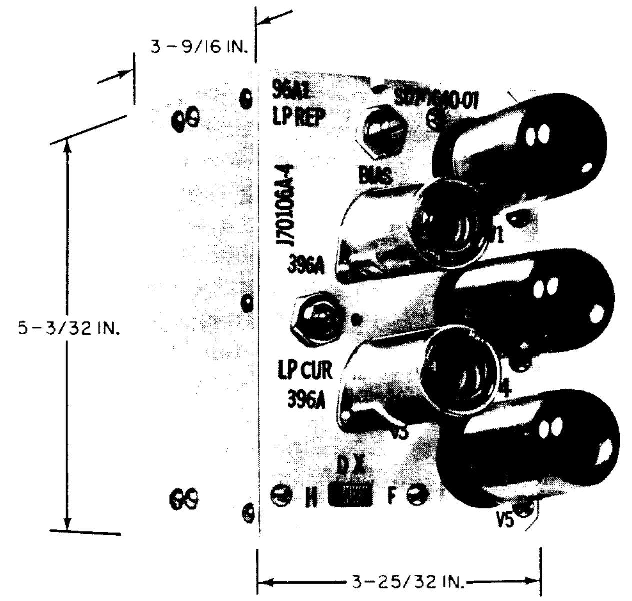


Fig. 1—96A1 Loop Repeater Equipped With 396A and 429A Electron Tubes

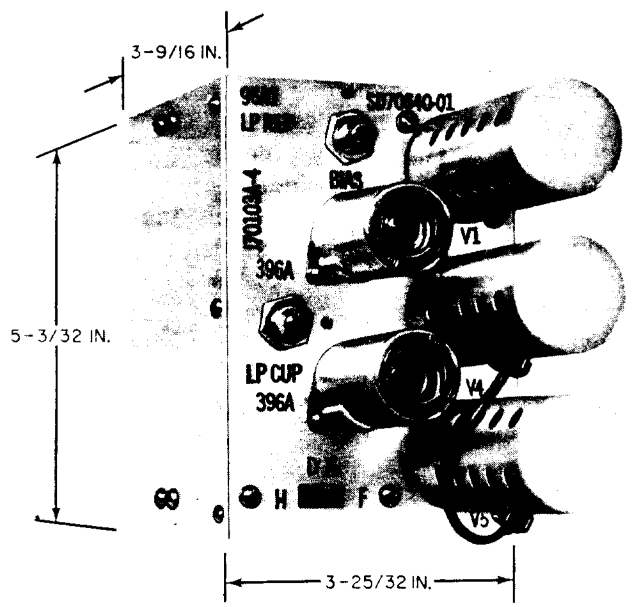


Fig. 2—96A1 Loop Repeater Equipped With 262-Type Switches and 396A Electron Tubes

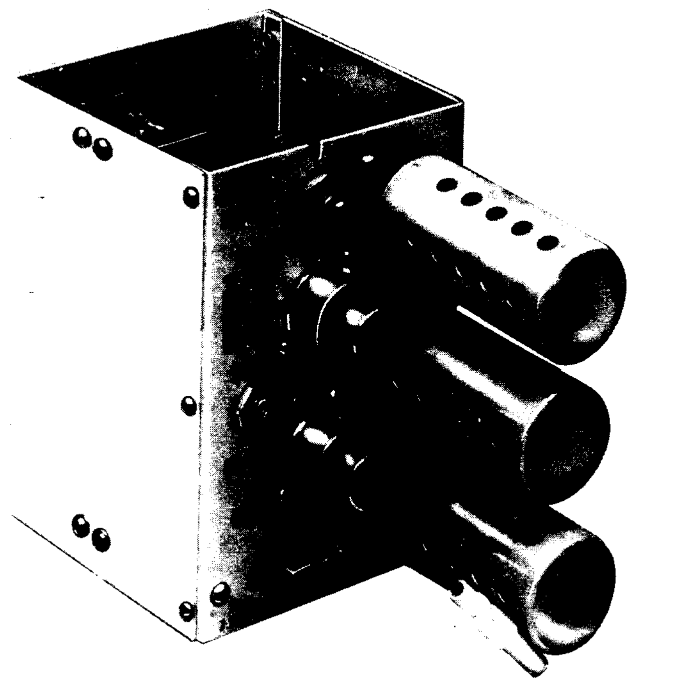


Fig. 3—96A1 Loop Repeater Equipped With 262-Type Switches and KS-21703 HINs

2.02 The 262-type switches used in the 96A1 loop repeater are shown in Fig. 4 and 5 for the 262A and 262C, respectively. These units are 2-stage transistorized circuits which are designed as plug-in modules for use as a direct replacement of the 429A electron tubes currently in use. The physical dimensions of the switches are also given in Fig. 4 and 5. The 262-type switches consist of three basic types: 262A, 262B, and 262C. Since the 96A1 repeater does not require the 262B type, a description of this unit is not provided.

(a) ***262A Switch:*** This switch is a direct replacement of the 429A electron tube mounted in socket V1 and provides the same hub driver function as the electron tube which it replaces. This unit contains a 2-stage, directly coupled circuit whose driver stage controls the output to the hub. The various components are mounted on a printed wiring board and attached to a 9-pin tube base. The board assembly mounts into a perforated can which fits over the board forming a cylindrical-shaped unit. The perforations in the assembly provide for heat dissipation.

(b) ***262C Switch and 4143B Network:*** This switch and network provide for replacement of the two 429A electron tubes mounted in sockets V4 and V5. This switch and network perform the same circuit functions as that of the tubes they replace. The mechanical configuration of the 262C module is similar to that of the 262A module but differs in that a 2-inch lead is attached near the top. This lead cross connects to a 4143B network which is described in paragraph (c). The electrical characteristics of this switch are similar to the 262A switch module; however, it differs in its capacity to handle higher output currents. In addition, capacitor C2 connecting between pins 2 and 4 of the base socket provides a filter for reducing noise interference into other circuits.

(c) ***4143B Network:*** The 4143B network is used in conjunction with the 262C switch to provide a loop path through resistor R1 and to a -130 volt loop supply. Resistor R1 connects from a connector plug near the top of the module to pin 2 in the network socket base, providing the required loop voltage drop for 62.5 milliampere (mA) loop operation. The physical size of the network is the same as the 262 switches.

2.03 ***KS-21703 Hybrid Integrated Circuits:*** The 396A electron tubes used in the 96A1 loop repeater may be directly replaced by KS-21703 HINs. In the 96A1 repeater, circuit constraints require that both 396A electron tubes be replaced with two KS-21703 HINs at the same time. The constraint exists because both 396A electron tubes have filaments connected in series with a 24-volt supply. Replacement of only one 396A electron tube with a KS-21703 HIN will open the 24-volt supply loop and remove the filament voltage from the remaining 396A electron tube.

2.04 The procedures for testing the 96A1 loop repeater equipped with KS-21703 HINs remain the same as the procedures for testing the 96A1 loop repeaters equipped with 396A electron tubes, except for the omission of those procedures which refer to filament voltages of the 396A electron tubes. The 165B test set is not capable of testing HINs. The KS-21703 HINs may be tested by the KS-21697 HIN tester. Further information on the KS-21697 HIN tester may be found in Section 103-469-100.

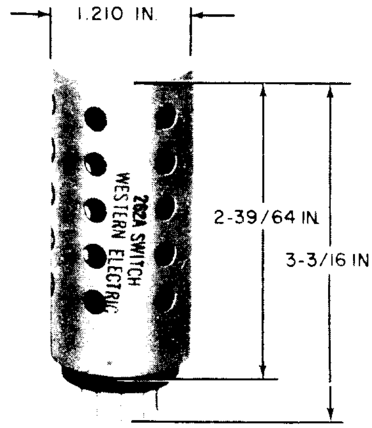


Fig. 4—Type 262A Switch Used for Hub Drive Circuit

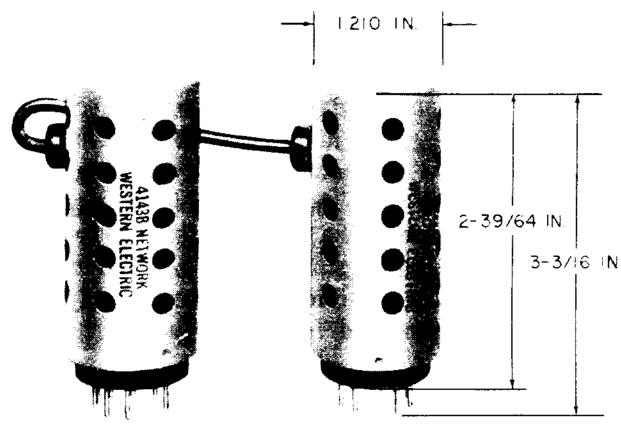


Fig. 5—Type 262C Switch and 4143B Network Used for Loop Drive Circuit

2.05 The KS-21703 HINs may be inserted into a powered 96A1 loop repeater. However, care should be taken that the HIN is properly oriented before insertion into the socket.

> ***Warning: When inserting a KS-21703 HIN into a powered 96A1 loop repeater, hunting, by rotating the HIN may create improper terminal connections and cause damage to the HIN.***

2.06 96A1 loop repeaters equipped with 262-type switches and KS-21703 HINs do not require filament voltages. When switches and HINs replace the tubes in a 96A1 loop repeater, the filament voltage supply may rise in value and, if common to other tube equipped 96A1 loop repeaters, require readjustment.

2.07 ***J70103A-4 List 3 Duplexing Modification Kit:*** This kit is to be used only to update all 96A1 repeaters which can only be operated HDX by permitting the selection of half- or full-duplex operation. The kit consists of a bracket, a full-duplex adjust potentiometer (FDX-ADJ), a 3-pole double-throw switch, and associated wiring. When the kit is installed, the overall repeater length is increased by approximately 1-1/2 inches in depth due to the addition of the mounting bracket and added hardware.

2.08 Four repeater units occupying the space of three 1-3/4 by 19-inch mounting plates are arranged to mount side by side on a shelf-type mounting plate. A maximum of 36 repeaters together with a filament supply adjusting panel may be located in an 11-foot 6-inch bay. In installations where only a few repeaters are required, the common filament supply adjust panel may be omitted and an individual filament adjusting potentiometer provided for each repeater.

3. DESCRIPTION OF 262 SWITCH OPERATION

A. General

3.01 The following information covers the operation of the 262A- and 262C-type switches along with the 4143B network associated with the 262C switch.

3.02 These units are solid state plug-in modules used to replace the hub switch and the loop driver functions previously provided by the 429A electron tube as used in the 96A1 loop repeater.

B. Operation of 262A Switch

3.03 A block diagram of this unit is shown in Fig. 6. This switch is inserted into tube socket V1 replacing the 429A electron tube. Input and output signals along with ground return and negative 130 volts are furnished through pins 8, 2, 5, and 4, respectively, in the V1 tube socket.

3.04 The connecting circuit of the repeater provides ground through a 2200-ohm resistor to pin 5. The output signal from the switch is supplied at pin 2 and carried to the telegraph hub through resistors R32 and R33 which are part of the repeater's hub connecting circuit. Input signals are applied to pin 8 from the connecting repeater and are either negative (with respect to pin 4 for a mark signal) or positive (for a space signal). A voltage of +60 volts represents a mark signal, while a voltage of -30 volts represents a space signal on receive hub lead RL when connected to the hub.

3.05 The input stage is comprised of transistors Q1 and Q2 plus a voltage regulator network consisting of zener diode CR1 and resistor R5. The voltage regulator network limits the voltage across Q1 and Q2 to a value of 12 volts.

3.06 The output stage of the switch is comprised of transistor Q3; silicon-controlled rectifier (SCR) Q4; resistors R6, R7, and R10; and capacitor C2. The SCR Q4 is controlled by Q3. The base junction of the SCR connects to a voltage divider consisting of R6 and R7. This divider limits the voltage on the base of Q4 to approximately 15 volts and also assures that the breakdown voltage of Q3 transistor is not exceeded. Output resistor R10 connected to pin 2 limits the output current to 30 milliamperes when the SCR is conducting and connected to the hub circuit. Capacitor C2 serves to filter out short duration noise spikes which may appear on the output signal.

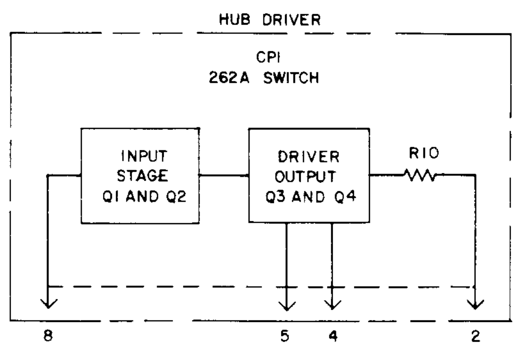


Fig. 6—262A Switch, Block Diagram

3.07 A marking signal (-60V with respect to pin 4) applied at pin 8 of the switch holds the input stage of Q1 and Q2 cut off. Transistor Q3, having its emitter-base junction returned through resistor R4 to -130 volts, maintains this stage cutoff under these conditions. Transistor Q3 turns off SCR Q4. During the time that Q3 is cut off, current will not flow through Q4.

3.08 A spacing signal (+30V with respect to pin 4) applied at pin 8 turns on transistors Q1 and Q2. In conjunction with turn-on of Q1 and Q2, the resultant current flow turns on Q3. Conduction of transistor Q3 causes Q4 to become forward biased; therefore, Q4 will conduct.

C. Operation of 262C Switch

3.09 A block diagram of this unit is shown in Fig. 7. The output of the switch is applied to the 4143B network via resistor R6 and a 2-inch connecting lead (Fig. 7). The 262C switch is the electrical equivalent of the 262A switch and operates in the same manner but differs in the enabling procedure for Q3 and SCR Q4. Transistor Q2 provides a path from the collector to the base of Q3 to obtain greater base drive current to Q3. This additional current maintains Q3 in a saturated condition when the voltage across Q3 rises. This voltage rise may occur due to telegraph loop trouble and increase the I R loss of Q3 producing excessive heat.

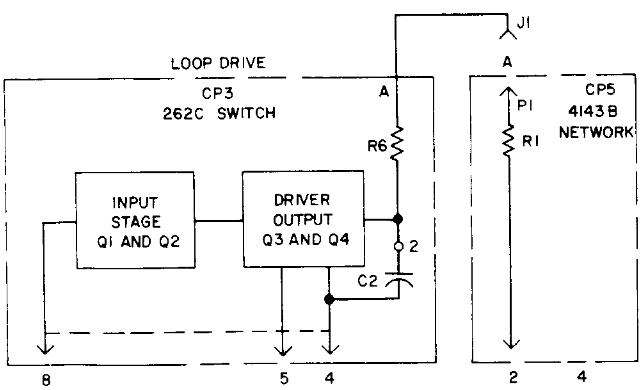


Fig. 7—262C Switch and Associated Network, Block Diagram

3.10 When the input signal voltage applied to pin 8 is negative with respect to pin 4, the switch is cut off; therefore, current does not flow through the output stage. When the input signal voltage applied to pin 8 is positive with respect to pin 4, the switch turns on and 62.5 mA of current will flow through the output stage.

4. PRINCIPLES OF SYSTEM OPERATION

A. Hub Operation

4.01 Figure 8 is a block diagram showing a 96A1 electronic loop repeater interconnecting a station loop and an electronic hub circuit operating in the half-duplex mode. Several loops may be connected to the hub either through other 96A1 loop repeaters, through 144-type coupling units, or other similar transmission equipment. The send and receive hubs are interconnected either directly by means of a hub link or indirectly through an electronic regenerative repeater such as the 143- or 145-type.

4.02 In the marking condition, the telegraph loop is held closed at the loop repeater by a 262C switch and 4143B network which are operated in series. Signals incoming from the loop produce marking and spacing voltages of -50 volts and -130 volts to ground, respectively, at the output terminals of the switch and network. Through the use of a circuit consisting of vacuum tube triode V3B and a bias network, these signal voltages are inverted within the repeater so that the spacing potential is more positive than the marking potential. These inverted voltages are used to drive a single 262A switch which performs the function of changing the receive hub potential from a +60 volt mark to a -30 volt space potential and vice versa. This switch in the conducting (spacing) condition causes a 30-mA current to flow from the hub. This 30-mA current drain from the receive hub will cause the hub potential to fall from a marking value of +60 volts to a spacing value of -30 volts. For an incoming mark signal, the 262A switch is cut off, resulting in no current drain from the receive hub. Thus, the marking hub voltage of +60 volts is restored.

4.03 Signal voltages on the receive hub reach the send hub through either a hub link or a regenerative repeater. From the send hub, the signal voltages are applied by means of a bias network in the electronic loop repeater to the 262C switch which serves to open and close the loop. A marking potential (+60 volts) on the send hub causes the 262C switch to conduct, thereby closing the loop and sending a mark to the station. A spacing potential (-30 volts) on the send hub cuts off the 262C switch and opens the loop circuit to send a space to the station.

4.04 In the case of a loop repeater which is operating in the half-duplex mode and which is repeating signals toward the receive hub, it is necessary that space signals be prevented from reflecting back toward the sending station via the send hub. This is accomplished by the directional control circuit in the loop repeater which maintains the input to the 262C switch sufficiently positive to prevent cutoff when signals are incoming from the loop.

B. Loop Operation

4.05 In transmitting toward the station, it is desirable that the current waveshape be symmetrical at the station so that signals received will remain undistorted for all loop lengths. This can be accomplished by making the loop impedances equal for marking and spacing pulses. In the case

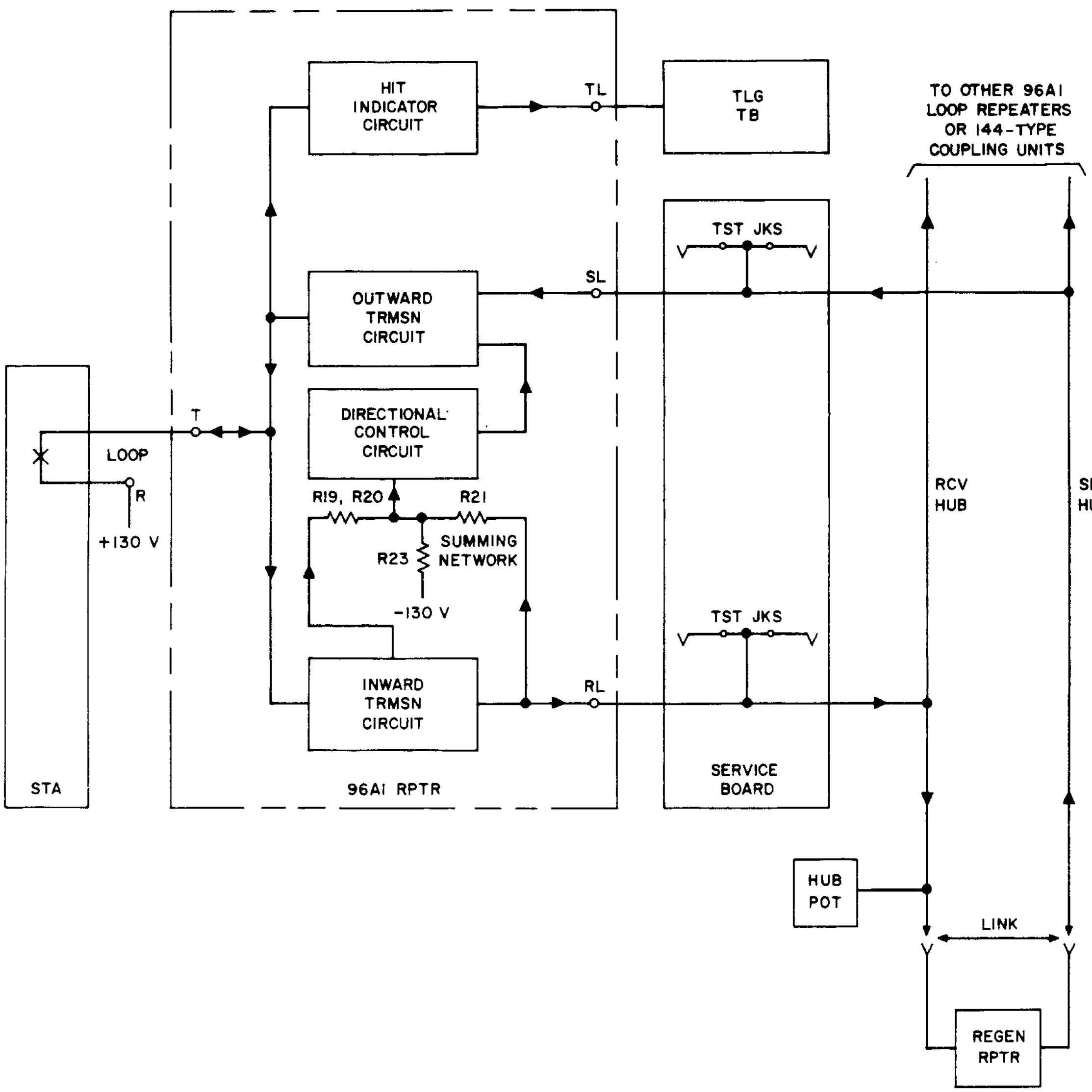


Fig. 8—96A1 Electronic Loop Repeater, Half-Duplex Operation, Block Diagram

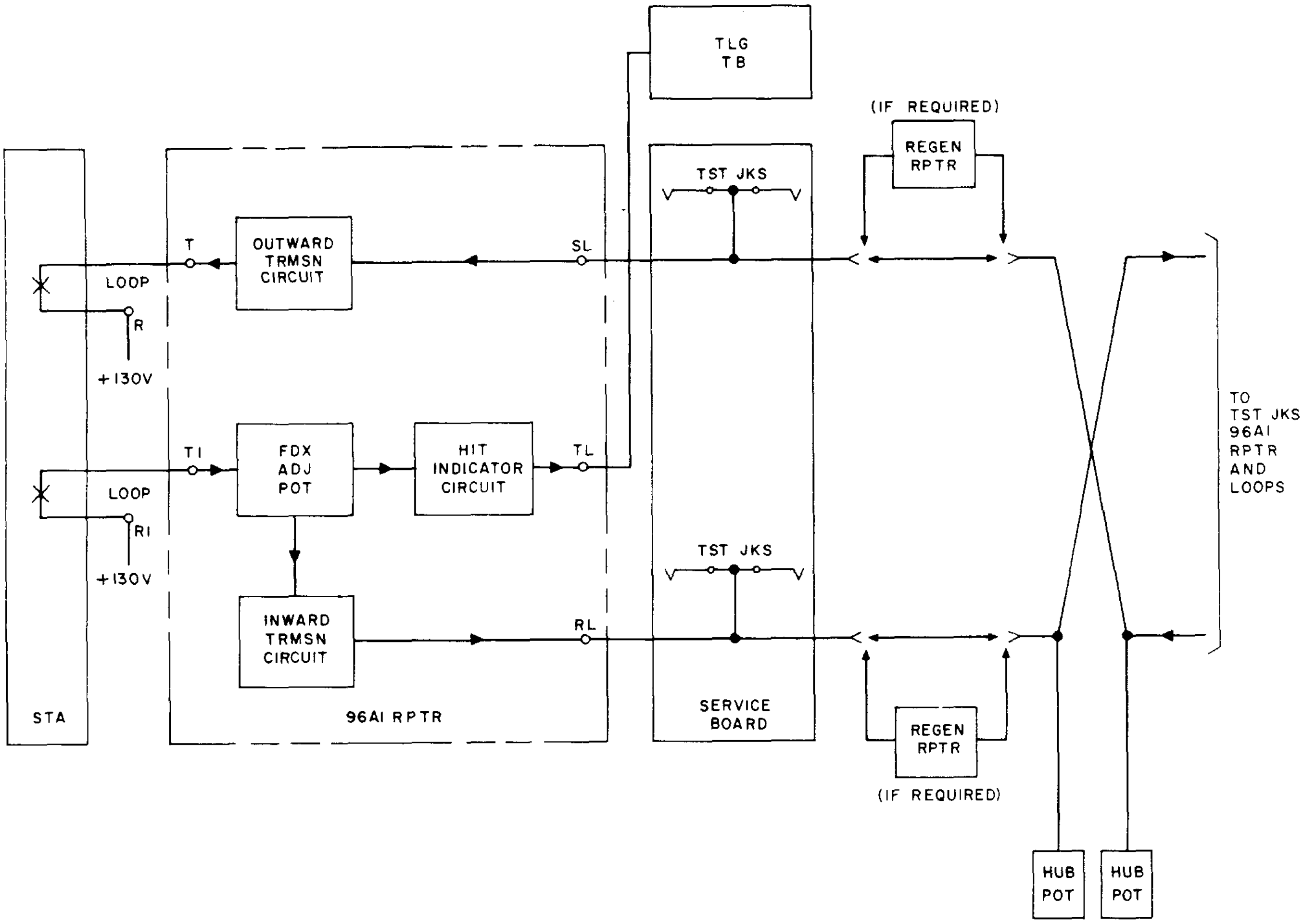


Fig. 9—96A1 Electronic Loop Repeater, Full-Duplex Operation, Block Diagram

of relay-type loop repeaters, the marking and spacing loop impedances are approximately equal when transmission toward the station is polar or effectively polar. However, if open-and-close loop operation is employed, the loop impedance is infinite for a space and relatively low for a mark. Therefore, the current wave is unsymmetrical. In the case of long high-capacitance loops, the charge stored in the cable when a space is sent momentarily sustains current flow at the station causing a marking bias at the station.

4.06 All loops are built out to provide a resistance of 2880 ohms external to the repeater. This is accomplished by equipping each loop with a loop pad.

4.07 Figure 9 is a block diagram showing a 96A1 electronic loop repeater arranged for full-duplex operation. The outward transmission circuit and the inward transmission circuit are separated and are connected by two independent loops to the station. Simultaneous transmission in both directions is possible. The operation of the full-duplex loop repeater circuits is similar to the loop repeater operation in the half-duplex mode, except that the inward transmission circuits and outward transmission circuits are independent of each other (directional control circuit is disconnected).

5. DESCRIPTION OF OPERATION

A. Half Duplex

Transmission

5.01 The loop repeater is connected internally for half-duplex transmission by operating the DX switch to the H position. Operation of the switch connects both the sending and receiving loop transmission paths to the T lead. As shown in Fig. 10, a single loop is used for transmission in both directions. The SL and RL leads are connected externally to a single hub. Signals can be transmitted in either direction but not in both directions at the same time.

(a) For inward transmission from the station loop to the receive hub, the path of the signals is indicated by the heavy lines in the lower part of Fig. 10. The potential of the receive hub is held at +60 volts for the marking condition by connection to the hub potentiometer. The receive hub assumes potentials of -30 volts for spacing and -60 volts for the "double-space" condition. The additional space signal applies a -130 volt source and series impedance supply in parallel to the existing -130 volt source and series impedance of the hub. This changes the voltage on the hub to -60 volts. However, this feature is not recognized by the 96A1 loop repeater.

(b) When the send and receive hubs are interconnected by means of a hub link, there is no time delay between the interconnecting hubs. If the hubs are interconnected by means of a regenerative repeater, the transmitted character received on the RL hub appears on the SL hub a one-half character element later. This is due to the inherent time delay of the regenerative repeater. When transmission is from the station loop to the receive hub (inward), it is necessary that the 262C switch and 4143B network, which operate in series, remain conducting in half-duplex operation. This is accomplished by means of the directional control circuit (see 5.07).

Inward Transmission

5.02 ***Mark Signal:*** The station closes the loop to send a mark signal, causing a current flow of 62.5 mA in the loop from the +130 volt potential at lead R to the -130 volt potential connected to pin 4 of the 262C switch. At this time, the potential at point A is approximately -50 volts (see Fig. 10) and is applied to a voltage divider circuit consisting of resistors R1, R2, and the BIAS potentiometer. The cathode of V3B is held at a potential of -47 volts. The potential on the grid, which is derived from the BIAS potentiometer, will be sufficiently positive with respect to the cathode so that the triode will conduct. With V3B in the conducting condition, the plate potential will be lowered to approximately zero volts. This voltage is applied to a voltage divider consisting of resistors R11 and R12. The lower end of this divider returns to a -310 volt bias potential supplied by a -330V bias voltage source in series with a 68K ohm resistor. The potential at the input to the 262A switch is thereby lowered to a voltage sufficiently negative to cause this switch to be cut off. With no current flowing from the receive hub through the switch, the hub marking potential of +60 volts, which is produced by the hub potentiometer, will remain unchanged.

5.03 ***Space Signal:*** The station interrupts the flow of current to send a space by opening the send loop. The potential at point A in Fig. 10 drops to nearly -130 volts. A small current continues to flow from the positive 130-volt potential through resistors R1, R2, the BIAS potentiometer, and the 262C switch. The potential at the grid of triode V3B becomes more negative than the cathode, causing the triode to cut off. The potential at the plate of triode V3B changes to approximately +105 volts and, in conjunction with the voltage divider of R11 and R12, provides a positive input potential to the 262A switch causing it to conduct. This switch, when conducting, draws a current of approximately 30 mA from the receive hub through resistors R32 and R33 causing the hub potential to drop to -30 volts (spacing potential).

Outward Transmission

5.04 ***Mark Signal:*** When in a marking condition, the send hub applies a +60 volt potential to the SL lead of each interconnected loop repeater (see Fig. 10). This voltage is applied to a voltage divider circuit consisting of resistors R4, R5, R6, and the -310 volt bias supply with the result that a voltage of approximately -105 volts will be applied to pin 8 of the 262C switch. This input potential is positive with reference to the -130 volts applied to pin 4 which results in conduction of the switch. A marking current of 62.5 mA will flow from the +130 volt supply through the loop and station through the 262C switch to the -130 volt supply. The proper potential applied to pin 5 of the 262C switch is obtained by rotating the LP CUR potentiometer to produce the desired 62.5 mA loop current. The voltage at point A at this time is approximately -50 volts.

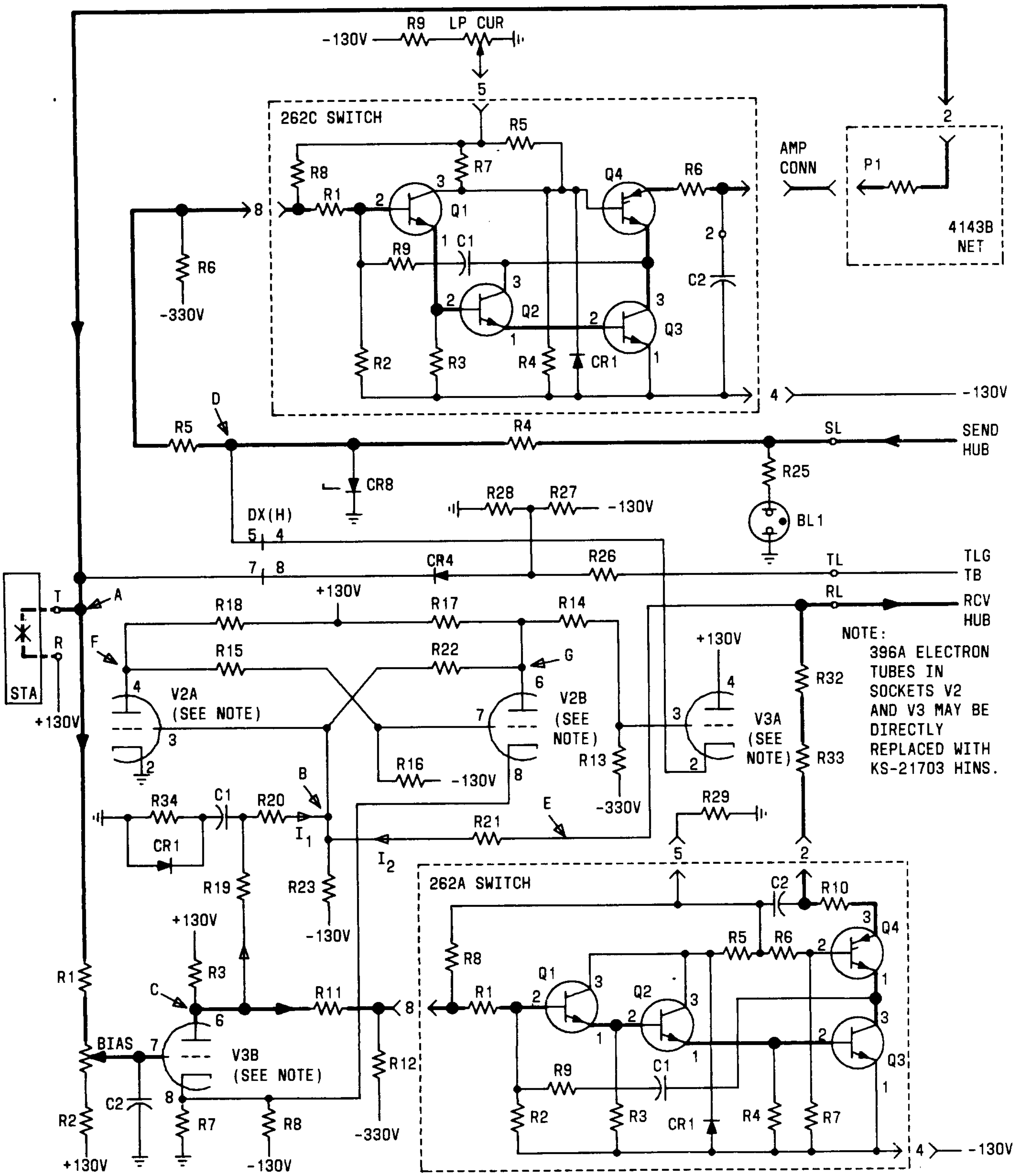


Fig. 10—96A1 Electronic Loop Repeater, Half-Duplex Operation, Simplified Schematic

5.05 ***Space Signal:*** When in a spacing condition, the send hub applies a -30 volt potential to the SL lead of each interconnected loop repeater. The voltage divider, which consists of R4, R5, and R6, applies a potential of approximately -160 volts to the input of the 262C switch, thereby cutting off the switch. This interrupts the flow of loop current with the result that the station receives a space. At this time, the voltage at point A is approximately +130 volts.

5.06 Zener diode CR8, connected between the junction of R4 and R5 to ground, prevents lead SL from building up a large negative potential in the event the repeater is disconnected from the hub. This diode also prevents excessive filament-to-cathode voltage on tube V3A.

Duplex Control Circuit

5.07 The directional control circuit which is part of Fig. 10 provides the following functions necessary for half-duplex operation.

(a) When a mark or space signal is applied to the loop, the repeater must sense the direction of the transmission and hold the 262C switch in the conducting state if the transmission is received from the loop.

(b) When any other leg sends a space signal into the hub, that signal must be allowed to go through to the sending side of the loop.

Note: Reference points provided in 5.08 through 5.10 refer to Fig. 10 and are indicated by arrows.

5.08 The heart of the directional control circuit is flip-flop dual triode tube V2, the action of which, through send triode V3B and connecting resistors, automatically conditions the send side (through SL lead) so that it can or cannot, as required, receive signals from the hub.

(a) The combination of resistor R23 and a -130 volt supply form a reference current source at point B. Resistor R19 connected to the plate of V3B, point C, forms a sensing point for data signals originating on the loop. This originating source is designated as point A in the illustration. Data signals which appear on the RL hub are sensed by the current change through resistor R21.

(b) The flip-flop operation of the V2 tube is such that when triode V2A conducts, triode V2B is cut off, and vice versa. When V2A is cut off, the directional control circuit permits signals (marks or spaces) to flow freely from the hub to the loop. When the left half of the tube conducts, the 262C switch is held steadily in conduction. Space signals appearing on the SL hub will not be transmitted to the loops.

5.09 The operation of the directional control circuit when the repeater is connected to a regenerative hub circuit is described in (a) through (e). With application of a mark-to-space signal to the repeater the following events occur:

(a) The loop current (62.5 mA) at point A in the illustration decreases to zero.

(b) The voltage at this point changes from -50 volts (marking voltage) to approximately -125 volts (spacing voltage).

(c) Tube V3B is cut off causing its plate voltage at point C to switch from approximately -30 volts to +130 volts. Point C becoming more positive causes current I1 to increase through resistor R20 and into the current summing point B. This same voltage change causes the 262C switch to conduct.

(d) The RL hub potential changes from a +60 volt mark to a -30 volt spacing potential. This potential change causes current I_2 through R21 to decrease.

(e) The algebraic sum of current I_1 and I_2 will increase at point B which raises the grid voltage of V2A from a negative value to zero volts causing V2A to conduct. Tube V3A, which is controlled by V2, is biased into conduction, and clamps the junction of R4 and R5 (point D), which ensures that the 262C switch will remain conducting regardless of any signal appearing on the SL hub.

5.10 ***Inward Transmission:*** While providing inward transmission, the directional control circuit prevents spacing signals (originating in the loop) from cutting off the 262C switch and thereby interfering with transmission from the loop. At this time, tube V2A is held conducting because the grid is at a potential of +11 volts for marking and +33 volts for spacing. The voltage at the plate of triode V2B, acting through the voltage divider consisting of resistors R13 and R14, applies a potential of approximately -20 volts to the grid of V3A. Triode V3A is thereby held conducting with its cathode held at approximately -14 volts regardless of the potential of the send hub. This ensures that the 262C switch will not be cut off by a space voltage on the send hub, and that the loop may transmit without interruption.

5.11 ***Outward Transmission:*** In providing outward transmission to the loop, a spacing signal is received on the RL hub from some other source which is also connected to the hub. This signal source causes a -30 volt potential to exist on the RL lead. This negative potential causes the directional control flip-flop triode V2A to cut off. Triode V2B of the directional control circuit is therefore conducting. For outward transmission, the plate potential of V2B is reduced to approximately zero. The -310 volt bias potential, applied through a voltage divider consisting of resistors R13 and R14, applies a potential of approximately -94 volts to the grid of V3A. cutting off its conduction. When V3A is cut off, the clamp at point D in Fig. 10 is removed. With the clamp removed, the hub voltage (appearing on the SL lead) back-biases the 262C switch, causing the current in the loop to drop to zero. This value of current represents a spacing signal in the loop.

5.12 ***Changing Direction of Transmission:*** Figure 11 shows the approximate values of the grid potential of V2A but does not allow for effects of grid current flow. Signal voltages appearing below the zero potential line represents outward transmission to a station. If the hub circuit is in the idle condition (steadily marking), the potential on the grid of V2A will be either +11 volts or -11 volts depending on the direction of the last spacing pulse (Fig. 11). If the last space was transmitted inward, the potential on the grid will be +11 volts as at point A of Fig. 11. At this time, point E (Fig. 10) will be +60 volts and point G (Fig. 10) will be +105 volts. If a space is now received from another source, the receive hub potential point E (Fig. 10) will be reduced to -30 volts causing the potential on the grid of V2A to swing from +11 volts to -11 volts. This will cause V2A to cut off and tube V2B to conduct. The voltage at point G (Fig. 10) will drop to nearly zero volts and swing the grid of V2A to -33 volts as shown at point B (Fig. 11). Marking and spacing signals on the receive hub will cause the potential on the grid of V2A to vary between -11 and -40 volts, respectively. Assume now that the receive hub ceases to receive signals from another source as shown at point C (Fig. 11). A space is received as shown at point D (Fig. 11) from the loop through the loop repeater. The potential at point C (Fig. 10) rises to +105 volts. The potential on the grid of V2A changes from -11 volts to +11 volts causing V2A to conduct. As soon as the flip-flop circuit has flipped so that V2A is conducting, the voltage at point G (Fig. 10) will rise to +105 and this will raise the potential on the grid of V2A to +33 volts, as indicated at point E (Fig. 11). Transmission of mark and space signals from the loop is represented by the mark and space voltages of +11 volts and +33 volts, respectively, appearing to the right of point E (Fig. 11). Each of these 22-volt transitions is composed of a 44-volt swing produced at point C (Fig. 10) and a 22-volt swing of the opposite polarity produced at point E (Fig. 10). When transmission from the loop ceases, the potential on the grid of V2A remains at +11 volts, as represented by point F (Fig. 11).

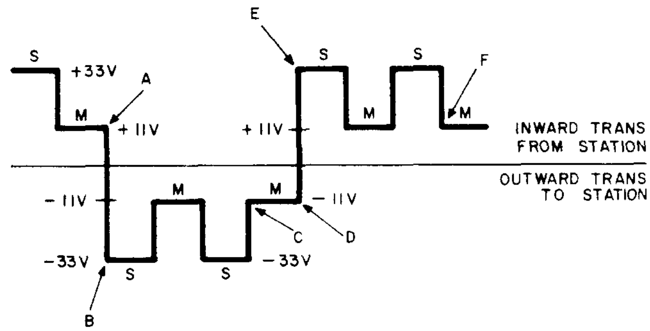


Fig. 11—Open Circuit Voltages, Duplex Control

5.13 ***Waveshaping Arrangement:*** The directional control circuit includes a waveshaping network which consists of diode CR1 shunted by resistor R34, in series with capacitor C1. This network is provided to round off the negative swing, which occurs at the grid of V2A when the voltage on the plate of V2B at point C (Fig. 10) changes from +105 volts to zero for a space-to-mark transition from the loop. In order to maintain V2A in conduction during the space-to-mark transition, it is necessary to delay the voltage contributed by V3B in relation to the voltage provided by the RL lead. This delay is provided by capacitor C1 and diode CR1 which allows C1 to draw current through resistors R20 and R23. Current flow occurs during the space-to-mark transition and is due to the low forward resistance of CR1. However, the high back resistance of CR1, in series with C1, during the mark-to-space transition can limit the reverse current and the delay effects to a negligible amount. In order to discharge C1, it is necessary to shunt CR1 with resistor R34. This is important to assure that the capacitor discharge time is less than the shortest pulse length of the transmitted signal.

Release of The Repeater From the Hub Circuit

5.14 ***General:*** When a repeater is released from the hub circuit at a serviceboard, a steady spacing signal is sent toward the loop. If the station happens to be sending a space so that the loop is open at the station, the station will receive the space from the repeater as soon as it attempts to send a mark.

Subscriber Loop Spacing Indication:

5.15 Lead TL (Fig. 10 and 12) connects from the loop repeater to the serviceboard where it serves to light a neon switchboard lamp to indicate that the loop is transmitting a space signal. One terminal of the lamp is connected to a -24 volt battery at the serviceboard, while the other terminal is connected to lead TL. The voltage divider resistors R27 and R28 normally furnish a potential of approximately -50 volts at their junction. When the circuit is idle (loop and receive hub are both marking), the potential at point A (Fig. 10) is approximately -50 volts. This potential is applied to the neon lamp via lead TL. However, since the potential difference is 50 volts minus 24 volts (26 volts), the lamp is not lighted. When the hub sends a space toward the loop, the potential at point A is +130 volts. In this state, diode CR4 is back biased, blocking current flow from point A toward lead TL. When the loop sends a space, the potential at point A decreases to -130 volts causing diode CR4 to conduct. The application of this current through resistor R26 to the neon lamp will cause it to be lighted.

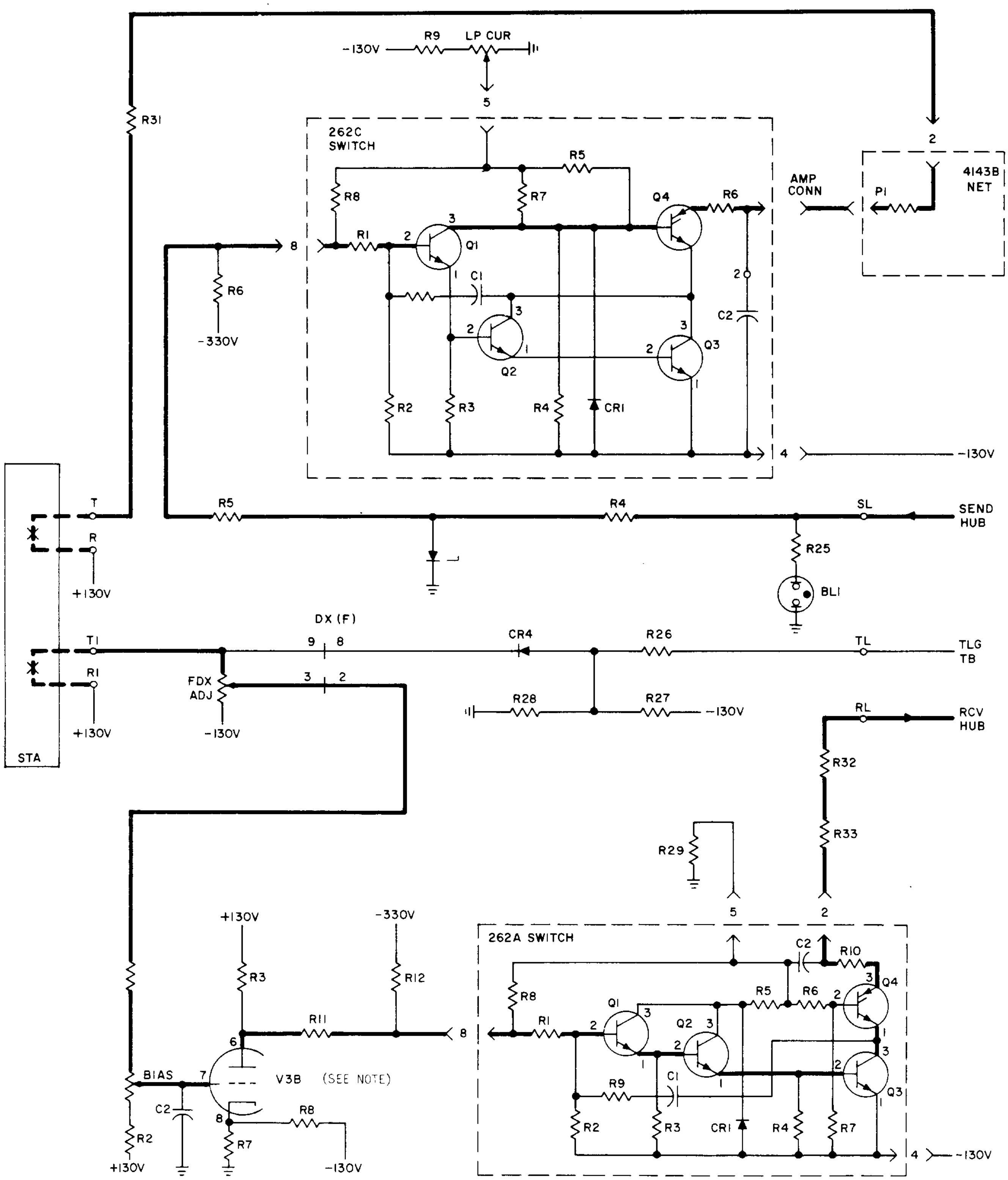
Bias Adjustment

5.16 The BIAS potentiometer is provided to adjust the bias of incoming signals from the loop. This is accomplished by preselecting the switching point of tube V3B on the mark-to-space and space-to-mark transitions. Capacitor C2 is part of a waveshaping network connected to the grid of V3B. Capacitor C2 will delay an inward space-to-mark transition from appearing on pin 8 of the 262A switch by delaying the operation (nonconduction-to-conduction) of tube V3B. This delay adds spacing bias to inward transmission originating in the loop. However, inward transmission through the subscriber cable tends to add marking bias to the signals. Therefore, by properly presetting the BIAS potentiometer, incoming transmission signals (containing mark bias) may be minimized. The adjustment of the BIAS potentiometer is normally done in conjunction with a 165B1 test set.

B. Full Duplex

5.17 The description of operation given in Part A assumes half duplex operation (duplexing switch in the H position). The 96A1 electronic loop repeater may also be operated in the full-duplex mode (duplexing switch in the F position). The operation of outward transmission and inward transmission circuits in the loop repeater is essentially the same as for the half-duplex mode. The full-duplex circuits are shown in simplified schematic form in Fig. 12. Each send and receive circuit is connected to the station over an independent loop so that the station can send and receive simultaneously. The directional control circuit used in half-duplex operation is not required, since signals may pass through the repeater in both directions simultaneously.

5.18 In full duplex operation, the resistance of the 262C switch and 4143B network in series is replaced by the FDX potentiometer. The FDX adjustment and the BIAS adjustment is the combination of the BIAS adjust previously set for HDX. The two potentiometers are required because of the difference in input arrangements of the repeater when used for full-duplex operation and for half-duplex operation. The FDX potentiometer is adjusted in conjunction with a 165B1 test set. The receive loops often use long lengths of cable. Signal current transitions of mark-to-space and space-to-mark generated at the subscriber set and transmitted over these loops can be distorted because of the capacitance of the cable. The mark-to-space transition time is always greater in loops which are capacitive. This difference causes a mark bias which changes the average value of the voltage waveform used for controlling the cutoff and



NOTE:
396A ELECTRON TUBE IN SOCKET V3 MAY BE DIRECTLY REPLACED WITH A KS-21703 HIN.

Fig. 12—96A1 Electronic Loop Repeater, Full-Duplex Operation, Simplified Schematic

conduction of tube V3B. The ADJ FDX and BIAS potentiometers are adjusted to offset the detection point on these gradual transitions and thus compensate for the mark bias.

5.19 For a given setting of the BIAS potentiometer, the FDX ADJ potentiometer can be adjusted independently. This adjustment is made using a 165B1 test set. The procedure for setting these potentiometers is described in Section 103-824-501 for use with the 165B1 test set.

6. REFERENCES

6.01 The following drawings, specifications, and sections provide additional information for the 96A1 electronic loop repeater and associated equipment.

SECTION	TITLE
312-405-300	96A1 Electronic Loop Repeater—Summary of Tests
312-405-500	96A1 Electronic Loop Repeater—Tests and Adjustments
103-824-101	165B Test Set for Testing 144-Type Coupling Units and 96A1 Electronic Loop Repeaters—Description
103-824-501	165B Test Set for Testing 144-Type Coupling Units and 96A1 Electronic Loop Repeaters—Operation
103-469-100	KS-21697 HIN Tester—Description
312-215-100	Negative 330 Volt Telegraph Supply Circuit—Description

NUMBER	TITLE
SD-&CD-70640-01	96A1 Electronic Loop Repeater
SD-&CD-70626-01	DC Telegraph, Carrier Telegraph Filament Supply Circuit
SD-&CD-70627-01	-330 Volt Bias Supply Circuit
SD-&CD-70563-01	Loop Pad, Wave Shaping, and Calling-In Relay Circuits