TELETYPE CORPORATION
Skokie, Illinois, U.S.A.

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# 32 AND 33 CALL CONTROL UNIT

## PRINCIPLES OF OPERATION

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## 1. GENERAL

1.01 This section is reissued to add coverage of the circuit switching call control unit. Since all changes are in 1.01, 1.06, and 5.01 through 5.52, marginal arrows are omitted.

1.02 The function of a call control unit is to couple a teletypewriter either to telegraph networks or, through a data set, to telephone networks. In some applications, the call control unit provides facilities for initiating, accepting, controlling, and completing calls; while in others, it acts as a connecting device only.

1.03 The call control unit used in Western Union TELEX service operates over short and intermediate length telegraph loops using neutral signaling or over longer loops with polar signaling when modified with proper polar-to-neutral converting circuitry. It includes a power supply, local-remote control circuits, a selector magnet driver circuit, and a motor delay timer circuit. Paragraphs 2.01 to 2.13 outline in general terms the call control unit's overall operation. Paragraphs 2.14 through 2.48 explain its detailed operation. The applicable schematic wiring diagram is 4779WD.

1.04 The call control unit is used in Bell System switched network service. When it is connected with the appropriate data set, it is connected with conventional telephone central offices having the required routing and message accounting equipment. These are generally the same offices and equipment serving telephone customers in the area. Direct current signals are used for both originating and terminating traffic—providing the same conditions as for conventional local telephone set operation. The dial on the call control unit, for initiation of call connections, may be either a dc pulsing or a multifrequency (MF) tone device. Also included in the call control unit are ringing or tone sounding apparatus for alerting the called party. Paragraphs 3.01 through 3.06 outline in general terms the call control unit's overall operation. Paragraphs 3.08 through 3.32 explain its detailed operation. The principal applicable schematic wiring diagram is 5918WD. For additional wiring information, see the pertinent wiring diagrams, associated with the call control unit or, when provided, the appropriate section.

1.05 The call control unit used in private wire service operates over short or intermediate length telegraph loops using neutral dc signaling. It includes a power supply, a selector magnet driver circuit and a power switch. Paragraphs 4.01 through 4.03 describe the call control unit generally, and paragraph 4.04 through 4.07 explain in detail its only manual control—the power switch. For wiring information see either 6353WD or 6355WD. For further wiring information see wiring diagram(s) associated with the particular call control unit or (when provided) appropriate section.

1.06 The call control unit used in a circuit switching network operates over short and intermediate length telegraph loops using neutral signaling or over longer loops with polar signaling when modified with proper polar-to-neutral converting circuitry. It differs from the call control unit used in Western Union TELEX service primarily in the call originating circuitry. Paragraphs 5.01 through 5.10 outline the unit's overall operation. Paragraphs 5.11 through 5.52 explain its operation in detail. The applicable wiring diagrams are 7227WD, 7267WD, and 6481WD.

Note: This unit can also be used in 35 equipment for certain circuit switching applications.

## 2. CALL CONTROL UNIT – WESTERN UNION "TELEX" SERVICE

### OPERATION

### A. General

2.01 A selector magnet driver circuit delivers marking signals of 0.500 ampere and spacing signals of essentially 0 ampere to the associated selector magnet. The signals trigger the selector magnet driver circuit at about half the current level for normal (0.060 ampere mark) neutral input signals. In teletypewriters modified for polar operation, the signal is applied to polar-to-neutral converting circuits and then to the selector magnet driver.

2.02 The operator's controls, used for originating calls, consists of a set of push-button keys and a telephone-type dial:

(a) There are four translucent, nonlocking pushbuttons. An illuminating lamp associated with each pushbutton is energized under the operating conditions described in the following paragraphs, except that the START lamp is a spare and does not light.

(b) The dial, a conventional telephone-type operates normally closed bifurcated pulsing contacts that open and close to send dialing pulses during the dial run-down interval. The pulses are produced at a rate of ten per second with the contacts open for 0.061 ± 0.003 second during each pulse interval. A pair of normally open off-normal contacts close when the dial wheel is rotated from its idle position. These contacts provide a steady mark current to "blind" the selector when dialing is undertaken. This prevents the printing of spurious characters if dialing is necessary when in the connected condition as in multi address calling.

### B. Neutral Signaling Condition

2.03 In the idle condition, with the motor and typing unit stopped and visual indicators de-energized, there is a positive current of 0.005 ampere in the telegraph loop. When the calling station operator depresses the START pushbutton, it causes the shunting of a major portion of the loop resistance, and the loop current increases to 0.060 ampere. The START pushbutton must be held in the depressed position, while switching apparatus in the telegraph exchange is made available. When the circuit is ready, the telegraph exchange interrupts the 0.060 ampere loop current for about 0.025 second. This "proceed-to-dial" signal causes the DIAL lamp to be illuminated at the calling station, and it locks in the shunt to the loop resistance so that the operator may now release the START pushbutton and proceed to dial the number of the called station. Rotation of the dial transmits signals consisting of no current for 0.06 second followed by full current (0.060 ampere) for 0.04 second during each dial pulse interval. When dialing is completed, the exchange furnishes the connection and signifies this by reversing the telegraph loop current from positive to negative which causes the typing unit motor to start and the CONN lamp to light. Message transmission can now be exchanged between the connected teletypwriters. The line signals are 0.060 ampere marking and zero current spacing.

2.04 If the distant called station is busy or disabled at the time of a call, the local telegraph exchange reverses the local loop current from positive to negative for about 0.2 second and then causes it to revert to positive current again. This causes the local motor to start and the CONN lamp to light momentarily, but they then both turn off. The teletypewriter returns to the idle condition as the positive current is detected.

2.05 The local telegraph exchange responds to an incoming call by reversing the idle signal loop from positive to negative current. At the local station, the CONN lamp is illuminated, and the motor is turned on as the shunt to the loop resistance is applied in response to the current change. Message transmission can now take place with unattended service at the receiving station.

2.06 Following completion of traffic a disconnect can be originated from either the calling or the called station. Holding the STOP pushbutton depressed causes the line to go open (zero current). In approximately 3 seconds the local exchange causes the connection to the distant station to be broken, and it reverses the current in the local loop so that positive current flows—limited by the local station loop resistance. This turns off the motor and extinguishes the CONN lamp. The STOP pushbutton is released after the CONN lamp goes out. The original idle condition is now restored. When a disconnect is initiated from a remote station, the local exchange recognizes the open line interval and breaks the connection. The loop current is reversed back to positive, and the local station is returned to the idle condition as stated above.

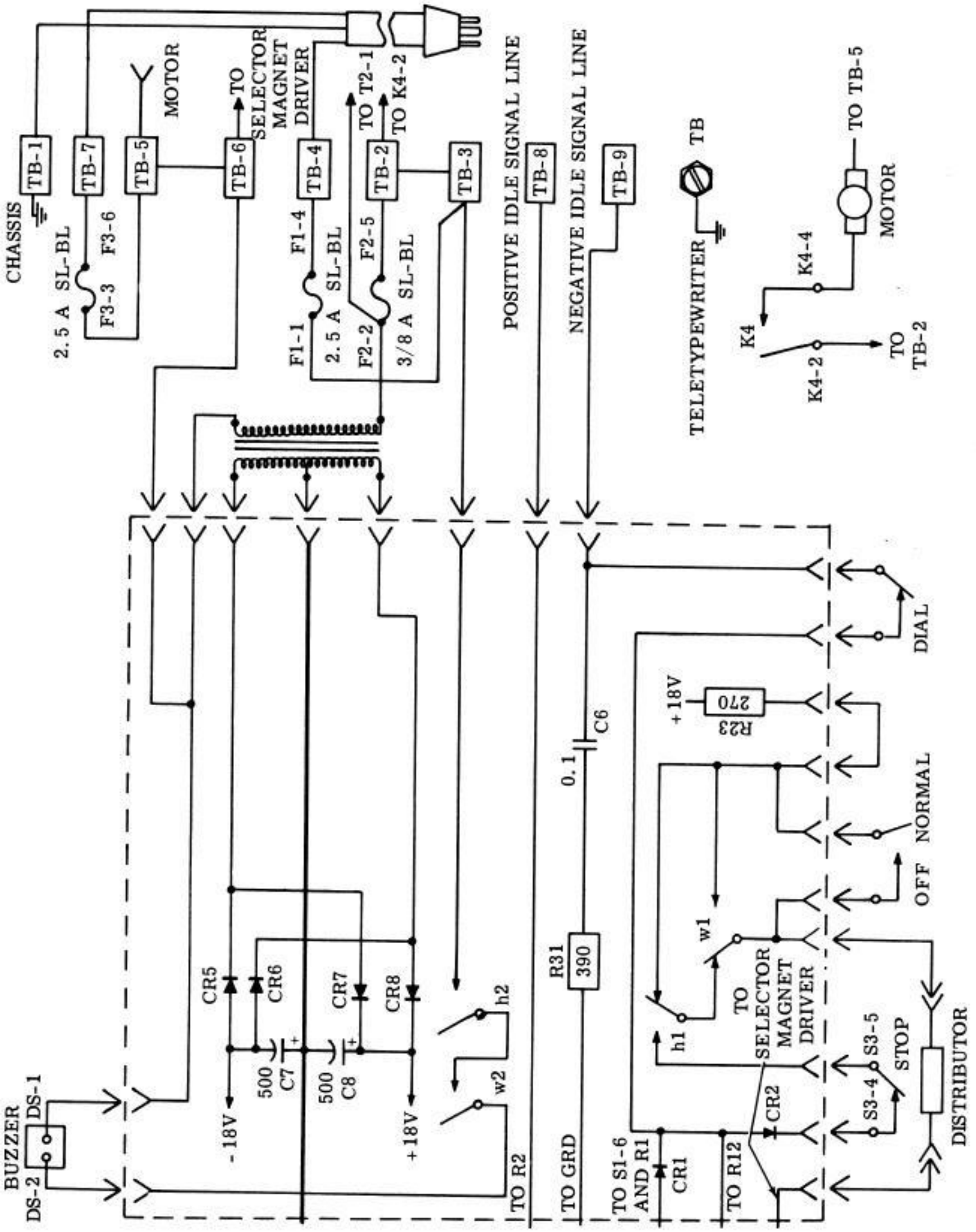



Figure 1 - Power Input Circuit

2.07 Local operation is provided by depressing the LOCAL pushbutton until the LOCAL lamp is turned on. This places the teletypewriter in an off-line operating condition for copy preparation, practice, or maintenance purposes. To return to the idle condition, the STOP pushbutton is held operated until the lamp is extinguished, or a call can be initiated by depressing the START pushbutton directly. If a call is received while the teletypewriter is in the local condition, the buzzer will sound for an interval of 2.6 seconds, and the teletypewriter will automatically shift over to the call-connected condition with the CONN lamp illuminated.

C. Polar Signaling Condition

2.08 Call control units that are modified for polar operation respond to and transmit polar telegraph signals on separate receiving and sending legs extending to the telegraph exchange facilities. The operating conditions and sequence are similar to that for neutral signaling.

2.09 In the idle condition the sending and receiving legs each have from 0.015 to 0.040 ampere positive current flowing. The sending leg current is supplied by the call control unit, and the receiving leg current is supplied by the central exchange. At the local station the polar adapter interconnects the legs with the neutral signaling control and teletypewriter circuitry. Operation of the START pushbutton causes the current in the sending leg to reverse to a negative polarity with a value equal to the positive current formerly applied (0.015 to 0.040 ampere). The telegraph exchange responds by reversing the current to negative on the receiving leg for 0.025 second. This causes illumination of the DIAL lamp at which time the START pushbutton should be released. The dialing signals go out over the sending leg in polar form with each pulse interval consisting of 0.06 second of positive current followed by 0.04 second of negative current. When the connection is completed, the exchange reverses the polarity of the receiving leg from positive to negative current. After 0.08 second of this reversal, the call control unit causes the motor to turn on, and the CONN lamp to be illuminated. Traffic can now be exchanged. Each station is arranged to record its transmitted copy. Transmitted and received signals consist of positive current for space and negative current for mark on both signal legs.

2.10 When receiving an incoming call, the local exchange reverses the receiving leg current from positive to negative. The local call control unit, after 0.08 second of negative current, turns on the motor and the CONN light and causes the sending leg current to be reversed from positive to negative.

2.11 If the distant station that is called is busy, it will result in the momentary application of negative current to the local receiving leg followed by a return to a continuous positive current. The motor may run briefly, but the teletypewriter will be quickly placed back into the idle condition.

2.12 In effecting a disconnect, operation of the STOP pushbutton causes the transmission of positive current on the sending leg. The exchange will then reverse the current on the receiving leg to positive as it breakes connection to the distant station. The call control unit detects the positive current. After 1.3 seconds it turns the motor and CONN lamp off as it applies a steady positive current to the sending leg and restores the teletypewriter to the idle condition. If the disconnect is initiated at the distant teletypewriter, the positive current disconnect signal, when applied to the local receiving leg, causes the local teletypewriter to go into the idle condition after 1.3 seconds, and the sending loop becomes positive again.

2.13 For local operation the internal conditions are the same as for neutral signaling. Externally, the signal legs remain on positive current unless a call is received. When a call is received, a negative current on the receiving leg for 0.08 second causes the buzzer to sound for 2.6 seconds. Following the buzzer sound, teletypewriter shifts to the call-connected condition.

POWER SUPPLY

2.14 Figure 1 illustrates a schematic diagram of the power input circuit.

2.15 A fused power supply operates on 115-volts ac ± 10% at 60 cps and a power input of 12 watts. It floats with respect to the input line; that is, it is not at earth ground. Therefore, the center tap of the transformer is ± 120 volts to earth ground in neutral signaling. The polar adapter, on teletypewriters equipped for polar operation, also contains a power supply. When operating on a polar line, this power supply, as well as that of the call control unit, is operated with ground to earth.

## LOCAL-REMOTE CONTROL CIRCUITS

### A. General

2.16 The local-remote control is a printed card assembly consisting of three circuits that accomplish the switching called for by the input line or operation of the call control unit pushbuttons. These circuits are the proceed-to-dial, connect, and local circuits. They are essentially binaries (flip-flops) that have been modified to perform their function. All the circuits are protected with a diode arc suppressor against transients and voltage pulses generated by their associated relays. A negative voltage, generated at the collector of a transistor, will be shorted through the diode to resistor R27. The transient will be developed across R27 and the lamp associated with the relay. The diodes performing this function are CR10, CR12, and CR19. The circuits are also protected from transient noise induced into them from leads in the cable to the dial and key and lamp assembly. A low-pass filter or delay network of the RC type is placed in a feedback loop in each binary. The delay network slows the response time of the associated binary. This reduces its susceptibility to noise. These delay networks are made up of R10 and C3, R21 and C4, and R39 and C11. The signal line inputs are filtered against spurious noise occurring on the signal line. There are two of these filters, both of the RC type. In the proceed-to-dial circuit, the delay network (R5 and C1) provides 0.001 second delay. In the connect circuit, the delay network (R12 and C2) provides a 0.02 second delay. The RC network, consisting of R31 and C6, in the 240-volt signal line acts as an arc suppressor to protect associated contacts.

### B. Proceed-to-Dial Circuit

2.17 Figure 2 illustrates a schematic diagram of the proceed-to-dial circuit.

2.18 This circuit consists of a binary with a line input amplifier. The amplifier consists of transistor Q1 and associated components, and the binary consists of transistors Q2, Q3, and associated components. The amplifier is connected to the binary through a low-pass filter or delay network (R5 and C1) which suppresses signal line noise. Input to the binary from the filter through R6 will turn on the proceed-to-dial circuit. Two other control inputs turn off the proceed-to-dial circuit. One of these is through resistor R15, and the other is through pushbutton contact S3-1. Operation of the transistors in the proceed to-dial-circuit is as follows:

(a) When transistor Q2 is in conduction, its collector is near neutral potential. Current will flow through Q2, R11, S3-1, S3-2, and R27. Current will also flow from +18 volts through R8 and CR9 to the collector of Q2. The base of Q3 will be held +0.8 volt with respect to the collector of Q2 due to the current flow through CR9. The base of Q3 will, therefore, be slightly positive with respect to neutral, and Q3 will be turned off. With Q3 turned off, its collector will be negative, and base current to Q2 will be supplied through the low-pass filter consisting of R9, R10, and C3 which holds Q2 in conduction.

(b) When transistor Q3 is in conduction, the proceed-to-dial circuit is on, and the collector is near neutral. Current flows through Q3, K1, DS-2, and R27. Since the collector Q3 is near neutral, current flow through R7, R9, and R10 produces a positive potential at the base of Q2 which holds Q2 off. With Q2 off, base current for Q3 will flow through CR9, R11, S3-1, S3-2, and R27 holding Q3 in conduction.

(c) If an input current in excess of 0.002 ampere flows from TB-8 across CR4 to neutral, a +0.8 volt is developed across CR4 This positive potential holds Q1 in conduction and its collector near neutral potential. Neutral potential at this collector has no effect on the base of Q2 because of isolation provided by R5 and R6. If the input current falls below 0.002 ampere, a -0.8 volt is developed across CR4 due to the flow of current through R3, R2, and CR4. This potential turns off Q1, and its collector becomes positive. Current flows through R4 and R5 to charge C1 toward a +18 volts. When sufficient voltage is developed across C1, the base of Q2 will be back-biased through R6. Transistor Q2 turns off, and Q3 turns on. The proceed-to-dial circuit is now on. Back-bias to the base of Q2 is supplied by the voltage divider R7, R9, and R10 so that the positive potential applied across R6 is no longer required to hold Q2 off. If more than 0.002 ampere begins to flow across CR4 again, Q1 will turn on, and its collector will go to neutral, but this will have no effect on the base of Q2.

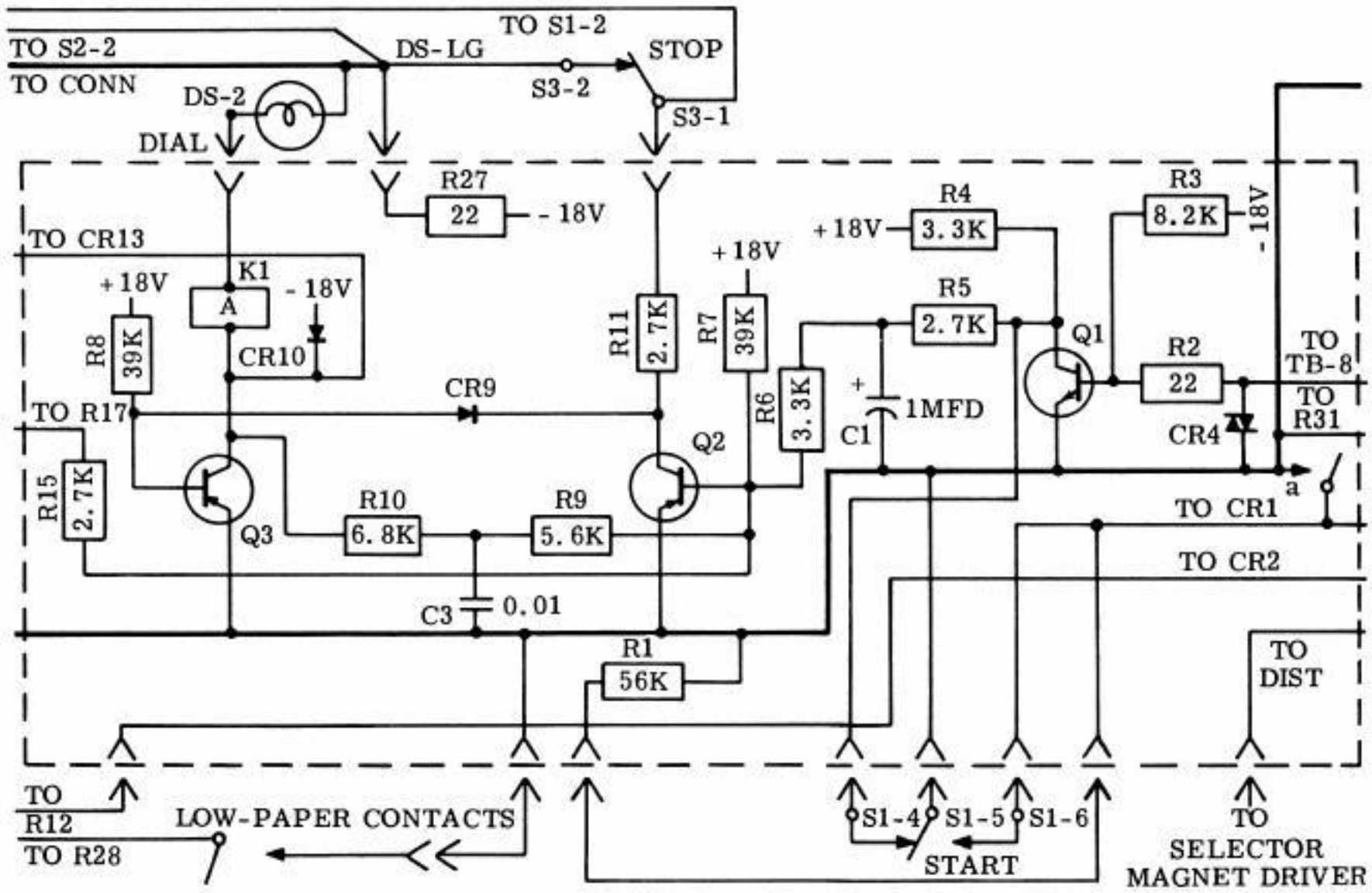



Figure 2 - Proceed-to-Dial Circuit

(d) If negative signal is applied to the side of R15 opposite the base of Q2, enough current will flow to forward-bias the base of Q2 and cause it to conduct. Q3 will turn off and supply sufficient base current through R9 and R10 to hold Q2 in conduction. The negative signal on R15 can now be removed, and Q2 will remain in conduction.

(e) With the proceed-to-dial circuit on, Q3 in conduction, base current for Q3 flows through R11 and CR9. By operating the STOP pushbutton, the current path through S3-1 is broken. Q3 will then turn off, and Q2 will turn on. Collector current will not flow in Q2 but will be near neutral and hold Q3 off. When the STOP pushbutton is released, collector current will flow in Q2. The proceed-to-dial circuit is now off.

C. Connect Circuit

2.19 Figure 3 illustrates a schematic diagram of the connect circuit.

2.20 This circuit consists of a binary (Q4 and Q6) of which one side is driven by emitter follower Q5. The only control input to this circuit is by the signal line through R12 and R13. C2 and R12 form a low-pass filter or delay network. Signal delay in the network is approximately 0.02 second. A single passive control, consisting of R28 and CR3, is used for low-paper conditions:

(a) Transistor Q5 controls the base of Q4. If Q4 is in conduction, its collector is near neutral. Voltage divider R17 and R18 hold the base of Q6 positive so that Q6 is off. The

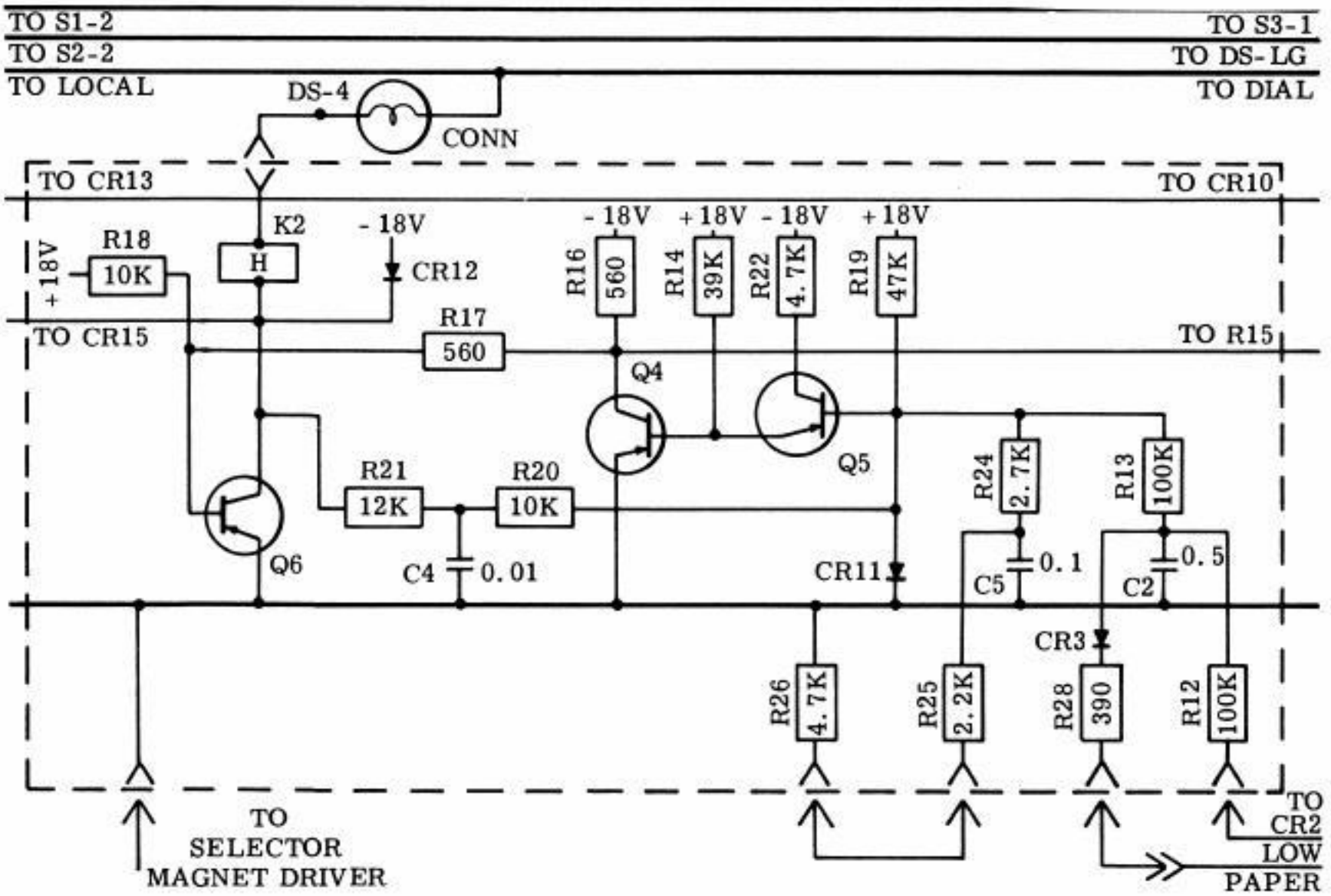



Figure 3 - Connect Circuit

collector of Q6 will then be negative, and the base of Q5 will be held slightly negative through R20 and R21. Since Q5 is an emitter follower, its emitter will be held at the same potential as its base. With its emitter at a negative potential, Q4 will be held on.

(b) When the connect circuit is on, Q6 is in conduction, and its collector is near neutral. The voltage divider R19, R20, and R21 holds the base of Q5 and therefore the emitter, positive. With the emitter of Q5 positive, the base of Q4 will be back-biased, and Q4 will be off. The collector of Q4 will then be negative. Base current for Q6 will flow through R16 and R17 holding the connect circuit on.

(c) To control the connect circuit a high voltage must be developed at the junction of CR1 and CR2. This voltage will be approximately ±200 volts. If a +200 volt signal is applied at this point, the base of Q5 will be biased positive, and Q4 will turn off. Q6 will turn on. If a -200 volt signal is applied, the base of Q5 will be biased negative, and Q4 will turn on. Q6 will turn off. An input signal at or near neutral will have no effect upon the connect circuit, and it will remain in its prior state.

(d) The base of Q5 is protected against excessively high voltages by transistor operation or by CR11. If a -200 volt signal is present, the voltage on the base of Q5 will fall and force its emitter to follow. When the emitter of Q5 becomes negative with respect to ground, Q4 will turn on. With Q4 in conduction, its base potential is held close to the emitter potential. Therefore, the base cannot go more negative than approximately -0.4 volt. This action also holds the base voltage of Q4 within -0.4 volt of its emitter. The base voltage of Q5, then, cannot become more negative than approximately -0.8 volt. If a +200 volt signal is present at the input, the base of Q5 will start to become positive. The diode CR11 is forward-biased to positive base voltages. It will limit the voltage on the base of Q5 to approximately +0.8 volt. There-

fore, under the severest input conditions, a voltage swing of more than ±0.8 volt is not expected.

(e) Resistors R24, R25, R26, and capacitor C5 are used where a polar converter is employed. As they are shown connected in 4779WD, they have no effect on the operation of this circuit.

D. Local Circuit

2.21 Figure 4 illustrates a schematic diagram of the local circuit.

2.22 A binary and a unijunction transistor timer make up the local circuit. Binary operation of Q8 and Q9 is the same as that of the proceed-to-dial circuit. There are four input controls available.

(a) Operation of the LOCAL pushbutton turns on the local circuit (Q9 on). When contact S2-1 is closed, base current is supplied to Q9 through R37 and R38, and Q9 will turn on. Q8 will turn off. If the anode of either CR13 or CR14 is neutral, current flowing through R38 will flow through one of the diodes and not reach the base of Q9. These two diodes allow the local circuit to be turned on only when the proceed-to-dial and connect circuits are off.

(b) The local circuit can be turned off by operation of either the START or the STOP pushbutton. When the local circuit is on, the base current for Q9 flows through contacts S1-1 of the START pushbutton and contact S3-1 of the STOP pushbutton. Since the contacts of the two pushbuttons are in

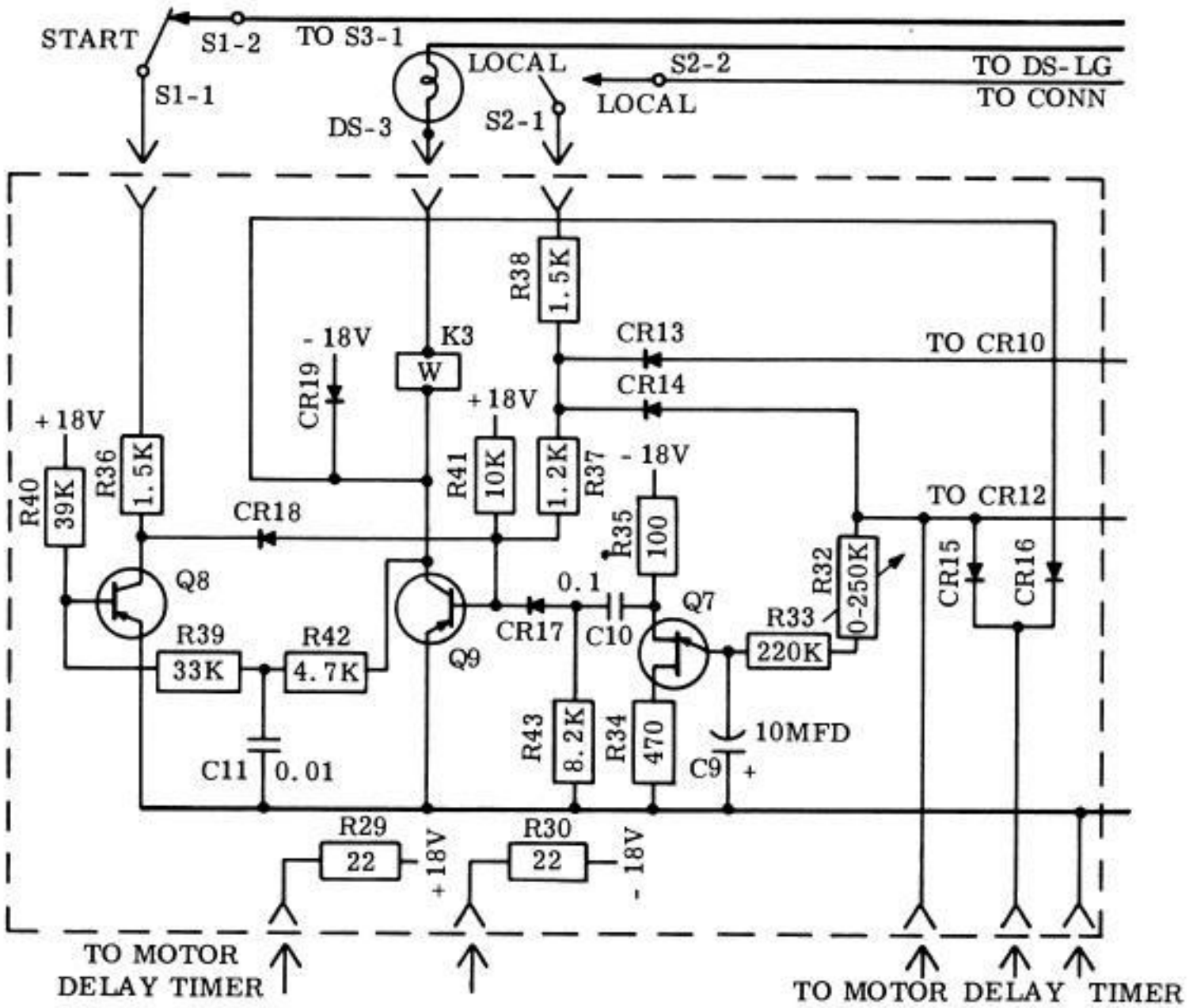



Figure 4 - Local Circuit

series, operating either of them will turn Q9 off.

(c) The unijunction transistor output will also turn off the local circuit. This transistor (Q7) is a breakdown device. If the voltage on C9 is more negative than approximately -8 volts, the resistance of the junction between the lead connected to C9 and the lead connected to R35 is high. When the voltage on C9 becomes more positive than approximately -8 volts, the resistance of this junction will become very low, and C9 will recharge through R35. The increase in current flowing through R35, while recharging C9, will cause an increase in the voltage drop across R35. The positive pulse is coupled through C10 and CR17 to the base of Q9 and causes it to turn off and Q8 to turn on. The local circuit is then off. As capacitor C9 is recharged, the resistance of the junction again becomes high.

(d) Capacitor C9 is discharged toward neutral or held at about -18 volts through R32 and R33. If the input to R32 is negative (connect circuit off), the capacitor will be held at -18 volts. If the input to R32 is near neutral (connect circuit on), capacitor C9 will discharge through R32 and R33 toward neutral. At the end of 2.3 seconds interval, the voltage on C9 will be approximately -8 volts and the unijunction will break down and turn the local circuit off as described above.

E. Circuit Interconnections

2.23 Figure 5 illustrates a block diagram of the local-remote control circuits.

2.24 Proceed-to-dial:

(a) In order to turn on the proceed-to-dial circuit, two conditions must be satisfied: The START pushbutton must be operated, and the proper line signal must be received from the exchange. The START pushbutton presents the proper signal to the exchange so that the request to dial is recognized. It also protects the proceed-to-dial circuit from an open line and long line breaks such as those generated when the dial is operated.

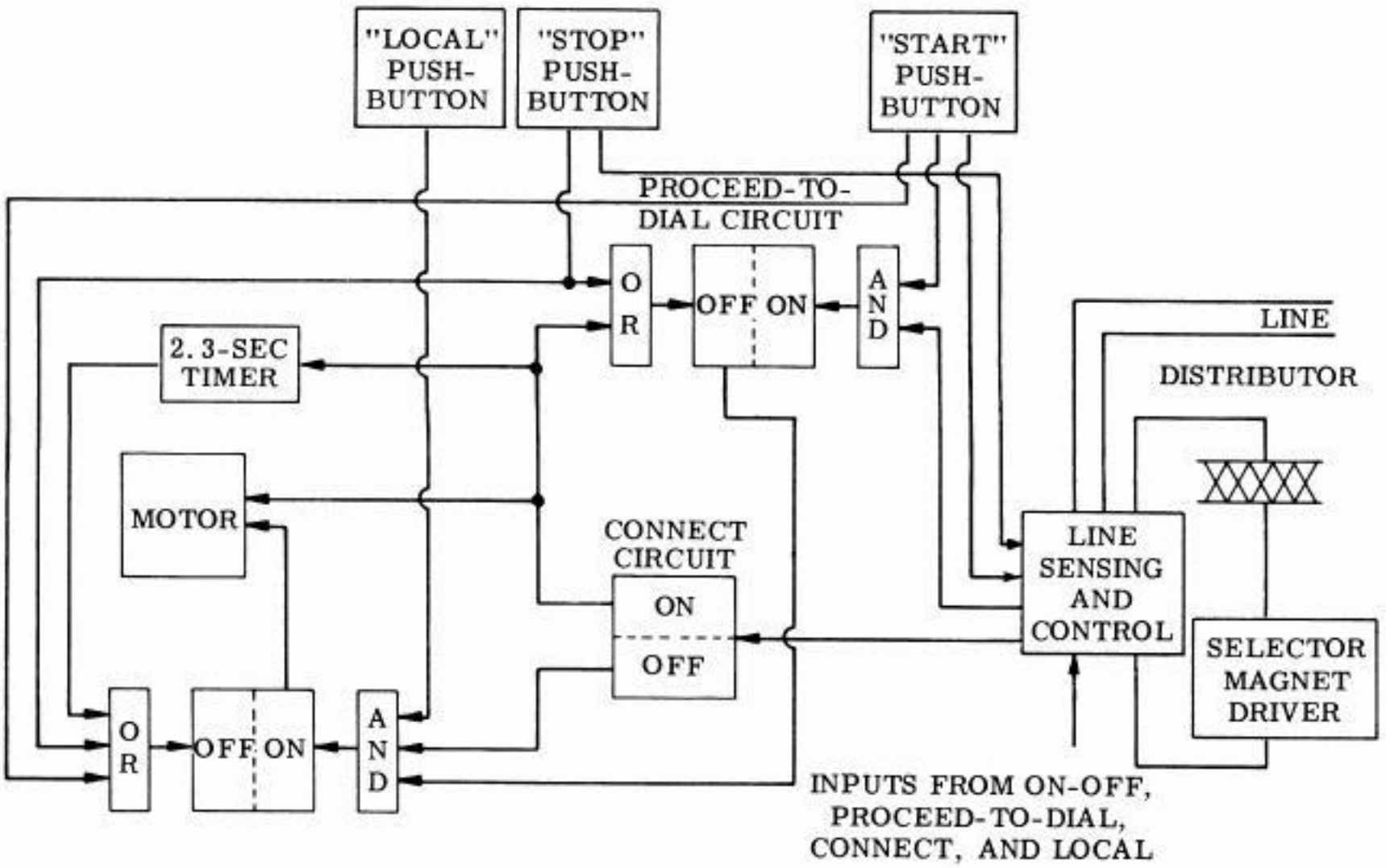



Figure 5 - Block Diagram of Local-Remote Control Circuits

(b) The proceed-to-dial circuit can be turned off in two ways: If the STOP pushbutton is operated or the connect circuit operates, the proceed-to-dial circuit will turn off. Local control is provided by operation of the STOP pushbutton, while the connect circuit provides automatic control initiated by the exchange.

2.25 The connect circuit is controlled only by the line and, therefore, has only one input. This input is from line sensing and control as shown in Figure 5.

2.26 Local Circuit:

(a) To turn the local circuit on, three conditions must be satisfied:

(1) The proceed-to-dial and connect circuits must be off, and the LOCAL pushbutton must be depressed.

(2) The input of both the proceed-to-dial and the connect circuit protect against accidental operation of the local circuit which would otherwise cause an automatic disconnect.

(b) The local circuit is turned off by operating the STOP pushbutton, the START pushbutton, or the 2.3-second timer. The START and STOP pushbuttons provide local control of the circuit, while the 2.3-second timer provides automatic control. The 2.3-second timer is controlled by the connect circuit which is, in turn, controlled by the line. The 2.3-second timer continues to oscillate as long as the connect circuit is on, but only the first timing pulse is required to turn off the local circuit.

(c) Each of the above three circuits has an input to the line sensing and control. The inputs are in the form of relay contacts which switch the line through the proper internal path in the local and remote control assembly. When either the connect or local circuit is on, a motor control relay is operated. The contacts of the relay are used to turn on the motor of the associated typing unit.

F. Idle Line Condition

2.27 Figure 6 is the first of two schematic diagrams which illustrates the local-remote control circuit. It shows the current flow during the idle line condition.

2.28 In this state all relays and lamps are off. This requires that transistors Q3, Q6, and Q9 be off and that Q2, Q4, and Q8 be in conduction. The output transistor of the motor delay timer is off, and the selector magnet driver is marking.

(a) The signal loop is a 240-volt source with 4000 ohms in series. In the idle condition the local-remote control offers 43,800 ohms of local resistance to the signal loop. The flow of loop current in this condition is shown in Figure 6. Current flows from TB8, the positive idle terminal, across CR4, through R1 and CR1 in parallel with the base emitter junction of Q4 and Q5, R13 and R12. From this point, current flows through the dial pulse contacts to terminal TB9.

(b) Loop current develops a positive potential at Ⓐ in Figure 6 holding transistor Q1 on. The collector of Q1 is shorted to ground through contacts S1-4 and S1-5 on the START pushbutton. Therefore, no signal is developed at the collector unless the START pushbutton is depressed. Loop current develops about -200 volts with respect to neutral at point Ⓑ. This potential holds Q4 in conduction and the connect circuit off (Q6 off).

(c) The selector magnet driver is supplied 0.060 ampere locally to hold the selector magnet. This current is supplied through R23 and flows through contacts "h1" and "w1," the distributor and the selector magnet driver to neutral.

G. Initiating a Call

2.29 A call can be initiated with the teletypewriter in either idle or local condition by depressing the START pushbutton. This performs three functions: Contacts S1-1 and S1-2 open and turn off the local circuit. Contacts S1-4 and S1-5 open and remove the short from the collector of Q1. The collector will remain at ground since more than 0.002 ampere is flowing through CR4. Contacts S1-6 and S1-5 close, shorting the local loop resistance which allows the loop current to rise to 0.060 ampere. The loop current now flows from TB8, through CR4, contact S1-5, contact S1-6, CR1, and the dial impulse contacts to TB9. Shorting out the local loop resistance causes the voltage at point Ⓐ to rise neutral. This has no effect on the state of the connect circuit.

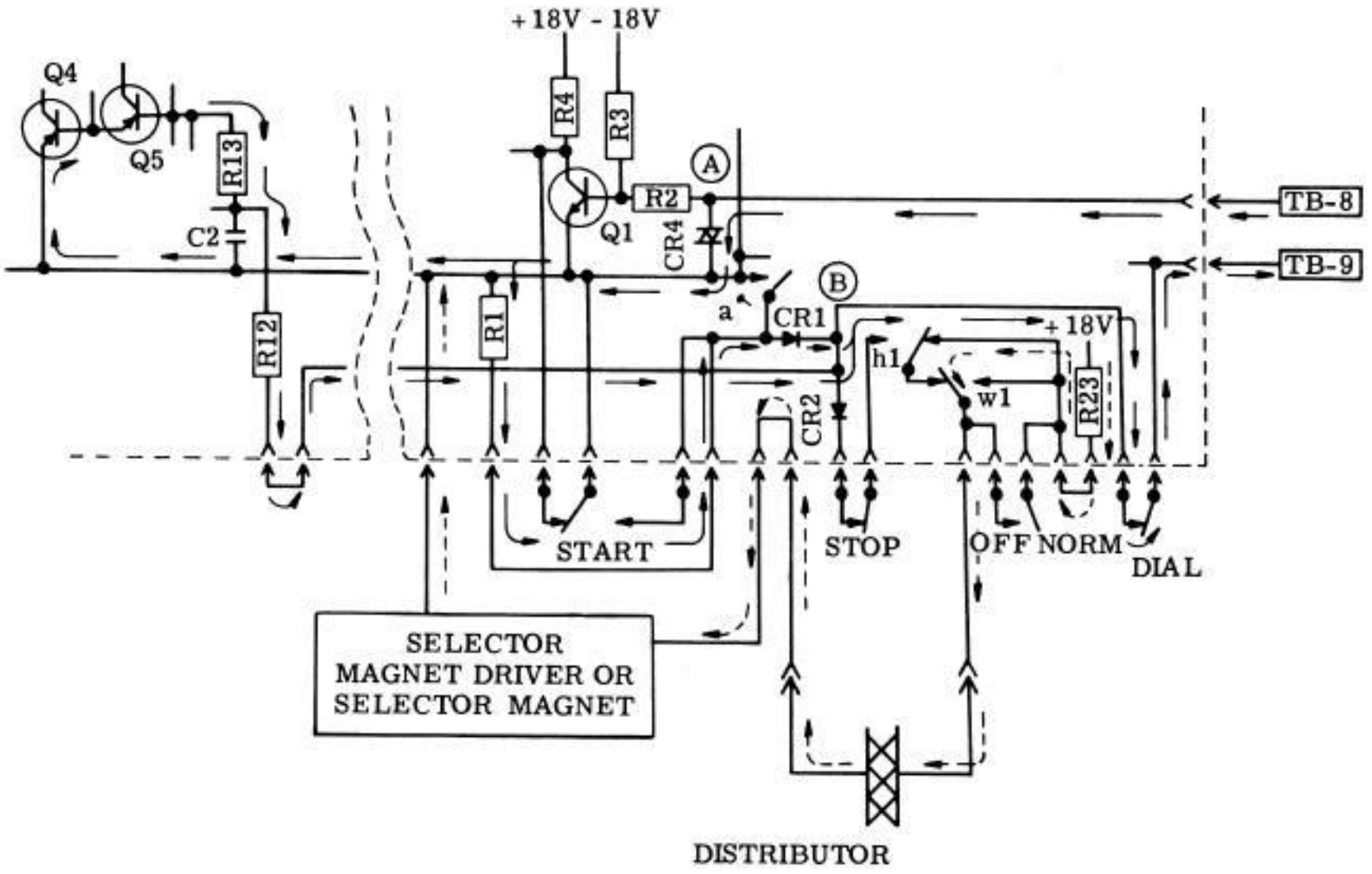



Figure 6 - Local-Remote Control Circuit—Current Flow (Idle)

(a) Proceed-to-dial: When the START pushbutton is depressed, a proceed-to-dial pulse will cause the collector of Q1 to go positive and, in turn, operate the proceed-to-dial circuit (turn on Q3). With Q3 in conduction, current will flow through the A(K1) relay and the DIAL lamp. This causes both of them to be operated. The normally open contact "a" of the A(K1) relay will operate the short contacts S1-6 and S1-5 of the START pushbutton. Loop current now flows from TB8, through CR4, contact "a," CR1, and the dial pulse contacts to terminal TB9.

(1) With Q3 in conduction, its collector will be near neutral. This holds the junction of R37 and R38 in the local circuit near neutral through CR13 as the LOCAL pushbutton is depressed. The local circuit cannot now be turned on. The proceed-to-dial circuit may be turned off by operating the STOP pushbutton. Contacts S3-1 and S3-2 will open and cause Q3 to turn off as described earlier. With Q3 turned off the teletypewriter will revert to the idle line condition, and the current loop will be as shown in Figure 6.

(2) In initiating a call, if the START pushbutton is released at any time before the proceed-to-dial pulse is given by the exchange, the teletypewriter will revert to the idle line condition. The exchange requires a short time to reset after the START pushbutton is released early and should not be reoperated for a few seconds.

(b) Dialing: The dial is in the signal loop at all times, but it may be used to transmit information to the exchange only during the proceed-to-dial and the connect conditions. Since the dial impulse contacts are in series with the loop, operation of the dial will completely break loop current. In order to prevent damage to the dial contacts, an arc suppressor, R31 and C6, is placed across the contacts.

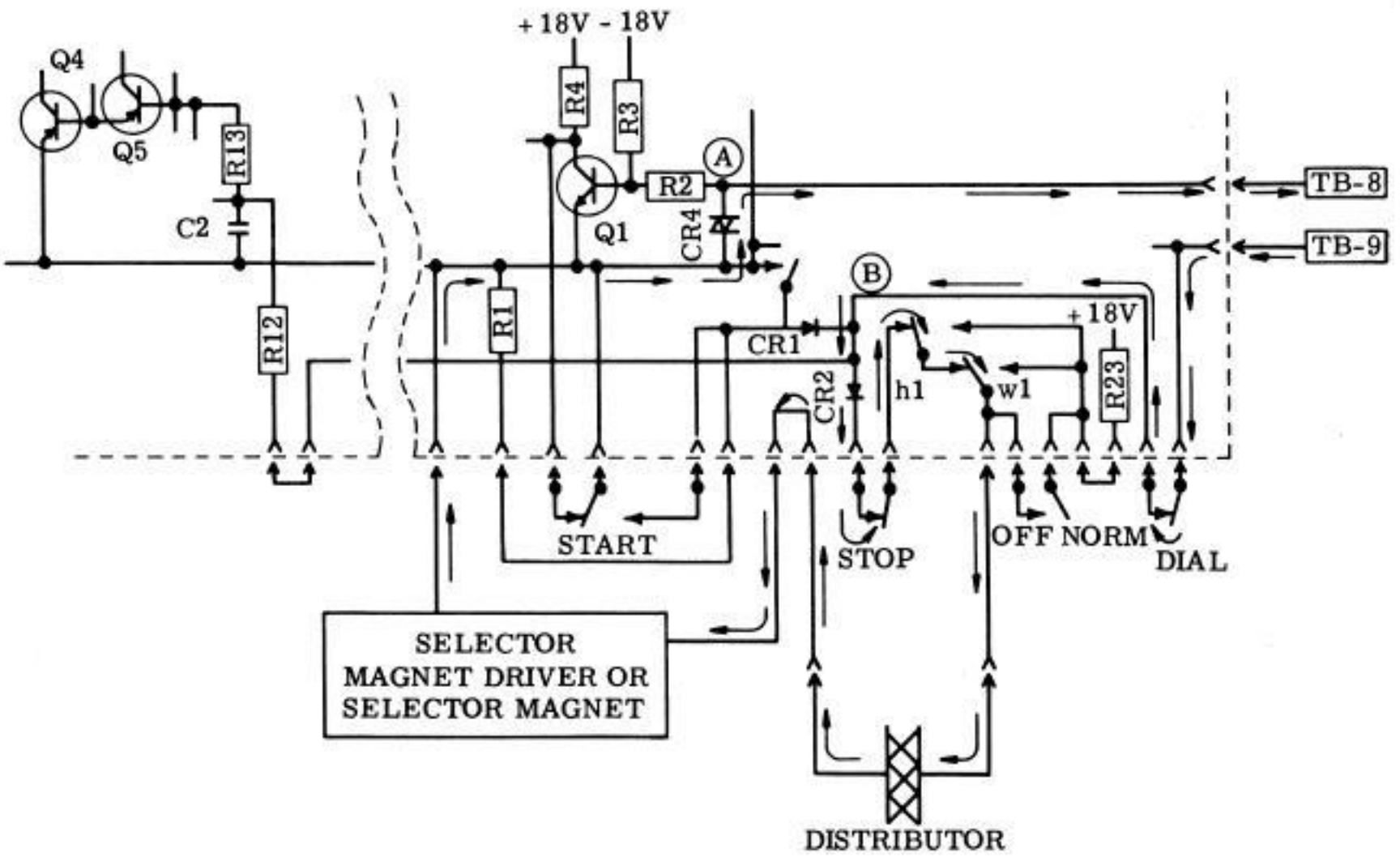



Figure 7 - Local-Remote Control Circuit—Current Flow (Local Connection)

H. Connection

2.30 Figure 7 is the second of two schematic diagrams which illustrates the local-remote control circuit. It shows the current flow during local connection.

2.31 Local Connection: If a call is initiated locally, current in the loop will be 0.060 ampere from TB8 to TB9 through the path described in 2.28 before connection. When the loop polarity is reversed by the exchange, current flow is from TB9 to TB8. Diode CR1 becomes reverse-biased and stops current flow except through R12 and R13. This current flow turns off Q4 and turns on the connect circuit (turns on Q6). With Q6 in conduction, the H(K2) relay will operate and the CONN lamp will light. The transfer contacts "h1" of the H(K2) relay will switch and allow loop current of 0.060 ampere to flow through the distributor and selector magnet driver as shown in Figure 7. Loop current now flows from TB9, through the dial pulse contacts, CR2, the contacts of "h1" and "w1," the distributor, the selector magnet driver and CR4 to TB8. Current will also flow through CR15 to operate the motor delay timer and, in turn, the motor control relay M when Q6 is in conduction. Contacts K4 will close and start the motor. Q4 is cut off, and its collector is negative. Feedback from the collector of Q4 to the base of Q2 through R15 will turn off the proceed-to-dial circuit. The A(K1) relay will release, and the DIAL lamp will go out. The "a" contact will open, but it does not have any effect upon the loop current flow, since it is not now in the current loop. The junction of R37 and R38 is held near neutral from the collector of Q6 through CR14, preventing local circuit operation.

2.32 Remote Connection: On an incoming call, the teletypewriter may be connected remotely while in the idle line or local conditions. The loop path is shown in Figure 6 for both of these conditions. The incoming call causes the exchange to reverse the loop polarity. This causes the potential at the junction of CR1 and CR2 to change from -200 volts to approximately +200 volts. The potential causes the connect circuit to operate as described in 2.31.

2.33 Low-Paper Circuit: If the paper in a teletypewriter has become low and the low-paper contacts operate, the junction of R12 and R13 will not be allowed to become positive. Q4 cannot be turned off, and a connection cannot be made. If low paper occurs during a call, the teletypewriter will remain in the connected state, since zero potential at the junction of R12 and R13 will not effect the connect circuit. A disconnect will occur in the normal manner, since CR3 will be back-biased to a negative potential at the junction of R12 and R13. If a call is initiated locally with a low-paper condition, the normal sequence of events will occur until a connection is attempted. When the exchange cannot connect, it will reverse the loop polarity, and the teletypewriter will return to the idle state.

I. Disconnect

2.34 Local Disconnect: Operation of the STOP pushbutton while in the connect condition opens contacts S3-4 and S3-5, which are in series with the loop, and breaks the loop. When the exchange recognizes the break, it reverses the loop polarity. The reverse polarity is blocked by CR2, and current flows through CR1 along the path shown in Figure 6. At point Ⓐ -200 volts is developed due to current flow as described in 2.27 and 2.28. This potential causes the connect circuit to turn off. The CONN lamp goes out and the H(K2) relay releases. The "h1" contacts return to the blinded condition, and the teletypewriter stops running open. The input to the motor delay timer becomes negative, and the timer will time out. After 0.55 second the motor control relay releases, and the motor will turn off. This delay allows the clutches to latch.

2.35 Remote Disconnect: The operation of the circuits and the loop paths are the same as those described in 2.32. The STOP pushbutton is not operated locally, but the signal conditions appear identical to the local-remote control.

J. Local Off-Line Operation

2.36 When the teletypewriter is in the idle line condition, operation of the LOCAL pushbutton will cause the local circuit to operate (Q9 turns on). If the control is in the proceed-to-dial or connect conditions, CR13 or CR14 will prevent operation of the local circuit. When the local circuit operates, the W(K3) relay operates and the LOCAL lamp will light. Contact "w1" of the W(K3) relay will short out contacts "h1" in the distributor-selector magnet driver loop. Current to this loop will then flow through R23, "w1," the distributor, and the selector magnet driver to neutral. Current will also flow through CR16 to turn on the output transistor of the motor delay timer. The motor control relay will operate, and the motor will start. The teletypewriter is now ready for off-line operation. To return to the idle line condition, the STOP pushbutton may be depressed. Contacts S3-1 and S3-2 open and turn off the local circuit. A call may be initiated in the local condition in the usual manner. When the START pushbutton is depressed, contacts S1-1 and S1-2 open and turn off the local circuit in the same way as the STOP pushbutton.

(a) If an incoming call is received while the teletypewriter is in the local condition, the action of the circuit is the same as that described in 2.27 and 2.28. The H(K2) relay operates to shunt the line through the distributor and selector magnet driver, but this operation cannot be accomplished, since the "w1" contacts have shorted the "h1" contacts out of the circuit. Operation of the "h2" contacts will complete the 115 volt ac circuit to the buzzer causing it to sound.

(b) When the connect circuit is turned on, the collector of Q6 approaches neutral. This causes the timer to start. At the end of a 2.3 second period, a positive pulse from the timer is coupled to the base of Q9 through C10 and CR17. The pulse causes the local circuit to turn off, the LOCAL lamp to be extinguished, and the W(K3) relay to be released. The "w1" contacts short the signal loop through the distributor and selector magnet driver. The "w2" contacts open and the buzzer will turn off. The teletypewriter is now in the connect condition.

SELECTOR MAGNET DRIVER

2.37 Figure 8 illustrates a schematic diagram of the selector magnet driver circuit.

2.38 The selector magnet driver, combined with an external power transformer, a resistor, and a filter capacitor, provides 0.500 ampere for driving a selector magnet from a telegraph signal source of appropriate input line current. The input signals are applied through terminals no. 7 and 13, with R1 determining the switching level.

2.39 For mark input, positive current is applied to terminal no. 7, providing a

positive bias to the base of transistor Q1 that overcomes the normal negative bias supplied through R1 and stabilized by Zener diode ZD1. Q1 turns off as the increasing positive current reaches one-half of its final value. The collector of Q1 goes negative, and the drop across the collector load resistor R3 is applied to the base of Q2. This turns Q2 on. R4 provides emitter bias to Q1, and supplies a regenerative action to the transition.

2.40 The selector magnet, in series with the external resistor, is connected between the collector of Q2 at terminal no. 6 and negative battery at terminal no. 15. It supplies the load for Q2. On marks, the current through Q2 quickly rises to 0.500 ampere, as set by the external resistor, and energizes the selector magnet.

2.41 On space input, the positive input bias decreases, and Q1 is turned on at the half-line current point by negative bias through R1. The collector of Q1 rises toward zero—applying reverse-bias to Q2, turning off Q2, and de-energizing the selector magnet. The selector magnet opposes the change in current, and it applies a transient to the collector of Q2 which is more negative than the battery potential at terminal no. 15. CR3 now conducts—passing the transient to C1 and R5 which limit the transient to a value well under the breakdown voltage of Q2 while the selector magnet energy is being dissipated.

MOTOR DELAY TIMER

2.42 Figure 9 illustrates a schematic diagram of the motor delay timer circuit.

2.43 The motor delay timer provides a means to delay motor turn-off in the teletypewriter. This allows the teletypewriter to complete its printing cycle and come to rest before the motor begins to stop. This circuit is mounted on the same circuit card assembly with the selector magnet driver, but the circuit is electrically independent of it. It is designed to drive a motor control relay connected between points no. 3 and 5 and is operated when either the connect or local circuit is on.

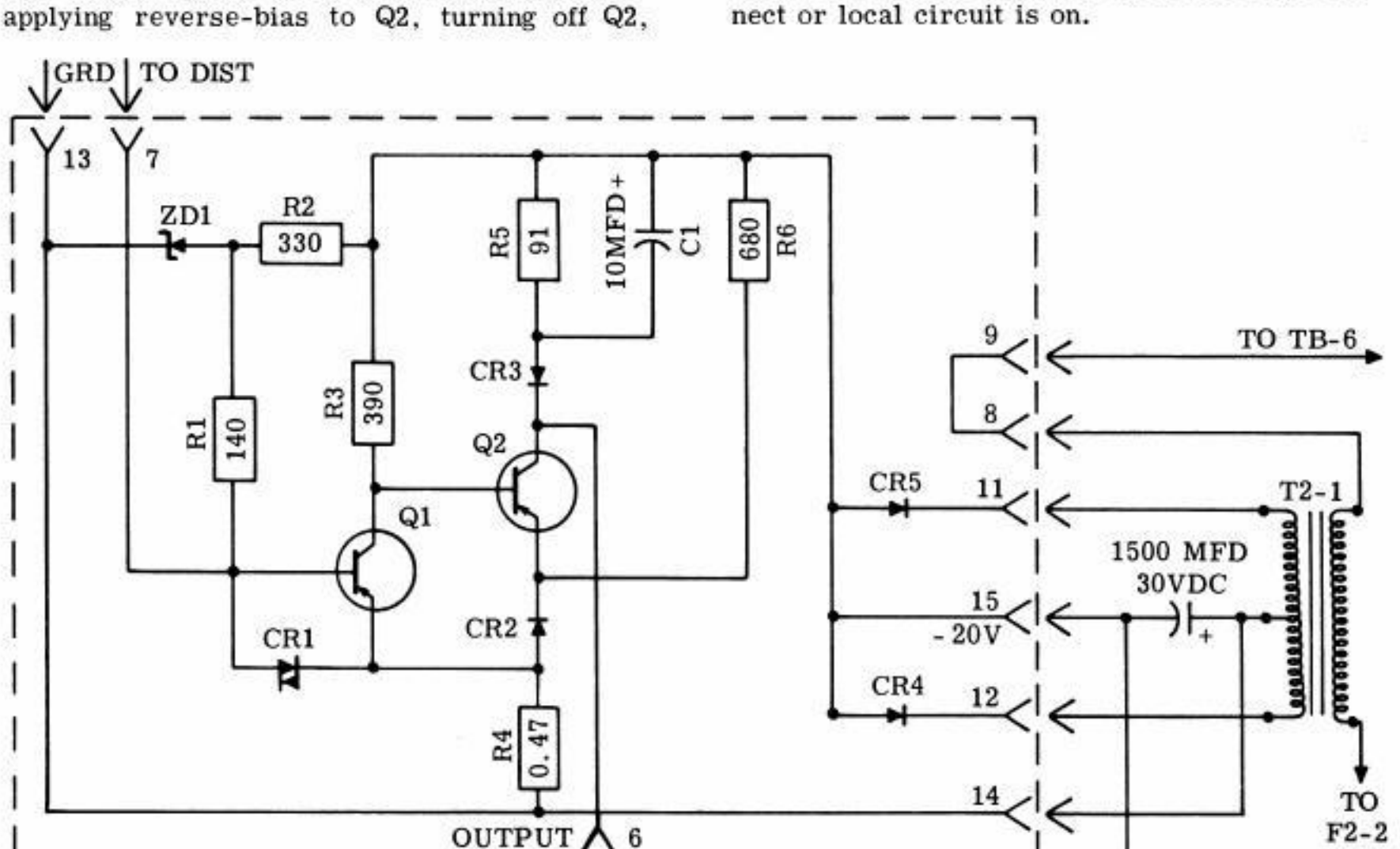



Figure 8 - Selector Magnet Driver Circuit

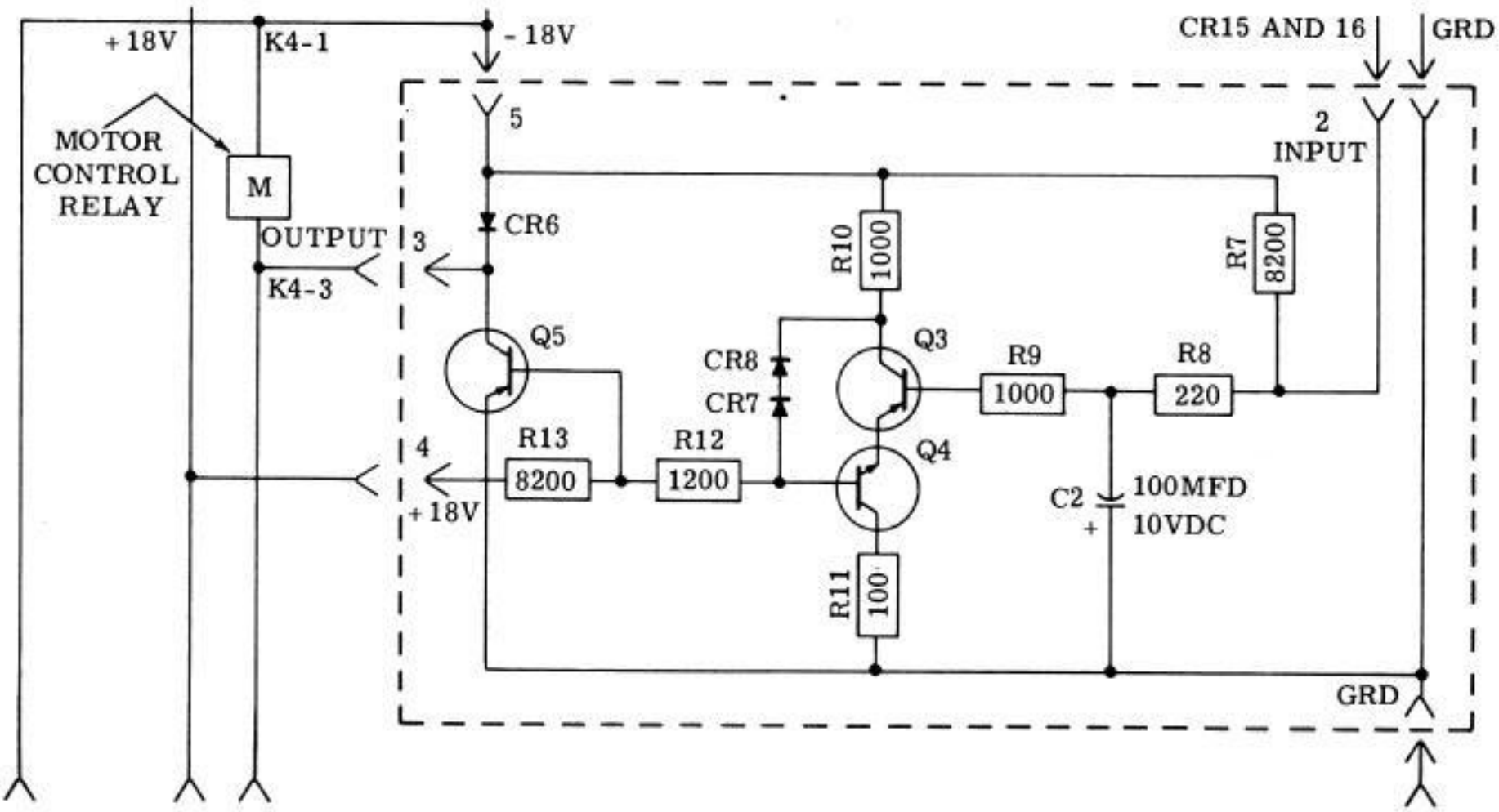



Figure 9 - Motor Delay Timer Circuit

2.44 The motor delay timer consists of a regenerative switch (Q3 and Q4) and an output driver (Q5). The input to the motor delay timer is from the collector of Q9 through diode CR16 or from the collector of Q6 through diode CR15 in the local and connect circuits of the local-remote control circuit. The diodes provide insulation between the input of the motor delay timer and the transistors of the local-remote control for negative signals. When the input of the motor delay timer at point no. 2 is grounded, the output driver will turn on immediately. When the input signal is removed, the output driver will remain in conduction for approximately 0.55 second while holding the motor control relay operated long enough to allow the teletypewriter to complete its printer cycle before turning off the motor.

2.45 When a negative input signal is applied to point no. 2, base current to Q3 will flow through R7, R8, and R9. Q4 will be held in conduction by base current flowing through R12 and R13. The collector of Q3 will be at approximately -1.6 volts. The voltage divider, R12 and R13, will hold the base of Q5 positive, and Q5 will be cut off.

2.46 If ground is now applied to the input, the base of Q3 will approach ground and become reverse biased. This turns Q3 off. The collector of Q3 will become -10.0 volts. This voltage will cause the voltage at the base and the emitter of the emitter follower Q4 to be -8.5 volts. The emitter of Q3 will be held at -8.5 volts by the emitter of Q4. This holds Q3 off. The -10.0 volts at the collector of Q3 will cause base current to flow to Q5 through CR7, CR8, and R12. Q5 will then go into conduction, and operate the external motor control relay.

2.47 If the ground input is now removed, current will flow through R7 and R8 and charge C2 toward -18 volts. After about 0.55 second the voltage on C2 reaches -8.5 volts, the voltage on the emitter of Q3, and Q3 goes into conduction with its collector going less negative. This causes the base of Q4 and, therefore, the emitter of Q3 and Q4 to become less negative. The process continues until both Q3 and Q4 are saturated. C3 will then discharge through R9 and the base of Q3 to ground. Base current to hold Q3 in conduction is supplied through R7, R8, and R9.

2.48 At 25 degrees C with 390 ohm output load, the delay of the motor delay timer is from 0.475 second to 0.675 second when the supply voltages are within 3 percent of their nominal values.

POLAR ADAPTER

A. General

2.49 The following description is based upon schematic wiring diagram 5923WD.

2.50 The polar adapter converts the types of signals received from the receiving leg and the teletypewriter into those usable by the circuitry and the sending leg. Some of the functions of the relay contacts are modified by the polar adapter, but they serve the same general purpose. The outward operations of the call control unit, with the polar adapter attached, are identical to those of the call control unit alone.

2.51 The polar adapter consists electrically of four basic parts. These parts are:

(a) Receiving polar relay: This relay converts the received signals into those usable by the circuitry of the adapter and the call control unit.

(b) Sending polar relay: This relay converts the make-break signals generated by the distributor into transmitted line signals.

(c) Connect control timer: This circuit is made up of four basic parts and differentiates between control and information signals.

(d) Current amplifier: This circuit amplifies the signals of the receiving polar relay to control the selector magnet driver.

2.52 The polar adapter operates on a 3-wire basis. Two of these wires are the sending and receiving legs. The third wire is an earth return for these two legs. The polar adapter will, therefore, not operate unless earth ground is supplied. The chassis of the polar adapter is grounded to the power supply. When installed in the call control unit, electrical connection is made through the chassis contact to the third wire in the power plug. This third wire in the power cord must be connected to a suitable earth ground.

2.53 The sending and receiving polar relays are of the non bridging mercury-wetted contact type. They are housed in metal cylinders with an 11-pin tube socket at their base. Because of the mercury in the relay capsule, they must be operated within 30 degrees of vertical to prevent shorting of the contacts.

(a) The coils of the polar relay are as follows:

Pins no. 2 and 11 - Drive coil
Pins no. 3 and 10 - Drive coil
Pins no. 5 and 9 - Bias coil
Pins no. 6 and 8 - Bias coil
Pins no. 1 and 7 - Contacts
Pin no. 4 - Tongue

(b) In the polar adapter, contact no. 7 has been chosen as the spacing contact and contact no. 1 as the marking contact. To close contact no. 1 and the tongue, current must flow from either pins no. 2 to 11, 3 to 10, 9 to 5, or 8 to 6.

2.54 All polar relay contacts are protected by arc suppressors. These arc suppressors slow the rate of change of voltage across the mercury wetted contacts of the polar relays. On the receiving polar relay the arc suppressors are made up of R32, R33, C5, and C6. On the sending polar relay they are made up of R43, R44, C7, and C8.

2.55 All voltage sources are isolated by at least 120 ohms. In the event of a momentary short, current through the polar relay contacts or the connectors is limited to 1 ampere or less. If a short is of long duration, the resistor will act like a fuse and open the shorted circuit. These resistors are R34, R36, R38, R41, and R42.

2.56 When polar signals are being transmitted by the sending polar relay, a noise suppressor is used in the sending leg. This suppressor consists of a "pi" filter and is made up of C11A, C11B, and R45. The filter rejects all high frequency components of the transmitted signal. It is <u>not</u> used when neutral signals are transmitted.

B. Receiving Polar Relay

2.57 This polar relay and its associated components convert incoming signals into those usable by the circuitry of the polar adapter and the call control unit.

2.58 Several types of input signals to this polar relay are possible. These modes of operation may be selected by appropriate strapping of the binding posts on the TP181607 printed card assembly. The various modes of operation are:

(a) Polar signals, battery supplied remotely. This is the normal mode of operation, and all polar adapters are supplied with strapping for this type of operation.

(b) Neutral signals, battery supplied by the polar adapter. In this condition, posts no. 3 and 4, 5 and 7 and 12 and 13 are strapped together.

(c) Neutral signals, battery supplied remotely (battery negative). In this condition, posts no. 5 and 12, 6 and 13, and 3 and 4 are strapped together.

(d) Neutral signals, battery supplied remotely (battery positive). In this condition, posts no. 3 and 4, 12 and 13, and 5 and 6 are strapped together.

2.59 With the wiring as described above, a spacing signal will cause the tongue (4) of the polar relay to rest on the space contact (7). With a marking signal, the tongue will rest on the mark contact (1). The tongue (4) of the polar relay is supplied with +120 volts through R34. It supplies this voltage to the selected contact, while the other contact has no potential applied. Both contacts have two outputs. One of these is a voltage or direct output, while the other is current output. The current output is through a diode and a resistor and will supply approximately 0.010 ampere to ground. The diode prevents reversed currents from flowing when the contact is not supplied with +120 volts from the tongue. The output diodes and resistors are CR11, CR12, R30 and R31.

2.60 The bias for this relay, when used in neutral operation, is 0.030 ampere and is supplied through R37 and strapped terminals no. 3 and 4. Operating current for neutral operation, when supplied locally, is supplied from -120 volts and is limited to 0.060 ampere by R46 and the signal line resistance.

C. Sending Polar Relay

2.61 This polar relay converts the neutral make-break signal generated by the distributor and the dial into those required on the sending leg. There are a variety of possible signal types that can be transmitted. These are:

(a) Polar signals, battery supplied by the polar adapter. This is the normal mode of operation and all polar adapters are supplied with strapping for this type of operation.

(b) Neutral signals, battery supplied by the polar adapter. In this condition, posts no. 10 and 11 are strapped together, and the straps between posts no. 8 and 9, 14 and 15, and 16 and 17 are cut.

(c) Neutral signals, battery supplied remotely. In this condition posts no. 6 and 10 are strapped together, and straps between posts no. 8 and 9, 10 and 11, 14 and 15, and 16 and 17 are cut.

2.62 Since both the drive and bias windings are wired in series, both windings are supplied with the same amount of current. The input current of 0.021 ampere to the drive windings is supplied through R40 from +120 volts. The 0.021 ampere to the bias is supplied through R39 from +120 volts.

D. Connect Control Timer

2.63 This circuit consists of four basic parts on the TP181606 assembly. These are: a strobe pulse generator two timing transmission gates, and binary.

2.64 The strobe pulse generator generates a 120 cps square wave. This square wave and the outputs from the receiving polar relay are used as inputs to the two timing transmission gates. The outputs of these two gates are used to control the binary. The output of the binary, in turn, is used to control the connect circuit in the call control unit.

2.65 The strobe pulse generator is made up of Q1 and Q2 and associated components. It is controlled and caused to oscillate by alternating current from the power transformer of the call control unit. This 12.5-volts ac (18-volt peak) sine wave is rectified by CR1 and CR2 to form a negative 120 cps wave. The base of Q1 is biased by R2 and R3 such that -3.9 volts is necessary at the junction of CR1 and CR2 to turn on Q1. When base current does flow to Q1, it will turn on, and its collector will become nearly ground. R4 and R5 form a voltage divider which back-biases the base of Q2

and holds it off. The voltage at the collector of Q2 will be set by a voltage divider made up of R8 and R9. This voltage is -9.1 volts. Feedback, through R6 from the collector of Q2 to the base of Q1, will help provide snap-action.

2.66 When the 120 cps wave becomes more positive than -3.9 volts, base current to Q1 will cease to flow. The collector of Q1 will become -5.7 volts. Base current to Q2 will flow through R5 and cause it to turn on. Its collector will become very nearly ground. This circuit will continue to oscillate as described as long as power is applied to the control unit transformer.

2.67 Two 1-percent tolerance resistors (R8 and R9) in the collector of Q2 set the voltage at that point at -9.1 volts. This voltage level is important in controlling the binary and setting the proper time delay intervals in the timing gates. The square wave generated at the collector of Q2 will be ground for approximately 0.0013 second and -9.1 volts for approximately 0.007 second.

2.68 When spacing signal is present on the receiving leg, +120 volts is applied to contact no. 7 and no voltage is applied to contact no. 1 of the receiving polar relay. No voltage will appear across R28, and the voltage at the junction of R28 and R26 is set by current flow through CR10 and R26. This voltage will be approximately -60 volts. CR8 will conduct and the voltage across C3 and at the anode of CR5 will be held at -60 volts. If Q4 is in conduction, its base will be nearly ground, and CR5 will be back-biased by 60 volts.

2.69 The 9.1 volt strobe pulse introduced at C1 will cause the voltage at the anode of CR5 to rise to -50.9 volts. The negative pulse, that follows in 0.0013 second will lower it to -60 volts. The net result of these strobe pulses upon the voltage on C3 is, therefore, zero, and CR5 is not forward-biased at this time.

2.70 When a marking signal appears on the receiving leg, +120 volts is applied to one side of R28 through the marking contact of the receiving polar relay. The voltage divider consisting of R26 and R28 sets the voltage at their junction at +22 volts and back-biases CR8. This isolates C3 from R26 and R28. C3 will begin to discharge through R20 from -60 volts toward ground. The voltage at the anode of CR5 will follow, thus reducing the back-bias on CR5. After approximately 0.08 second the voltage on C3, and, therefore, at the anode of CR5, will have risen to -9.1 volts. The next strobe pulse to appear at C1 will cause CR5 to become slightly forward-biased, and part of the pulse will appear at the base of Q4.

2.71 The gate just described is the connect timing gate and produces a signal delay of approximately 0.08 second. The disconnect timing gate operates in a similar manner. The input to R27 is from the spacing contact. When mark appears on the receiving leg, R25 and CR9 hold the voltage on C4 at -60 volts. When a spacing signal appears, CR7 will be back-biased, and C4 will discharge through R19 from -60 volts toward ground. In approximately 1.3 seconds the voltage across C4, and, therefore, at the anode of CR4, will become more positive than -9.1 volts. The next strobe pulse introduced across C2 will cause CR4 to be forward biased, and part of the strobe pulse will appear at the base of Q3.

2.72 C3 will recharge to -60 volts from -9.1 volts in 0.004 second. C4 will recharge in 0.01 second. Both of these recharge times are less than one code element length and can be considered instantaneous.

2.73 The outputs of the transmission gates control the binary which is made up of Q3 and Q4 and associated components. The operation of this binary is similar to that of the binaries in the call control unit. The control of the binary by the transmission gates is the same as that of the 2.3-second timer controlling the local circuit in the call control unit. A positive pulse at the base of Q4, through CR5, will turn off Q4 and turn on Q3. The collector of Q3 will then be near ground. Current will flow through R35 and through ZD1 to the collector of Q3. The cathode of ZD1 will be +9.1 volts with respect to its anode, so that the voltage at the cathode will be +9.1 volts. This point is the output to the connect circuit of the call control unit.

2.74 A positive pulse at the base of Q3 through CR4 will turn off Q3 and turn on Q4. The collector of Q3 will go negative. Current flow through CR6 and R23 will hold this voltage to -18 volts. Current flow through R35 and ZD1 will hold the voltage at the cathode of ZD1 to +9.1 volts of -18 volts. The output will then be -8.9 volts. A negative output (Q3 off) will hold the connect circuit of the call control unit off, and a positive output (Q3 on) will hold the connect circuit on.

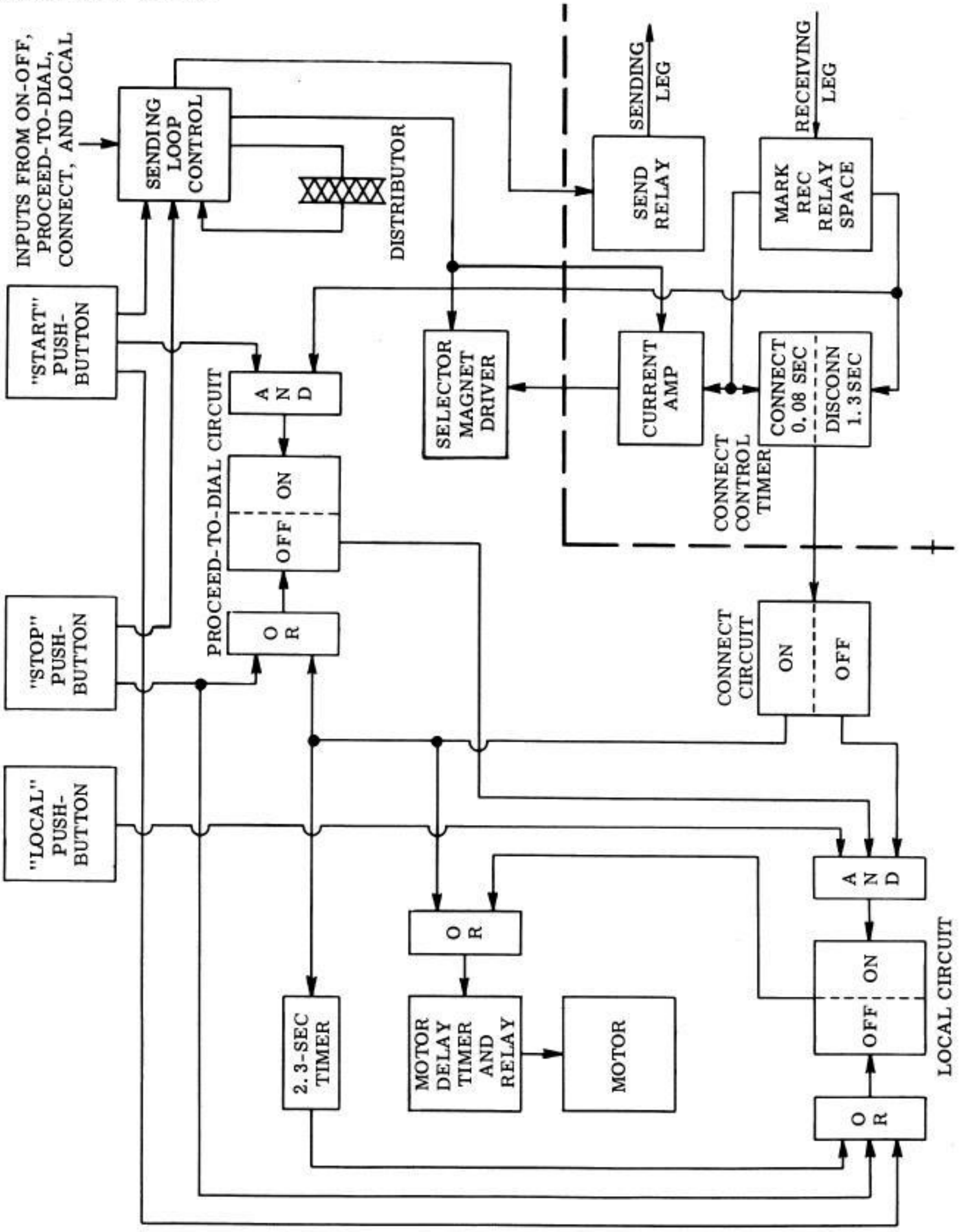



Figure 10 - Block Diagram—Polar Adapter Circuit

E. Current Amplifier

2.75 This circuit is made up of Q5 and associated components on the 181606 assembly. Base current to this amplifier is supplied through CR12 and R31 from the marking contact of the receiving polar relay.

2.76 If ground is applied to the emitter of Q5 through CR3 or by strapping binding posts no. 1 and 2, the base is back-biased by the voltage divider made up of R13 and R14. If base current is now supplied, the transistor will turn on. With the collector load as shown in Figure 12, 0.060 ampere of collector current will flow.

2.77 If the ground to the emitter of Q5 through CR3 is switched to +120 volts, CR3 will become back-biased. The emitter is biased to near +18 volts through R12. Since both the emitter and collector are biased to +18 volts, no current will flow between them. Base current supplied to the transistor will flow into both the collector and emitter. The current in the collector will flow from the base, through the collector, the selector magnet driver, and R23 to +18 volts. This current flow is in the reverse direction of the normal control current for the selector magnet drive, and it will be held spacing.

2.78 The amplifier will supply marking current only when ground is applied to the emitter, and base current is supplied. If either of these conditions is not fulfilled, the selector magnet driver will not be supplied input current, and its output will be spacing.

2.79 Strapping post no. 1 and 2 will permanently apply ground to the emitter and allow duplex operation of the teletypewriter.

F. Circuit Interconnections

2.80 Figure 10 is a block diagram showing the polar adapter connected to the call control unit. The call control unit portion of the block diagram is the same as that shown in Figure 5 with one exception. The line sensing and control block of the call control unit is rewired through the connectors (J4, J5, and J6) and is now called the sending loop control. All of the components are identical in these two blocks, but rewiring allows the block to control the sending leg rather than the signal loop. This block also has outputs to the current amplifier and the selector magnet driver. The input to the current amplifier allows the teletypewriter to read its own copy. The input directly to the selector magnet driver is for teletypewriter blinding.

2.81 The receiving polar relay marking contact supplies inputs to both the connect control timer and the current amplifier. The input to the current amplifier allows the teletypewriter to read incoming copy. The input to the connect control timer allows the polar adapter to recognize a connect signal. The spacing contact supplies inputs to both the connect control timer and the proceed-to-dial circuit of the call control unit. The input to the connect control timer allows the polar adapter to recognize a disconnect signal. The input to the proceed-to-dial circuit supplies current for spacing signals and no current for mark. This allows this circuit to operate in the normal manner.

G. Idle Line Condition

2.82 In this condition both the sending and receiving legs are spacing. All the circuits in the call control unit are off. The spacing contact of the receiving polar relay is +120 volts and allows C4 to be discharged. CR4 will then allow strobe pulses to pass to the base of Q3 and hold it off. The output of the connect control timer is then negative and holds the connect circuit in the call control unit off.

2.83 Figure 11 is a schematic wiring diagram of the sending loop control circuit with the current amplifier and the sending polar relay. Blinding current to the selector magnet driver flows from +18 volts through R23, J5-2, the selector magnet driver, J4-3, and "hl" contact, the "wl" contact, J4-9, and the distributor to ground. No current flows in the drive coils of the sending polar relay, since neither the start contact, the "a" contact, nor the "hl" contact are operated to supply ground.

2.84 The marking contact of the receiving polar relay has no voltage applied. No base current will then flow from this contact to Q5. The emitter of Q5 is biased to +18 volts through R12. The cathode of CR3 is at +120 volts which is supplied through R39 and the sending relay coils, and CR3 is back-biased.

H. Initiating a Call

2.85 A call may be initiated when the call control unit is in either the idle line or local conditions as described earlier. Depressing the START pushbutton will allow current

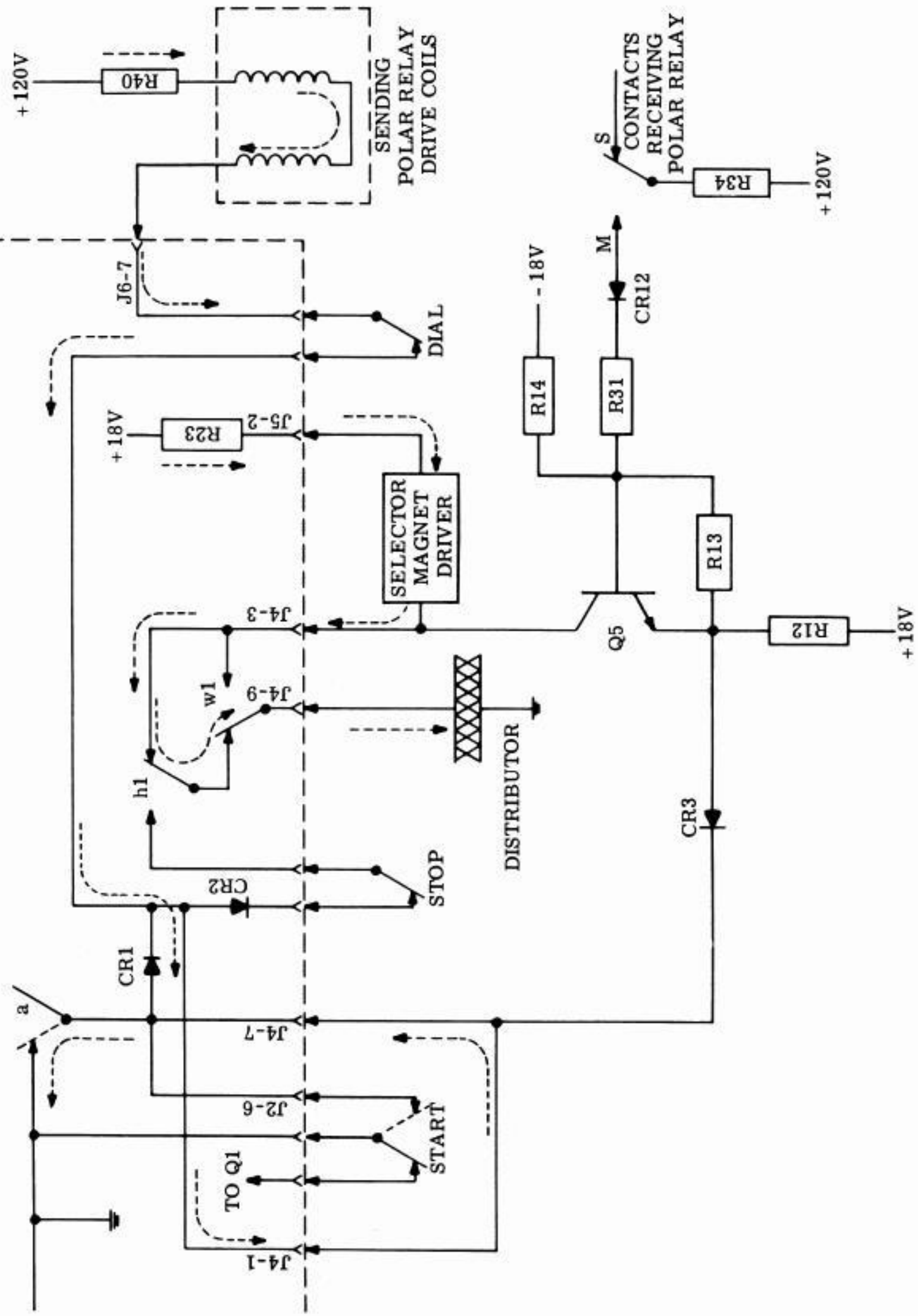



Figure 11 - Sending Loop Control Circuit with Sending Polar Relay

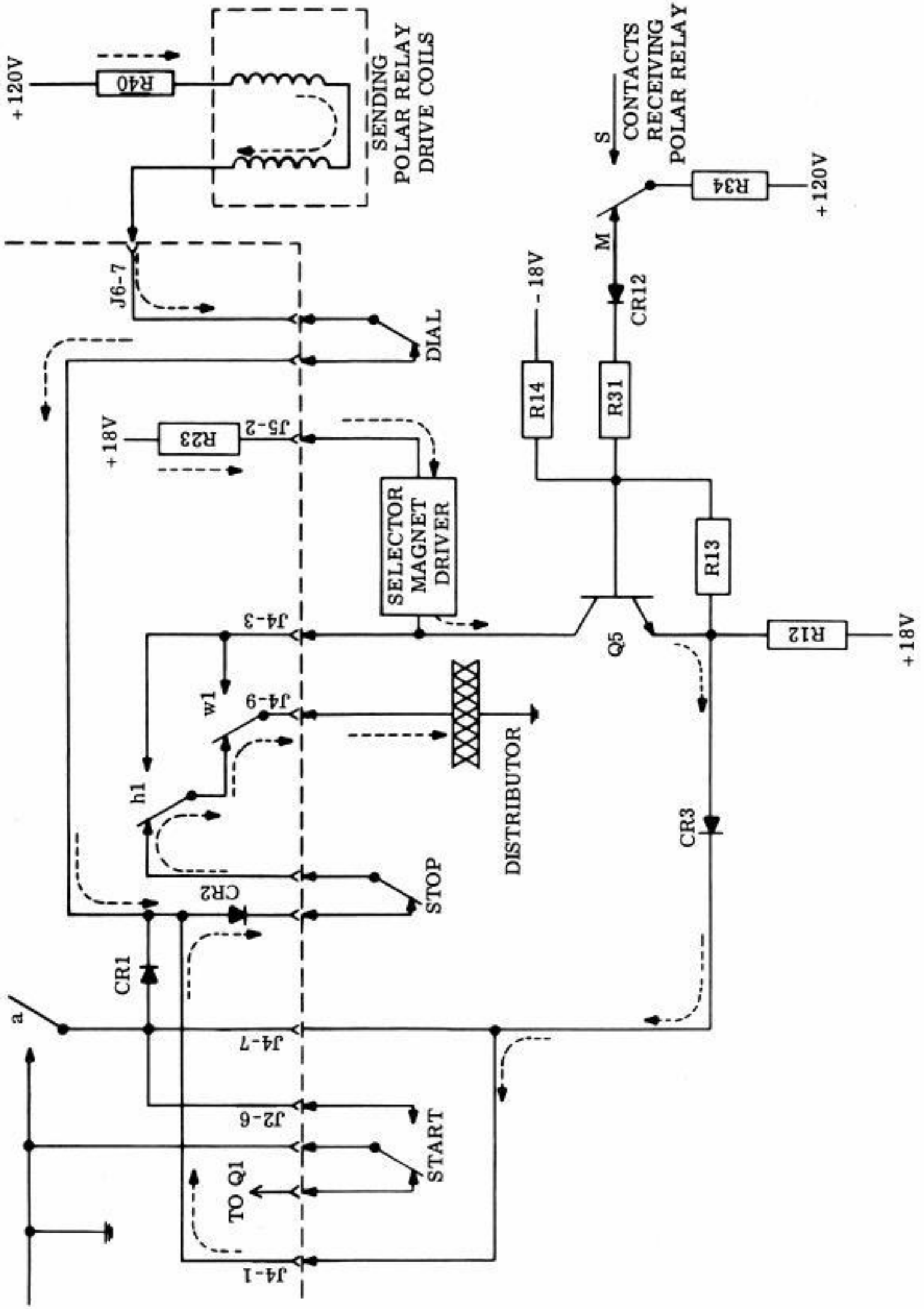



Figure 12 - Receiving Loop Control Circuit with Receiving Polar Relay

to flow through the drive coils of the sending polar relay. This sending polar relay will then transmit a marking signal on the sending leg. The current path through the coils is shown dotted in Figure 11.

2.86 Operating the START pushbutton will also remove ground from the collector of Q1 in the call control unit. Current to the input of the proceed-to-dial circuit (base of Q1) is supplied from the spacing contact of the receiving polar relay. This is not shown in Figure 11. The proceed-to-dial circuit will not operate until this current is interrupted.

I. Proceed-to-Dial

2.87 The exchange will recognize the marking signal transmitted as a request to dial. When the exchange has selected the proper equipment, it will transmit a 0.025 second marking signal on the receiving leg. The receiving polar relay will respond to this signal by interrupting the current flow to the input of the proceed-to-dial circuit. This circuit will then turn on, and energize the A(K1) relay and the proceed-to-dial lamp. The "a" contact will operate and shunt out the START pushbutton contact. The START pushbutton may now be released.

2.88 When the receiving polar relay responds to the 0.025 second pulse, C3 in the connect control timer will start to discharge. After 0.025 second the receiving leg returns to spacing and causes C3 to be recharged to -60 volts. In the 0.025 second interval, the voltage across C3 will not rise to -9.1 volts, and no strobe pulses will be passed by CR5. The connect control timer, therefore, will not respond to a proceed-to-dial pulse.

J. Dialing

2.89 The dial signaling contacts are in series with the drive coils of the sending polar relay as shown in Figure 11. The dial contacts will thus energize and de-energize this relay whenever current is flowing through them. The make-break signal generated by the dial contacts will be transmitted as mark-space signals by the sending polar relay. These mark-space signals are used by the exchange to make the necessary connection.

K. Call Connection

2.90 With the call control unit in the proceed-to-dial condition, the sending leg is marking, and the receiving leg is spacing. When dialing is completed, the exchange will switch the receiving leg to marking. This signal causes the tongue of the receiving polar relay to transfer and apply +120 volts to R28. CR8 will become back-biased, and C3 will begin to discharge toward ground. After 0.080 second, the voltage across C3 will be approximately -9.1 volts. The next strobe pulse to appear will pass through CR5 to the base of Q4. The output of the connect control timer will then become positive and cause the connect circuit to turn on. As described earlier, the proceed-to-dial circuit will turn off. As the connect circuit turns on, the H(K2) relay will operate, the "h1" contacts will transfer, the CONN lamp will light, and the motor will turn on.

2.91 Current flow to the drive coils of the sending polar relay is now through R40, the drive coils, the dial contacts, CR2, the stop contacts, "h1," "wl," and the keyboard contacts to ground as shown in Figure 12. Base current to Q5 is now supplied from the marking contact of the receiving polar relay through CR12 and R31. Input current to the selector magnet driver will flow from +18 volts through R23, the selector magnet driver, Q5, CR3, J4-1, CR2, the stop contacts, "h1, "'w1," and the distributor contacts to ground.

2.92 Both the current paths for the drive coils of the sending polar relay and the selector magnet driver are through the distributor contacts. If the distributor is operated, the signal will be transmitted on the sending leg and cause the selector magnet of the teletypewriter to operate. When information is received from the distant station, the receiving polar relay will operate and make and break base current to Q5. This will cause Q5 to make and break current flow to the selector magnet driver without affecting the sending circuit.

2.93 The longest possible normal spacing signal generated by the distant teletypewriter will be less than 1.3 seconds. This is the length of spacing signal required to cause the connect control timer to disconnect. Therefore, under normal signaling, the connect control timer will not be affected by information signals.

L. Remote Connection

2.94 The call control unit may be connected remotely from either the idle line or local condition. An incoming call is indicated by the exchange by its transmission of a marking

signal on the receiving leg. The connect control timer after 0.080 second, will turn on the connect circuit in the control unit. When the "hl" contacts transfer, a current path to ground is set up through the drive coils of the sending polar relay. It will then transmit a marking signal on the sending leg to signify that the unit has connected. The remainder of the operations are the same as described in 2.90 through 2.93.

2.95 If the paper in the teletypewriter has become low and the low-paper contacts operate, the voltage across C3 will be held at -60 volts through R29. This will stop any connections from occurring. If the call control unit is already in the connect condition, when the low-paper contacts close the call may be completed, but subsequent connections will be blocked.

2.96 If a call is originated locally with a low-paper condiion, the normal sequence of events will occur until the connection is attempted. When the exchange does not receive a marking signal on the sending leg, it will return the receiving leg to spacing (idle line condition).

M. Call Disconnect

2.97 If the STOP pushbutton is depressed while the teletypewriter is in the connect condition, the stop contacts in series with the drive coils of the sending polar relay will open. The relay output will then be spacing. The exchange will recognize this long spacing signal as a request to disconnect and will send a spacing signal on the receiving leg. The receiving polar relay contacts will transfer and allow C4 to discharge toward ground. After 1.3 second, the voltage across C4 will be -9.1 volts, and the next strobe pulse will pass through CR4 to the base of Q3. The output of the timer will become negative and turn off the connect circuit in the call control unit. When the "hl" contacts transfer, current to the drive coil of the sending polar relay will be held off so that the STOP pushbutton may be released. The "hl" contacts will now also supply blinding current to the selector magnet driver. The control unit is now in the idle line condition.

N. Remote Disconnect

2.98 When the remote unit generates the spacing signal to disconnect, the receiving polar relay will allow C4 to discharge and after 1.3 seconds the timer will turn off the connect circuit. The "hl" contacts will transfer, stopping current flow to the drive coils of the sending polar relay and blinding the selector magnet driver. The call control unit is now in the idle line condiion.

O. Local Off-Line Operation

2.99 This operation is identical to that of the call control unit without polar adapter except for the current path to the selector magnet driver. This path is shown in Figure 11.

## 3. CALL CONTROL UNIT—BELL SYSTEM SWITCHED NETWORK SERVICE

### OPERATION

A. General

3.01 The call control unit provides for signaling speeds of 100 wpm from dc marking and spacing intelligence pulses originating from the distributor in the associated teletypewriter. These pulses are directed to the input of the selector magnet driver in the call control unit where they are amplified and returned to the typing unit as 0.500-ampere dc pulses to operate the selector magnet.

3.02 If the originate (ORIG) pushbutton (nonlocking) on the call control unit has been depressed and connection with a called station has been satisfactorily completed, the intelligence pulses originated by the distributor are sent to the data set. The data set converts the dc pulses to tone signals for transmission over telephone lines. Another data set, located at the called station, converts the tone signals back to dc pulses, which are directed to the input of the selector magnet driver to operate the selector in the teletypewriter of the called station. The teletypewriter at a given station copies both the transmitted and received dc signals, operating on a half-duplex basis.

3.03 Although the data set is not a part of this equipment, a brief discussion of its function is necessary to understand the operation of the system. Start-stop dc signal pulses form essentially a square wave which cannot readily be transmitted over telephone lines. The data set is basically a converter which changes the dc signals from the sending or calling station into frequency-shifted tones for transmission over the telephone network. A marking pulse from a sending station is converted to a 1270-cycle marking signal ($F_1$ mark) and a spacing pulse becomes a 1070-cycle spacing signal ($F_1$ space).

The data set at the receiving or called station sends a 2225-cycle marking signal ($F_2$ mark) and a 2025-cycle spacing signal ($F_2$ space). During transmission of a message the calling station sends mark and space tones ($F_1$ mark and space) while the called station sends a continuous mark tone ($F_2$ mark). In this way the telephone facilities are operated on a full-duplex basis. If the signal received at either station ($F_1$ mark and space at the called station and $F_2$ mark at the calling station) shifts to a space tone for more than one second, or if the received signal is lost for one second, the data set will cause the station to be disconnected. This provides assurance that the connection is maintained for the entire period of message transmission.

3.04 The call control unit used with the data set operates with conventional telephone central offices that have the necessary routing and accounting facilities. In operation, a call is originated by depressing the ORIG pushbutton. A lamp illuminates the pushbutton and the dial tone will be heard through a loudspeaker. If the line is busy, a busy signal will be heard and the clear (CLR) pushbutton (non-locking) should be depressed. If the line is not busy, the operator dials the number of the desired station. This causes the called station to go into connect condition. If the teletypewriter is manually operated, the called station operator presses the answer (ANS) pushbutton (non-locking). Following a short interval, about 1-1/2 seconds, in which telephone facilities are connected, the called station transmits a mark tone ($F_2$) and receives a mark tone ($F_1$) from the calling station. Receiving the continuous $F_2$ mark tone from the called station for second causes the calling station to go into connect condition, and its motor is turned on. Likewise, the continuous $F_1$ mark tone from the calling station for 1 second causes the called station to go into connect condition, and its motor is turned on. Either station can now transmit.

3.05 At the end of the message, either station may originate a disconnect by depressing the CLR pushbutton, at which time each station goes back to its idle condition, ready to receive or originate other calls. For keyboard practice, maintenance purposes, or preparation of copy, the local mode (LCL) pushbutton (locking) is depressed. This turns on the motor and disables automatic answering facilities, if present. In the event of an incoming call during local operation, the call control unit responds to ringing signals and the ANS pushbutton must be operated manually. Operation of the test (TST) pushbutton (locking) causes received signals to be retransmitted to the test center for maintenance purposes. A lamp, associated with each pushbutton, illuminates the pushbutton whenever that pushbutton has been operated and the operating condition exists. The ANS lamp is pulsed in response to ringing signals of an incoming call, and lights continuously when the call is answered. The CLR lamp is automatically extinguished 1.5 seconds after the pushbutton has been depressed, and disconnect is completed.

3.06 A steady mark signal blinds the associated teletypewriter during all intervals, except when in the connect condition. This prevents spurious characters from being printed except when due to loss of signals, circuit noise, or deliberate break or space-disconnect signals.

B. Power Requirements

3.07 Power input to the teletypewriter is 115V ±10 per cent, 60 cps ±2 percent. Average power consumption is 35 watts (not including typing unit motor) with peaks up to 50 watts permitted.

PROGRESS OF A CALL

3.08 To originate a call, the ORIG pushbutton is momentarily depressed. This connects the station to the line and lights the ORIG lamp. During the period of time in which connection is being made, the telephone central office makes no time measurements. When the ORIG pushbutton is closed, the call control unit is connected to the telephone line through the data set and an off-hook condition is set up. The amplifier is connected into the circuit so that the dial tone from the central office is heard. The called station is dialed while the amplfier monitors the progress.

3.09 At the called station audible and visible signaling devices are operated. The called station goes off hook and into the connect condition upon operation of the ANS pushbutton circuit, by manual or automatic means, at the distant point. At this time, there is a nonsignaling interval of 1.225 seconds during which accounting and toll recording facilities at the telephone exchange will be cleared. Following the nonsignaling interval, the called station transmits its $F_2$ mark tone and sets its monitoring timer to respond to the $F_1$ mark tone

from the calling station. When the continuous $F_2$ mark tone is received at the calling station for a period of 1 second, indicating that a station has answered, it will go into the connect condition and turn on its motor. When the continuous $F_1$ mark tone is received at the called station for an interval of 1 second, it will go into the connect condiion. The station may now acknowledge the call either by operator keyboarding, or by automatic answer-back message transmission. The monitoring timers at both stations are set to respond to reception of a space tone from the distant station. Traffic can now be exchanged from either station on a half-duplex basis.

DISCONNECTING A CALL

3.10 During the time the two stations are connected (traffic interval), either station can initiate a disconnect as follows:

(a) A call is normally terminated by the end-of-transmission (EOT) code combination which provides fast disconnect without introducing hit characters. This is accomplished by the data set in response to EOT contact closures in function boxes of both the sending and receiving teletypewriters.

(b) A call connection can also be cleared manually by momentarily depressing the CLR pushbutton. Operation of the CLR pushbutton at either station will cause transmission of a spacing signal of 1.5 seconds duration, after which the station originating the disconnect will discontinue its tone transmission and go back on hook. The other station, after receiving the spacing signal for 1 second, will automatically transmit its 1.5-second spacing signal and then go on hook. Both stations will then be back in their original idle condition in which calls can be either originated or accepted.

ANSWERING A CALL

A. Manual Answering

3.11 To answer a call manually, momentarily depress the ANS pushbutton. This connects the station to the line and lights the ANS lamp. The lamp remains lighted until the answer mode is terminated. Manual answering is necessary only when the automatic answer-back circuit is disabled. The automatic answer-back circuit is disabled by low-paper contacts, data set relay contacts (when in local mode), and the OUT OF SERV. key.

B. Automatic Answering

3.12 Call control units equipped with automatic answering facilities will respond to received ringing signals, turning the teletypewriter on at the end of the ringing interval and proceeding through to the connect condition. Automatic message answer-back is a part of this feature. The presence of an operator is required in order to complete disconnect and return the teletypewriter to idle condition. For unattended service, an automatic disconnect timing device (optional) actuated when a call is answered, will cause the teletypewriter to go through the connect condition, send the 1.5-second spacing tone, and go back on hook if the $F_1$ mark tone is not received within 8 seconds after the called station answered. This is designed to prevent the unattended station from being made busy by (telephone) calls that fail to cause a full connection to be set up. This feature does not affect normal automatic disconnect upon receiving the 1-second spacing tone or loss of tones due to a dropoff.

LOCAL MODE

3.13 The local mode (LCL) provides off-line operation of the teletypewriter. The operator selects the local mode by depressing the LCL pushbutton. This lights the LCL lamp and operates the motor control relay (MCR) to energize the motor. The data set connects the sending circuit to the receiving circuit and enables the keyboard and answer-back to transmit. In this condition the teletypewriter can be used for preparing copy, for operator practice, or for maintenance purposes. If an incoming signal is received during this time, ringing signals are received and manual operation of the ANS pushbutton is required in order to receive the message. If the teletypewriter is in a terminal hunting group, the operator must turn the out-of-service (OUT-OF-SERV.) knob to the RESTORE position momentarily and then to NORMAL.

"OUT-OF-SERV." SWITCH

3.14 The OUT OF SERV. switch prevents the automatic answering of incoming calls. In its NORMAL position (arrow on knob upright), it has no effect or function; in the OUT OF SERV. position (knob rotated counterclockwise and detented) it sets the following conditions:

(a) A contact is closed that causes the OUT OF SERV. lamp to light.

(b) A contact is closed that shorts the ringer coils. This makes the ringer inoperative. As an option the contact can be located to shunt both the ringer and series capacitor (i e , the telephone line). This makes the station appear to be in an off-hook condition or busy to the central office.

(c) A contact is opened that breaks the automatic answer circuit to the answer relay. This prevents the relay from operating in response to the ring-up relay and thus the teletypewriter will not answer.

3.15 For stations that are not in terminal hunting groups, the operator may return the teletypewriter to service by turning the OUT OF SERV. knob to the NORMAL position. For terminal hunting stations, however, the operator must turn the knob to the RESTORE position and hold it until a dial tone is heard. In this position:

(a) A contact is closed that shorts the tip to ring (off-hook condition). This condition is detected by the central office which then releases the teletypewriter from lockout and applies the dial tone.

(b) A contact is closed that completes a path from the speaker amplifier to ground. This permits the amplifier to pass the line signals (dial tone).

The OUT OF SERV. switch is then restored to NORMAL.

LOW-PAPER ALARM

3.16 A low-paper alarm is provided in the teletypewriter. When a low-paper condition occurs, make contacts in the low-paper switch provide ground to the low-paper buzzer, permitting it to operate. Depressing the buzzer-release (BUZ-RLS) pushbutton (locking) in the call control unit silences the buzzer and causes the BUZ-RLS lamp to light. Attempting to release the pushbutton without replenishing the paper supply will result in the buzzer operating. When the paper has been replenished, the teletypewriter is returned to normal by releasing the BUZ-RLS pushbutton.

3.17 Break contacts on the low-paper switch disable the automatic answer-back circuit. The operator can override this condition by answering manually. If the low-paper alarm accurs during a call the operator has the option of completing the call before changing the paper, or interrupting the call. To interrupt the call, the operator stops transmission by depressing the keyboard BREAK key, and then depressing the BRK-RLS pushbutton to notify the distant station of the problem. The connection is cleared by simultaneously operating the control (CTRL) and EOT keys on the keyboard. Turning the OUT OF SERV. knob to the detent position insures that the teletypewriter will not automatically answer a call while paper is being replenished.

3.18 To restore the teletypewriter to service after the paper has been inserted, depress the CLR pushbutton and return the OUT OF SERV. knob to its NORMAL position. (For teletypewriters in terminal hunting groups, turn the knob to its RESTORE position and hold it there. When dial tone is heard, release the knob.) The teletypewriter is now in a normal idle operating position.

RESTRAIN LAMP

3.19 This high intensity restrain (REST) lamp lights when a restraining signal is received from an 8-level to a 5-level converter used in transmission to 5-level TWX stations on the DDD switching plan. The lamp remains lighted until the restraining signal is removed. The purpose of this feature is to limit the sending speed from 8-level teletypewriter transmitting at 100 wpm to 5-level teletypewriters receiving at 60 wpm.

TEST MODE

3.20 If the TST pushbutton is operated while the teletypewriter is connected to a test center, the message sent by the test center will be recorded on the teletypewriter and turned around and sent back for analysis. This is accomplished by connecting the teletypewriter to the data set through a set of transfer contacts and a break contact to ground. This type of operation can be terminated by momentarily operating any of the nonlocking pushbuttons which will then release the TST locking pushbutton.

SIGNAL GENERATION

3.31 The teletypewriter can send by operating the keyboard, answer-back mechanism, or BREAK key. The keyboard signal generator contacts and answer-back contacts are in parallel with the signal generator (distributor) which is, in turn, connected to the data set. The BREAK key connects to the data set via separate leads.

SELECTOR MAGNET DRIVER

A. General

3.22 The data set supplies a 20-ma dc signal to the selector magnet driver associated with the teletypewriter. The selector magnet driver amplifies the signal to 500 ma to operate the selector on the teletypewriter. The selector magnet driver is a 2-stage transistorized amplifier capable of switching high output currents (0.500 ampere) at very closely controlled input current levels. The output of the selector magnet driver is automatically regulated and is essentially independent of normal variations in power supply voltage and of selector-magnet and current-limiting resistance values.

B. Circuit Description

3.23 Figure 13 illustrates a schematic drawing of a selector magnet driver circuit.

3.24 Open Line: When the line circuit is open (spacing), transistor Q1 will be turned on by the regulated current flowing through R1 into its base. This current, which is controlled by R1, will be set near the desired switching level. With Q1 conducting, Q2 will be cut off, since the potential at the base of Q2 will be more positive than at the emitter. In this condition only small leakage currents will flow in the collector circuit.

3.25 Space-to-Mark Transition: As the space-to-mark transition begins, the negative bias current flowing in the base of Q1 is diverted to the line circuit. As the line current rises toward the marking current value, it

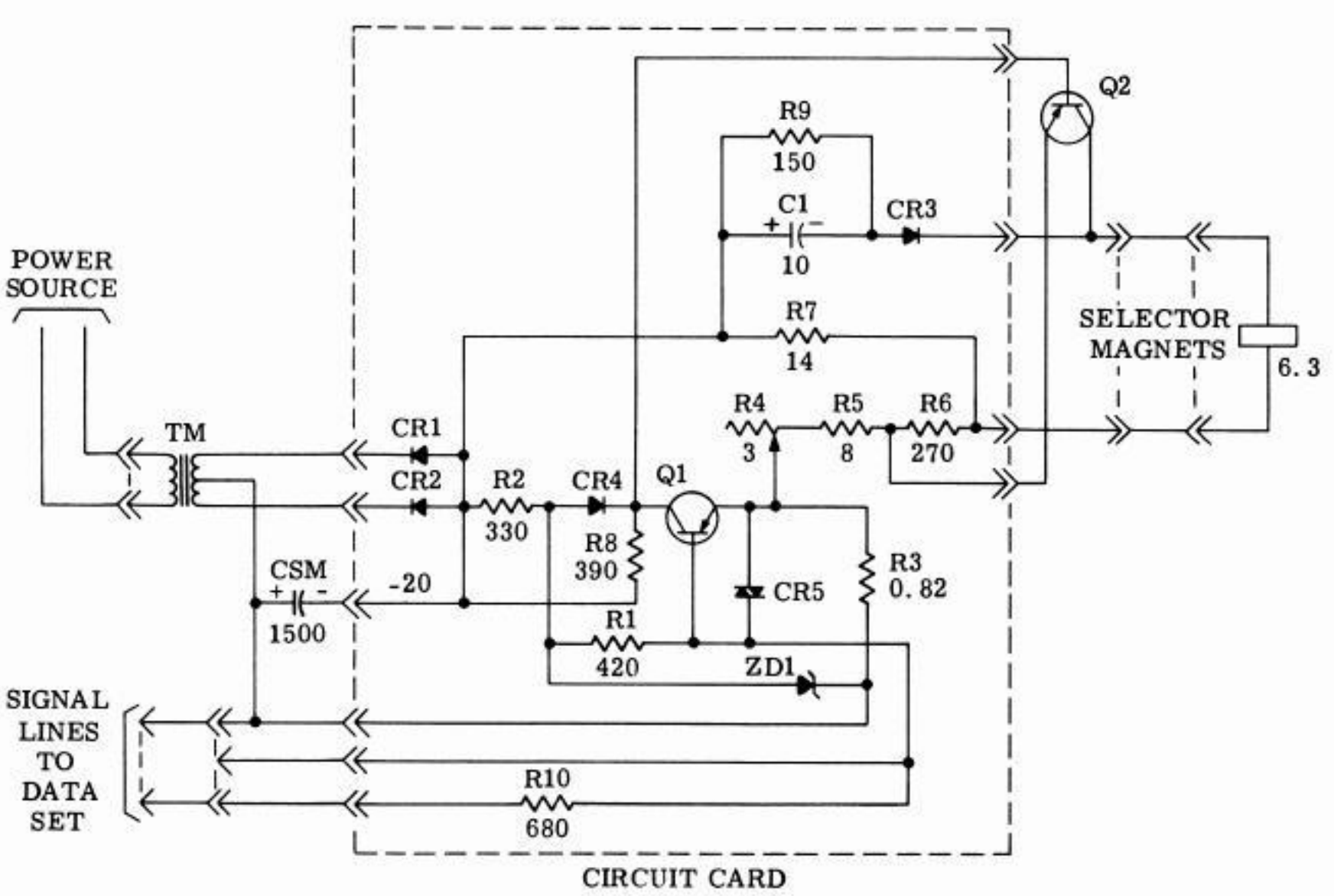



Figure 13 - Selector Magnet Driver Circuit

extracts base current from Q1. When the line current approaches the total current supplied to the base of Q1 to within 0.001 ampere, which is about one-half the nominal mark current value, Q1 begins to turn off. Q2 will then begin to receive forward bias current from R8 and begin to turn on. The base current will then be amplified by Q2, and a current which is a multiple of the base current will appear in the emitter circuit. This increase in emitter current results in an increase in the negative potential measured across R3. The increase in the negative potential at the emitter of Q1 causes it to go further into cutoff. The feedback process continues until the current in the selector magnet reaches a value which is determined by the Zener reference voltage, clamp diode CR4, and the emitter resistance of Q2 (the emitter resistance of Q2 is adjusted by R4 to compensate for component variations. As the line current completes the transition to the final marking current value, the base of Q1 becomes positively biased. The positive bias current will be approximately one-half the total marking line current. The positive potential to the base of Q1 is clamped to approximately 0.6 volt by the input protecting varistor, CR5.

3.26 Mark-to-Space Transition: The line current, in changing from mark to space, will finally reach the point where R1 will begin to supply some forward current to the base of Q1. The line current level at which this occurs will be a little more negative than the point at which the circuit switched from space to mark, due to the common emitter resistor voltage feedback. As Q1 begins to turn on, the current through R8 will be diverted from the base of Q2, causing it to begin to turn off. As Q2 turns off, the voltage across R4 will begin to go positive, causing Q1 to be further turned on. This effect gives regeneration to the mark-to-space transition.

3.27 Mark-to-Space Switching Transient: When Q2 is turned off during the mark-to-space transition, a negative voltage transient is developed at its collector. This transient is due to dissipation of the energy stored in the magnetic field of the driven magnet when energized by 0.500 ampere. If the high voltage developed at the collector of Q2 were not limited, it would continue to rise until it reaches the point where the collector-to-emitter breakdown voltage is exceeded. It has been found that repeated breakdown of this kind causes deterioration of the transistor and finally a collector-to-emitter short circuit. Therefore, it is necessary to provide a transient suppressing network at the collector of Q2. The transient-suppression network presently in use is a compromise which affords a minimum peak voltage combined with a magnet release time to provide for adequate teletypewriter margins. The network consists of C1 in parallel with R9. CR3 isolates the network from voltages more positive than negative battery potential.

SPEAKER AMPLIFIER SYSTEM

3.28 Figure 14 illustrates a schematic diagram of a speaker amplifier circuit.

3.29 The speaker amplifier is powered only after the ORIG key is operated and is quieted when the station connects. It has two inputs, one from the telephone line via the buffer amplifier in the data set limiter and the other from the multifrequency (MF) tone dialer. Three outputs are provided: (1) into the speaker or optional hand-held receiver; (2) into the telephone line through the sending amplifier in the data set; and (3) an auxiliary output into the data set. The line-to-speaker connection permits monitoring of supervisory signals when originating a call. The TOUCH-TONE dial-to-line and TOUCH-TONE dial-to-speaker connection provides for amplification of the outgoing MF dialing signals and for monitoring them during outpulsing. The line-to-second-output connection is provided for the dial tone detector (when furnished). The various connections mentioned are established by switching in the data set and by the common switch in the TOUCH-TONE dialer.

3.30 The speaker amplifier is a conventional direct-coupled, 2-transistor audio amplifier. The input signals from the telephone line are fed through the receiving buffer amplifier in the data set into the primary winding of the input transformer (T1). The primary winding continually carries approximately 4 ma quiescent current from the receiving buffer amplifier. The other input, from the TOUCH-TONE dialer is fed directly into Q1 through C5. Both inputs are dc isolated from the amplifier stages.

3.31 Two outputs are taken from transistor Q2, one from the collector circuit and the other from the emitter.

(a) The collector output is fed through a step-down output transformer (T2) into

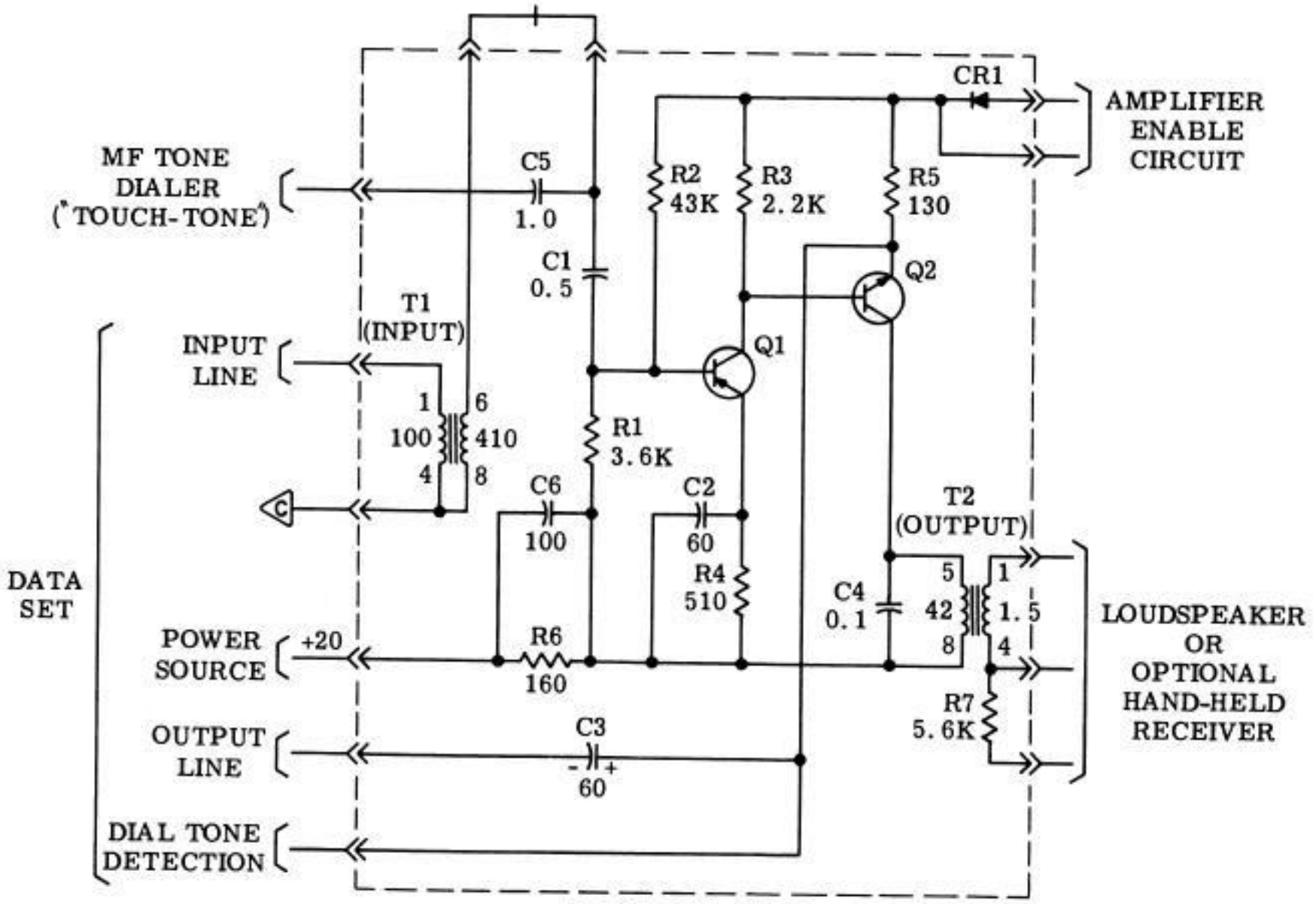



Figure 14 - Speaker Amplifier Circuit

the speaker (or receiver). A potentiometer is used to set proper volume for varying loop loss and ambient noise level. The TOUCH-TONE dialer signals are independent of loop loss.

(b) The emitter output splits into two signal lines: one for injecting the MF dial tones into the data set sending amplifier, and the other for feeding the dial-tone detection circuit (when provided). The signal level from the emitter output is essentially independent from the setting of the potentiometer.

3.32 Bypassed R6 is a supply voltage dropping resistor. Diode CR1 is provided to block a sneak path (in the answer mode) from ground through the ANS and ORIG lamps. Without the CR1, the ORIG lamp would be dimly lit and the amplifier would not be silent when the station is in the answer mode. The amplifier operates only in the originate mode until the station connects. In any mode other than originate, the ground is disconnected. When the station connects, the amplifier input is short-circuited in the dial set.

DIALER MECHANISMS

A. Pulsing Rotary Dialer

3.33 For rotary dialer applications, a pulsing contact of the rotary dialer is inserted into the telephone line. The manual rotary dialer is equipped with a normally closed pulsing contact and a normally opened off-normal contact. The pulsing contact is inserted into the telephone line when the station originates a call. When answering, a short circuit is applied across the pulsing contact. The off-normal contact is placed across the output of the amplifier and silences the speaker whenever the dialing disc is moved.

B. Pulsing Card Dialer (40A Dialer)

3.34 The 40A dialer is operated by direct current furnished from the central office.

3.35 To use the card dialer, the ORIG push-button is depressed. After a dial tone has been received, a card with the telephone number punched in it is inserted in the slot and entirely pushed in. This operation winds a spring motor, which later pushes the card out of the slot as the dialing proceeds.

3.36 The card dialer is started by momentarily depressing the START bar. This operates the card dialer start contact and establishes a path from the ring side of the telephone line through point no. 5 on the card dialer, the released pulsing relay K(P) contacts, released home and dial start contacts, operated dial start contacts, and point no. 2 on the card dialer to the tip side of the telephone line. The current from the central office battery operates the K(P) contacts which transfers the ring-to-tip path to the matrix. This path is closed or opened according to the code punched in the card. The dial pulse is transmitted as the sensing springs sense the holes in the card.

3.37 Sending of the dial pulse means interruption of the current in the telephone line. This releases the K(P) contact. Movement of the K(P) relay armature rotates the scanning drum by 1/16 revolution so that the next digit pulse can be sensed and transmitted as the K(P) relay reoperates. After two pulses have been transmitted, the home contacts operate and remain operated until the end of the scanning drum revolution. This establishes a direct operating path for the K(P) relay so that, when the station is returned on hook in the middle of the digit, the digit pulsing can be completed and the drum will be returned to its normal (home) position.

3.38 In this manner, the drum completes the revolution in 16 steps. Ten of the steps are required to send the digits, and six to provide the interdigital time. At the completion of the revolutions, an escapement is tripped which permits the next row of holes on the card to be placed in position for sensing.

3.39 This sequence is repeated at each row as the card advances out of the card dialer. If no "stop" code is punched in the card, the card dialer will keep advancing the card (even if no number code is punched) until the card is released. If the "stop" code is sensed, the card dialer stop contacts operate. With the home contacts released, a transmission path is established from the telephone line to the data set input as follows: Ring side of the telephone line through point no. 5, dial stop contacts operated, home contacts released, point no. 1, hybrid transformer in the data set, to the tip side of the telephone line. The data set can then complete the connection.

3.40 When the station is connected, the card can be released by operating the RELEASE bar. No attempt should be made to release the card by reoperating the START bar, as this will trigger the card dialer mechanism and the following short circuit will be placed across the output of the data set: Point no. 1, home and dial start contacts released, dial start contacts operated, point no. 2. And, after the two first pulses on each revolution: Point no. 1, home contacts operated, point no. 6. This shunt will prevent the station from receiving or sending until the card is disengaged. If this condition persists, the data set will disconnect.

C. Pulsing Card Dialer (41A Dialer)

3.41 Figure 15 illustrates a schematic drawing of a pulsing card dialer (41A dialer).

3.42 In locations with 60-cycle ac power the 41A dialer is used. In this dialer the power to operate the commutator disc is derived from a synchronous motor powered by the 14V ac source in the teletypewriter. The power to advance the card in the dialer is derived from a spring wound by inserting the card in the slot. The switching functions and the motor control are independent of the signal path. These features result in a superior performance as compared with the 40A dialer.

3.43 To operate the dialer, the card is inserted and the START bar is momentarily operated. This closes the start contacts and power is applied to the motor which starts driving the commutator disc. In rotating, the disc closes and opens the path between points no. 5 and 6, causing the dial pulses to be sent to the line.

3.44 When the pulses sent reach the number punched in the card, control relay K1 operates. Operation of K1 applies a short circuit between points no. 5 and 6 and disengages the clutch, allowing the disc to return home. Mechanical linkage then permits the spring, wound by inserting the card, to advance the card for the next digit to be read and dialed.

3.45 As the "stop" code is read, the dialing stops. The card can then (as also at any

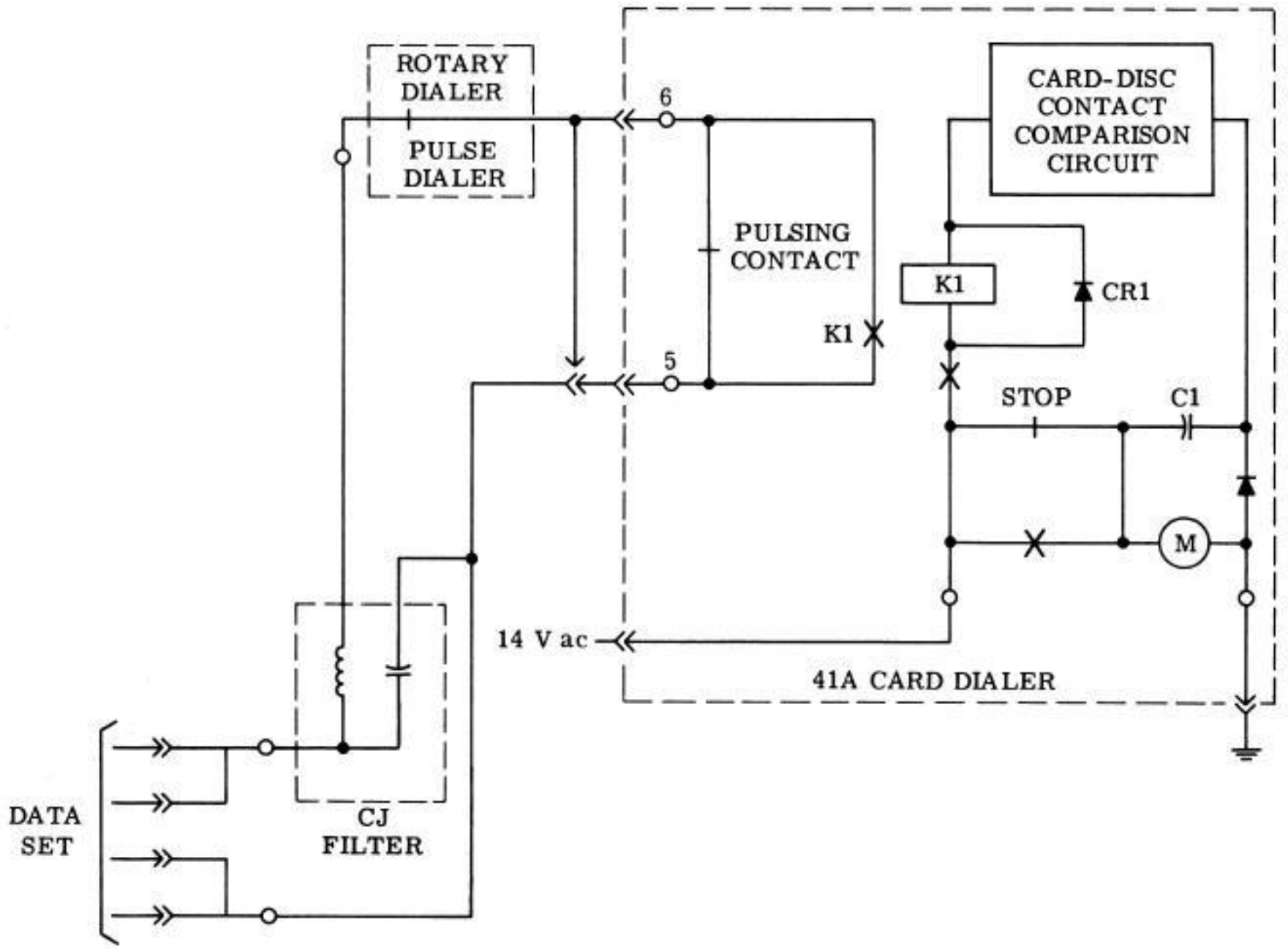



Figure 15 - Pulsing Card Dialer (41A Dialer) Circuit

other time) be released by operating the RELEASE bar.

D. TOUCH-TONE Dialer

3.46 Figure 16 illustrates a schematic drawing of a TOUCH-TONE card dialer circuit.

3.47 For multifrequency (MF) dialing applications, the dialing frequencies generated by the TOUCH-TONE dialer are fed through the loudspeaker amplifier and into the telephone line via the sending amplifier in the data set. As the station connects, the output of the TOUCH-TONE dialer is disconnected from the data set so that there is no hazard connected with improper operation of the TOUCH-TONE dialer at that time.

3.48 The TOUCH-TONE MF signal generated is a 1-transistor oscillator generating two frequencies any time a single pushbutton is operated. Seven frequencies are provided, with each dial digit corresponding to two frequencies according to the table below:

TOUCH-TONE

Frequencies

| cps → / ↓ | 1209 | 1336 | 1477 | |
|---|---|---|---|---|
| 697 | 1 | 2 | 3 | |
| 770 | 4 | 5 | 6 | Dial |
| 851 | 7 | 8 | 9 | Digits |
| 941 | | 10 | | |

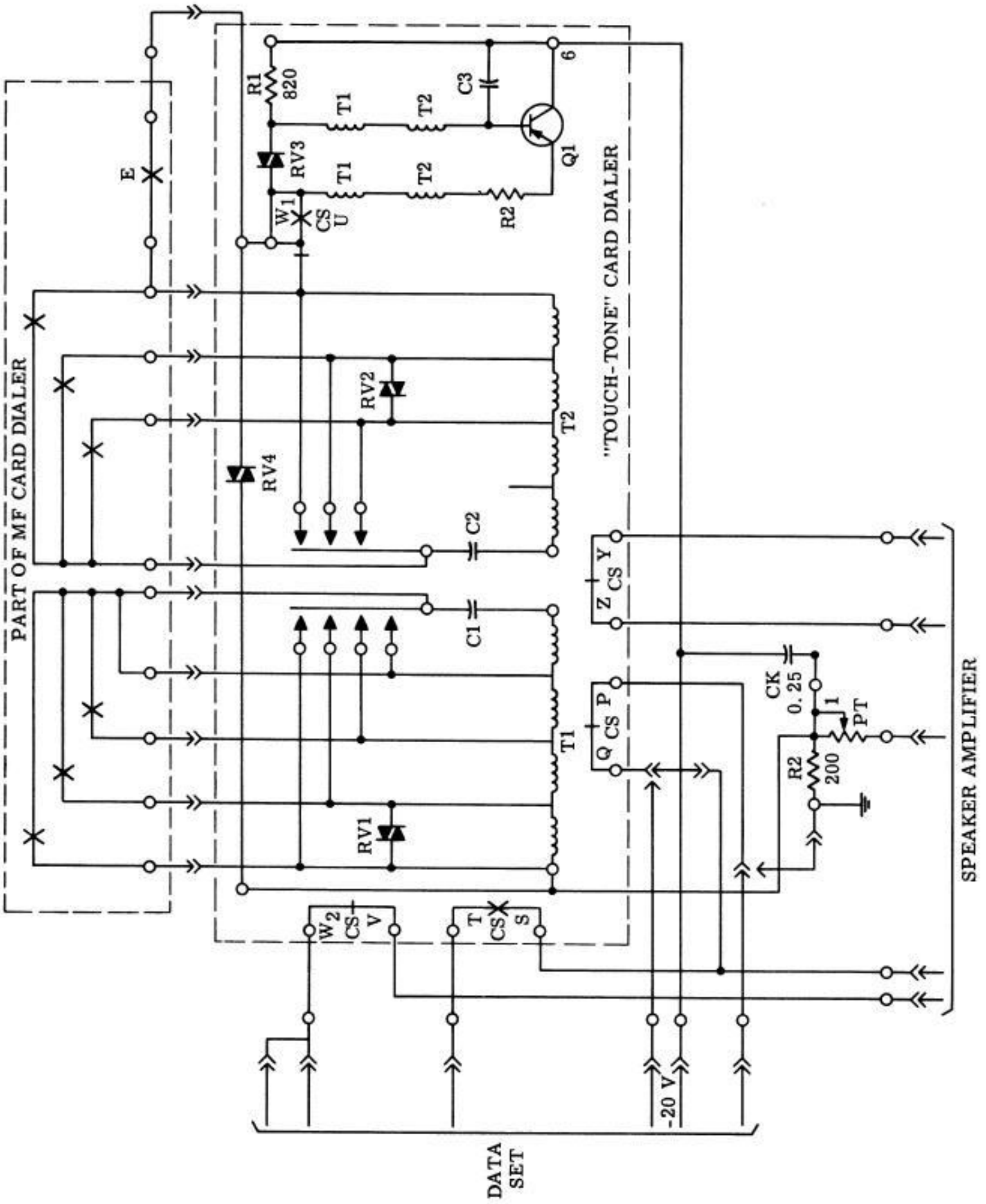



Figure 16 - TOUCH-TONE Card Dialer Circuit

3.49 When the station is idle, a current of about 25 ma flows from ground through PT resistance of point no. 1 of the TOUCH-TONE dialer; then through varistors RV3 and RV4, resistor R1, and out of point no. 6 to -20V in the data set. The transistor Q1 is energized, so that there will be no click when the circuit starts to generate the MF signal. The oscillations are suppressed by dc current through the tank coils T1 and T2 maintained by the potential difference across RV4. By interrupting this initial coil current the oscillation build-up time is minimized.

3.50 To dial a digit, a pushbutton on the dialing plate is operated. This closes two frequency-determining contacts, one for the T1-C1 tank circuit, and the other for the T2-C2 tank circuit. The common switch (CS) operates in the following sequence:

(1) Y-Z contacts open, making the speaker amplifier input available to MF signal only.

(2) S-T contacts close and establish a path from the speaker amplifier, through the sending amplifier in the data set, and into the telephone line. The feedback through the receiving buffer amplifier in the data set back into the speaker amplifier is disabled by previously operated Y-Z contacts.

(3) $W_2$-V contacts open, disabling the receiving buffer amplifier in the data set. This eliminates a possibility of false connect due to MF signals.

(4) Q-P contacts open, together with $W_2$-Y contacts, resetting the dial-tone detecting circuits, when furnished.

(5) $W_1$-U contacts open, interrupting the dc current through the tank coils. Since the tank T1-C1 and T2-C2 are coupled to the coils in the Q1 circuit, the unit starts oscillating with a very short build-up time.

3.51 The same functions could be assured with $W_2$-V contacts operating first and Y-Z contacts eliminated. However, the interruption of current in the primary coil of the input transformer in the speaker amplifier would cause a loud click to be heard every time a digit is dialed.

3.52 The frequencies above 1000 cps are generated at a somewhat higher level to compensate for greater line loss at those frequencies. There is also a variation of amplitude for various digits. The PT resistor is set at the time of assembly of the call control unit with the data set for an output of 0 dbm on the telephone line for the digit with the highest output level.

E. TOUCH-TONE and Card Dialer

3.53 To use the automatic card dialer, the ORIG pushbutton is depressed. After the dial tone has been received, a punched card is inserted into the slot and pushed down. The START bar is then momentarily operated. The card dialer proceeds with dialing under power of a spring motor wound by insertion of the card. When a "stop" code is read, the dialing stops. The card should then be released by re-operating the START bar.

3.54 The sensing contacts in the card dialer are in parallel with the frequency-determining contacts in the associated TOUCH-TONE dialer. As the card advances out of the slot, the sensing contacts sense the holes punched in the card and thus determine the proper frequencies to be transmitted. This occurs for every row on the card.

3.55 The normally opened E contacts in the card dialer are placed across the excitation $W_1$-U contacts in the TOUCH-TONE dialer. When dialing manually, the E contacts are opened and there is no interference from the card dialer. With the card down in the slot, the operation of the START bar closes the E contacts and operates the common switch, through mechanical linkage, for the duration of dialing. The common switch connects the input and output circuits of the loudspeaker amplifier, as described previously. Opening of the $W_1$-U contacts transfers the excitation function to the E contacts in the card dialer. As the card advances out of the slot, the E contacts open for each row, exciting the TOUCH-TONE dialer into generating the MF signals.

3.56 During dialing, there are short intervals of time when all the sensing contacts are opened and the E contacts are open. Therefore, the TOUCH-TONE dialer will break into spurious oscillations somewhere between 7 and 14 kc. Although this frequency band is suppressed by the telephone line, these frequencies would be noticeable on the loudspeaker. The actions of capacitors CK and C4A in the

speaker amplifier combine to suppress this spurious signal from reaching the loudspeaker.

3.57 Since the card advances out of the slot very rapidly, there is no need for a separate RELEASE bar. When the station connects, relay contacts in the data set disconnect the MF signal input and remove any hazard connected with false operation of the TOUCH-TONE dialer.

## 4. CALL CONTROL UNIT—PRIVATE WIRE SERVICE

### OPERATION

4.01 Power for the motor, selector magnet driver, local power supply, and tape reader power pack, when provided, is supplied from fused 115-volt ac, 60 cps power. Direct current of either 0.020 or 0.060 ampere is required for the signal line(s) and for operation in the local mode. Battery for the signal line(s) is supplied by the customer's facilities, while local battery for operation in the local mode is furnished through the operation of the local power supply circuit in the call control unit. At the rear of the call control unit is a terminal strip which provides the point of entry for the ac power and the signal line(s) into the teletypewriter.

4.02 The purpose of the selector magnet driver is to amplify received dc marking and spacing intelligence pulses. Received dc intelligence pulses are directed to the input of the selector magnet driver circuit in the call control unit where they are amplified and returned as 0.500-ampere dc intelligence pulses to operate the typing unit selector. A detailed description of the operation of a selector magnet driver is given in 3.22 through 3.27. The selector magnet driver described there is similar to the ones used in private wire service.

4.03 A 3-position rotary power switch is the only manual control on the call control unit. Its purpose is threefold: Through the operation of the rotary power switch, the teletypewriter can be (1) placed in the external signal line loop for communication with other teletypewriters, (2) removed from the external signal line loop for local operation, or (3) placed in the off condition.

### POWER SWITCH

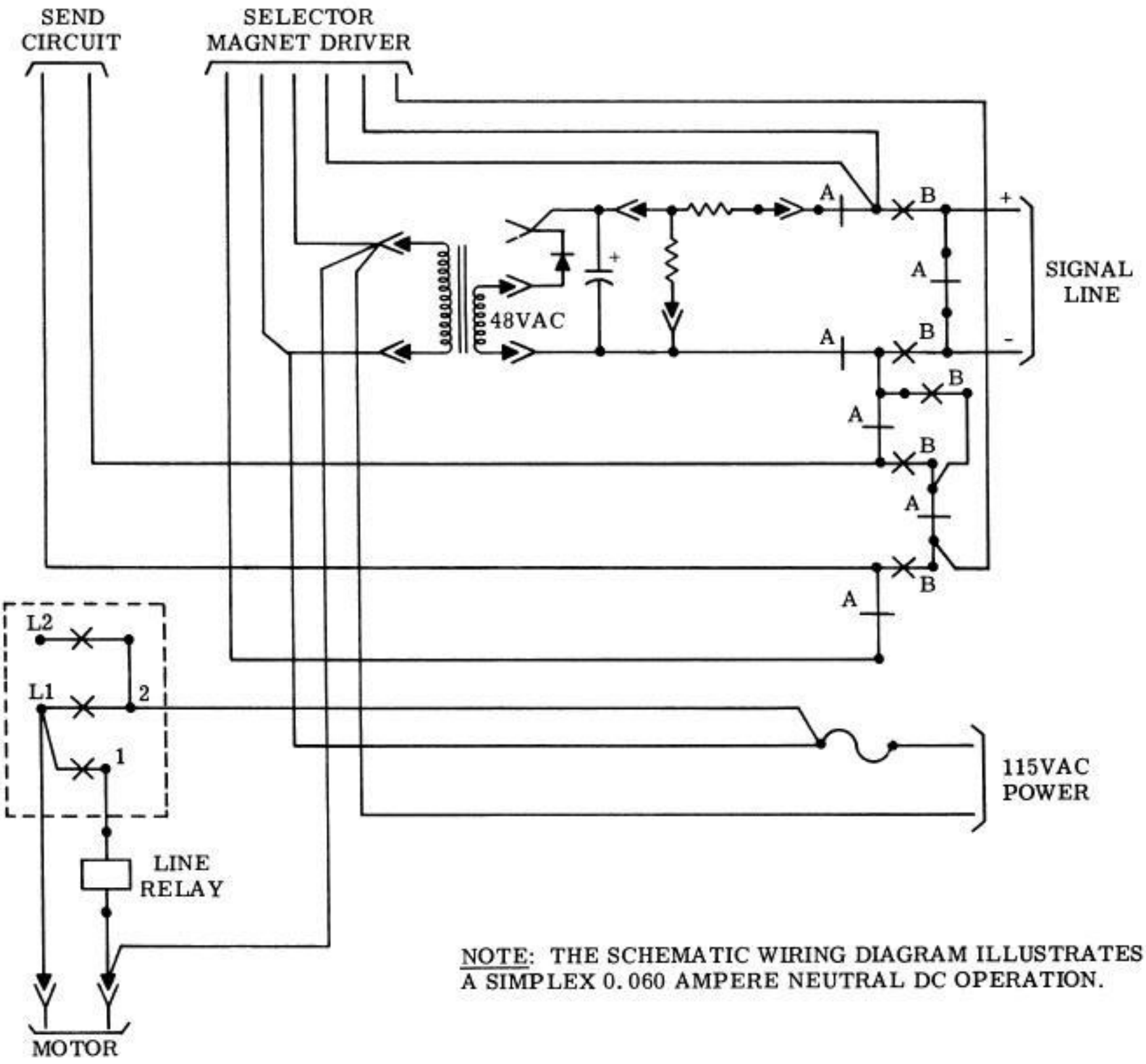
4.04 Figure 17 is a schematic drawing of the rotary power switch and local power supply circuits. The following chart indicates the condition of the rotary power switch contacts - either open or closed - when the control knob is turned to one of its positions:

| Knob Position | Line Segment From | To | Contacts Condition |
|---|---|---|---|
| LINE | L1 | 2 | Closed |
| | L1 | 1 | Closed |
| | L2 | 2 | Open |
| LOCAL | L1 | 2 | Closed |
| | L1 | 1 | Open |
| | L2 | 2 | Closed |
| OFF | — | — | All Open |

4.05 With the rotary power switch in the off mode — the control knob is in the OFF position—the signal line is diverted around the local teletypewriter, and other teletypewriters in the external signal line loop can communicate without interference. All power in the call control unit, except the ac power to the selector magnet driver, is off.

4.06 When the rotary power switch is placed in the local mode—the control knob turned to the LOCAL position—the line relay is not energized. The normally closed contacts A remain closed, and the normally open contacts B remain open. In this condition the circuit is such that (1) local battery is supplied to the selector magnet driver and the send circuit, (2) the external signal line loop is divorced from the selector magnet driver, and (3) the external signal line loop is shunted so that other teletypewriters in that loop can communicate without being affected by the operation of the local teletypewriter.

4.07 If the rotary power switch is placed in the line mode—the control knob turned to the LINE position—the line relay is energized. This causes the normally closed contacts A to open and the normally open contacts B to close. Thus, the normally closed contacts A and the noramally open contacts B are conditioned such that (1) the external signal line loop is united with the selector magnet driver, and (2) the local teletypewriter is placed in the external signal line loop, so that it can communicate with




NOTE: THE SCHEMATIC WIRING DIAGRAM ILLUSTRATES A SIMPLEX 0.060 AMPERE NEUTRAL DC OPERATION.

Figure 17 - Rotary Power Switch and Local Power Supply Circuit

other teletypewriters in that loop. With battery on the signal line, any transmission from the keyboard or tape reader, when provided, will cause the typing unit distributor to send start-stop signals to other teletypewriters in the external signal loop. Also, the local teletypewriter is able to receive, through the typing unit selector, the start-stop signals transmitted from other teletypewriters in the external signal line loop.

## 5. CALL CONTROL UNIT – CIRCUIT SWITCHING SERVICE

### OPERATION

### A. General

5.01 The call control unit provides the facilities for operating a teletypewriter in a circuit switching network. The facilities include means of initiating or accepting, and controlling calls over telegraph loops utilizing neutral signaling. Provisions are made for including a polar adapter. In the following discussion, refer to wiring diagrams 6481WD, 7227WD or 7267WD, as applicable.

5.02 A selector magnet driver circuit delivers marking signals of 0.500 ampere and spacing signals of essentially 0 ampere to the associated selector magnet. The signals trigger the selector magnet driver circuit at about half the current level for normal (0.060 ampere mark) neutral signals. In teletypewriters modified for polar operation, the signal is applied to the polar-to-neutral converting circuits and then to the selector magnets.

5.03 The operator's controls consist of four pushbuttons for selecting the various operating conditions. They are designated REQUEST, CONN, LCL, and DISCONN. Each pushbutton except DISCONN contains an internal lamp to provide a visual indication.

### B. Idle Signal Line

5.04 When the telegraph loop is quiescent (positive current of 0.005 ampere applied through the designated terminal), the teletypewriter is idle with motor off and all visual indicators extinguished.

### C. Request Circuit

5.05 Operation of the REQUEST pushbutton shunts the major portion of the loop resistance, causing loop current to increase to 0.060 ampere. The REQUEST lamp lights and the motor turns on. The lamp is extinguished when the pushbutton is released or when a connection is made. The motor turns off when the REQUEST pushbutton is released before a connection is made.

### D. Connect Circuit

5.06 The exchange facilities acknowledge the request signal by connecting a register unit to the calling position's telegraph lines. A register attached signal is transmitted to the calling station. This signal is a reversal of loop current, which lights the CONN lamp and extinguishes the REQUEST lamp. The calling station may then proceed, by tape, to send the prefix and call numbers of the called subscriber to the register. The register stores the characters and then proceeds to set up the connection. If a connection can be made, the register seizes the called station, turning on its motor and lighting the CONN lamp by reversing the loop current from positive to negative. The register then transmits the character WRU to the called station, tripping its answer-back. As the answer-back is transmitted, the register compares it with the stored call number to insure that the correct subscriber was reached. If the comparison indicates a correct connection, the register releases from the circuit. Transmission of traffic may now proceed using line signals of 0.060 ampere for mark and zero current for space.

### E. Disconnect Circuit

5.07 When transmission has been completed, the operator at either station may release the connection by depressing the DISCONN pushbutton which causes an open line (zero current). The exchange initiates a disconnect at the distant station by reversing the loop current. Within three seconds, and with the DISCONN pushbutton depressed, the local motor turns off and the CONN lamp is extinguished. The idle condition is restored.

### F. Remote Disconnect Circuit

5.08 When the called station initiates a disconnect, the exchange reverses the loop current at the local station to positive and the station is restored to idle as above.

### G. Busy Signal

5.09 In the event the distant station is busy, the register transmits the designated characters to the calling station, initiates a disconnect, and releases the connection.

H. Local Circuit

5.10 Operation of the LCL pushbutton places the teletypewriter in an offline operating mode. The associated lamp lights giving a visual indication of the condition. The teletypewriter is restored to idle when the DISCONN pushbutton is depressed. A call can be initiated, without first disconnecting, by depressing the REQUEST key. If a call is received while the teletypewriter is in LCL, a time interval of not more than 2.6 seconds will elapse during which time an audible alarm (buzzer) is sounded. The teletypewriter automatically switches to the call-connected condition and lights the CONN lamp.

ANALYSIS OF CIRCUITS

A. Selector Magnet Driver

5.11 The selector magnet driver is described in Paragraphs 2.37 through 2.41. It is illustrated schematically in Figure 8.

B. Motor Delay Timer

5.12 The motor delay timer is described in Paragraphs 2.42 through 2.48. It is illustrated schematically in Figure 9.

C. Polar Adapter

5.13 The polar adapter that may be used with the call control unit for circuit switching service is described in Paragraphs 2.49 through 2.99.

D. Request Circuit (Figure 18)

5.14 This circuit consists of a binary with a line input amplifier. The binary consists of transistors Q2 and Q3 and associated components. The low pass filter or delay network is made up of R5 and C1. The line input amplifier consists of Q1 and associated components and is connected to the binary through a low pass filter or delay network, which is used to suppress line noise. Input to the binary from the filter through R6 turns the request circuit on. One other control input is available, through resistor R15 which turns the request off when the set is connected.

5.15 When transistor Q2 is in conduction, its collector is near neutral potential. Current will then flow through Q2, R11, S3-1, S3-2, and R27. Current also flows from +18 volts through R8 and CR9 to the collector of Q2. The base of Q3 is held at +0.8 volts with respect to the collector of Q2, due to the current flow through CR9. The base of Q3, therefore, is slightly positive with respect to neutral, and Q3 is turned off. With Q3 off, its collector is negative and base current to Q2 is supplied through a low pass filter consisting of R9, R10 and C3 which holds Q2 in conduction.

5.16 When transistor Q3 is in conduction, the request circuit is on and the Q3 collector is very near neutral. Current flows through Q3, K1, XDS-1 and R27. Since the collector of Q3 is near neutral, current flow through R7 and R9, and R10 produces a positive potential at the base of Q2 which holds Q2 off. With Q2 off, base current for Q3 flows through CR9, R11, S3-1, S2-3, and R27, holding Q3 in conduction.

5.17 When an input current of less than 0.008 ampere flows from terminal T8 across CR4 to neutral, a potential of -0.8 volts is developed across CR4, and holds Q1 off. The collector of Q1 becomes positive. Current flows through R4 and R5 to charge C1 towards +18 volts. When sufficient voltage is developed across C1, the base of Q2 is back-biased through R6. Transistor Q2 turns off and Q3 turns on if a negative potential is connected to its base. Back-bias to the base of Q2 is then supplied by the voltage divider R7, R9 and R10, and the positive potential across R6 is no longer required to hold Q2 off. Should more than 0.008 ampere flow across CR4 from terminal T8 to neutral, a potential of +0.8 volt will develop across CR4 turning on Q1. The Q1 collector then goes to neutral.

5.18 If a negative signal is applied to the side of R15 opposite the base of Q2, sufficient current flows to forward-bias the base of Q2 and bring it into conduction. Q3 will turn off and supply sufficient base current through R9 and R10 to hold Q2 in conduction. The negative signal at R15 may now be removed, and Q2 will remain in conduction.

5.19 With the request circuit on, Q3 is in conduction, base current for Q3 flows through R11 and CR9. By operating the DISCONNECT pushbutton, contacts S3-1 and S3-2 open the current path. Q3 will then turn off and Q2 will turn on. Collector current does not flow in Q2, but its collector is near neutral, holding Q3 off.

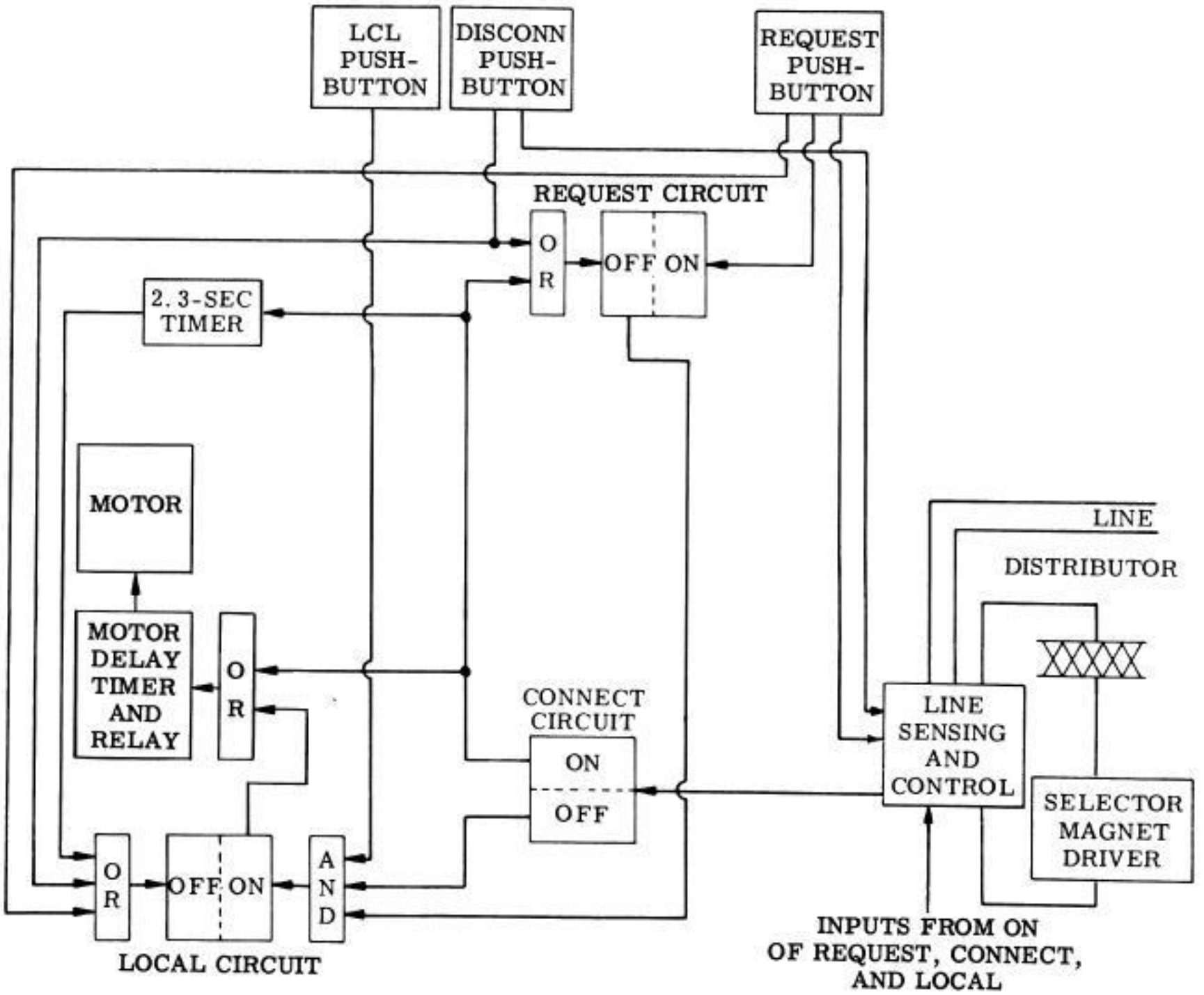



Figure 18 - Block Diagram of Control Circuits

E. Connect Circuit (Figure 18)

5.20 This circuit consists of a binary (Q4 and Q6), one side of which is driven by an emitter follower. The only control input used is connected to the emitter follower through R12 and R13. C2 and R12 form a low pass filter or delay network. The signal delay in the network is approximately 0.02 second. The control is by the signal line only and no positive local controls are available. A single passive control, consisting of R28 and CR3 is used for low paper conditions.

5.21 Emitter follower Q5 controls the base of Q4. If Q4 is in conduction, its collector is near neutral. The voltage divider, R17 and R18, holds the base of Q6 positive and off. The collector of Q6 is negative and the base of Q5 is held slightly negative through R20 and R21. Since Q5 is an emitter follower, its emitter is at the same potential as its base. With its emitter at a negative potential, Q4 is held on.

5.22 When the connect circuit is on, Q6 is in conduction and its collector is near neutral. The voltage divider consisting of R19, R20 and R21 holds the base of Q5 (and therefore the emitter) positive. With the emitter of Q5 positive, the base of Q4 is back-biased and Q4 is off. The collector of Q4 will then be negative. Base current for Q6 flows through R16 and R17, holding the connect circuit on.

5.23 To control the connect circuit, a high voltage must be developed at the junction of CR1 and CR2. This voltage will be approximately ±200 volts. If a +200 volt signal is present, the base of Q5 is biased positive and Q4 will turn off, turning on Q6. If a -200 volt signal is present, the base of Q5 is negative and Q4 will turn on, turning Q6 off. An input signal at or near neutral does not have any effect on the connect circuit and it will remain in its previous state.

5.24 The base of Q5 is protected against excessively high voltages by transistor operation or by CR11. If a -200 volt signal is present, the voltage at the base of Q5 will fall, and force its emitter to follow. When the emitter of Q5 becomes negative with respect to neutral, Q4 turns on. With Q4 in conduction, its base potential is held close to the emitter potential. Therefore, the base cannot go more negative than -0.4 volt. This action also holds the base voltage of Q4 within -0.4 volt of its emitter. Therefore, the base voltage of Q5 cannot become more negative than approximately -0.8 volt. If a +200 volt signal is present at the input, the base of Q5 will become positive. Diode CR11 is a forward-biased diode to positive base voltages, and will limit the voltage on the base of Q5 to approximately +0.8 volts. Therefore, under the severest input conditions, a voltage swing of more than ±0.8 volt is not expected.

5.25 Resistors R24, R25, and R26 and capacitor C5 are used when a polar converter is employed. As they are connected in 7267WD and 6481WD, they have no effect upon the operation of this circuit.

F. Local Circuit (Figure 18)

5.26 This circuit consists of a binary and a unijunction transistor timer. There are four input controls available. Operation of the binary is the same as that of the request circuit. The local circuit is turned on (Q9 on) by means of the LCL pushbutton. If contact S2-1 is closed, base current is supplied to Q9 through R37 and R38. This base current causes Q9 to turn on, turning Q8 off. If the anode of CR14 is neutral, current flowing through R38 goes through the diode and does not reach the base of Q9. This allows the local circuit to be turned on only when the connect circuit is off. If the anode of CR3 is also neutral, current from R38 flows through both CR14 and CR13 keeping the local circuit off when the teletypewriter is in a request condition. The local circuit may be turned off by two inputs consisting of two pushbutton contacts in series. The contacts are S2-1 of the REQUEST pushbutton and S2-3 of the DISCONN pushbutton. If the local circuit is on, the base current for Q9 flows through these contacts. Operating either of these pushbuttons will turn Q9 off.

5.27 The unijunction transistor output also turns the local circuit off. The unijunction transistor Q7 is a breakdown device. If the voltage at C9 is more negative than approximately -8 volts, the resistance of the junction between the lead connected to C9 and the lead connected to R35 is high. When the voltage at C9 becomes more positive than approximately -8 volts, this junction will become very low in resistance and C9 will recharge through R35. The increase in current through R35, while recharging C9, will cause an increase in the voltage drop across R35. This positive pulse is coupled through C10 and CR17 to the base of Q9, causing it to turn off and Q8 to turn on. The local circuit is then off. As capacitor C9 is recharged, the junction obtains a high resistance.

5.28 Capacitor C9 may be discharged toward neutral or held at approximately -18 volts through R32 and R33. If the input to R32 is negative (connect circuit off), the capacitor will be held at -18 volts. If the input to R32 is near neutral (connect circuit on), capacitor C9 will discharge through R32 and R33 toward neutral. At the end of a 2.3 second interval, the voltage at C9 will be approximately -8 volts and the unijunction will break down and turn the local circuit off as previously described.

G. Circuit Interconnections (Figures 18, 19 and 20)

5.29 To turn on the request circuit the REQUEST pushbutton must be operated. This connection is shown in Figure 18. Depressing the REQUEST pushbutton presents the proper signal to the line so that the request is recognized.

5.30 When the connect circuit is operated by reversing the polarity of the input signal from the line, the request circuit is turned off. The connect circuit is controlled only by the line and therefore has only one input, from the line sensing and control portion of the call control unit, as shown in Figure 18.

5.31 To turn the local circuit on, three conditions must be met. The request and connect circuits must be off and the LCL pushbutton must be operated. The connect circuit

input protects against accidental operation of the local circuit during the connected condition, which would cause an automatic disconnect. The request input also protects against accidental operation of the LCL pushbutton.

5.32 The local circuit may be turned off by operating the DISCONN pushbutton or the REQUEST button, or through the 2.3 second timer. The REQUEST and DISCONN pushbuttons provide local control of the circuit, while the timer provides automatic control. The timer is controlled by the connect circuit, which is in turn controlled by the line. The timer will continue to oscillate as long as the connect circuit is on, but only the first timing pulse is required to turn off the local circuit.

5.33 When either the connect or local circuit is on, the motor delay timer output is operated. The contacts of the motor delay relay associated with the timer are used to turn on the motor of the teletypewriter. When either the local or connect circuit turns off, the motor delay timer holds the relay on for approximately 0.550 second.

H. Idle Line Condition (Figures 19 and 20)

5.34 In the idle line condition all relays and lamps are off. To accomplish this transistors Q3, Q6, and Q9 are off and Q4, Q2 and Q8 are in conduction. The output transistor of the motor delay timer is off and the selector magnet driver is marking. The signal loop is a 240 volt source furnishing 0.060 ampere. In the idle condition the call control unit supplies 43,800 ohms of local resistance to the signal loop. The flow of loop current in this condition is shown in Figure 19. Current flows from TB8, the positive idle terminal, across CR4, through R1 and CR1 in parallel with the base emitter junction of Q4 and Q5, R13 and R12 to terminal TB9.

5.35 The loop current develops a positive potential at point (A) in Figure 19 holding Q1 on. The collector of Q1 is shorted to ground through contacts S1 (4-5). Therefore, no signal may be developed at the collector unless the REQUEST pushbutton is depressed. The loop current develops approximately -200 volts with respect to neutral at point (B). This potential holds Q4 in conduction and the connect circuit off.

5.36 The selector magnet driver is supplied 0.07 ampere locally to hold the selector magnet energized. This blinding current is supplied through R23 from +18 volts and through a resistor in the 120 volts auxiliary power supply, through CR3 in the power supply. This current flows through contacts K2-1 and K3-1, the sending apparatus (keyboard signal generator and distributor) through the selector magnet driver and to neutral.

I. Initiating a Call (Figures 19 and 20)

5.37 A call may be initiated with the teletypewriter or local condition. To initiate a call, the REQUEST pushbutton must be depressed. Depressing this key performs four functions. Contact S1 (1-2) opens and turns off the local circuit. Contact S1 (4-5) opens and removes the short to neutral across the Q1 collector. Contact S1 (5-6) closes shorting out the local loop resistance. This allows the loop current to rise to 0.060 ampere. Contact S1 (1-3) closes and provides negative battery to the base of Q3 and the collector of Q2. The last three contacts must operate in a sequence to complete the request function, as explained below.

5.38 Loop current then flows from TB-8, through CR4, contact S1 (5-6), CR1 to TB-9. Shorting out the local loop resistance causes the voltage at point (A) to rise to neutral with no effect upon the state of the connect circuit as explained above.

5.39 As the REQUEST pushbutton is depressed, contact S1 (4-5) opens, removing the shunt from the collector of Q1 to neutral. This allows the collector to go positive. C1 charges towards +18 volts and the base of Q2 is back-biased through R6. Q2 turns off. As the pushbutton is depressed further, contact S1 (1-3) closes and -18 volts is applied to the base of Q3. Q3 conducts, turning on the K1 relay and the REQUEST lamp. Contact S1 (5-6) closes, allowing the loop current to increase to 0.060 ampere. The base of Q1 is forward-biased and Q1 turns on with no effect on Q2.

5.40 With Q3 in conduction and its collector near neutral, the junction of R37 and R38 in the local circuit is held near neutral through CR13 as the LCL pushbutton is operated. The local circuit can not be turned on. The near neutral condition at the collector of Q3 results in the base of Q3 in the motor delay timer being reversed-biased. The transistor is turned off and its collector is negative, causing the base of Q2 in the timer to be forward-biased. Q2 then conducts, and the motor control relay energizes, turning on the teletypewriter motors.

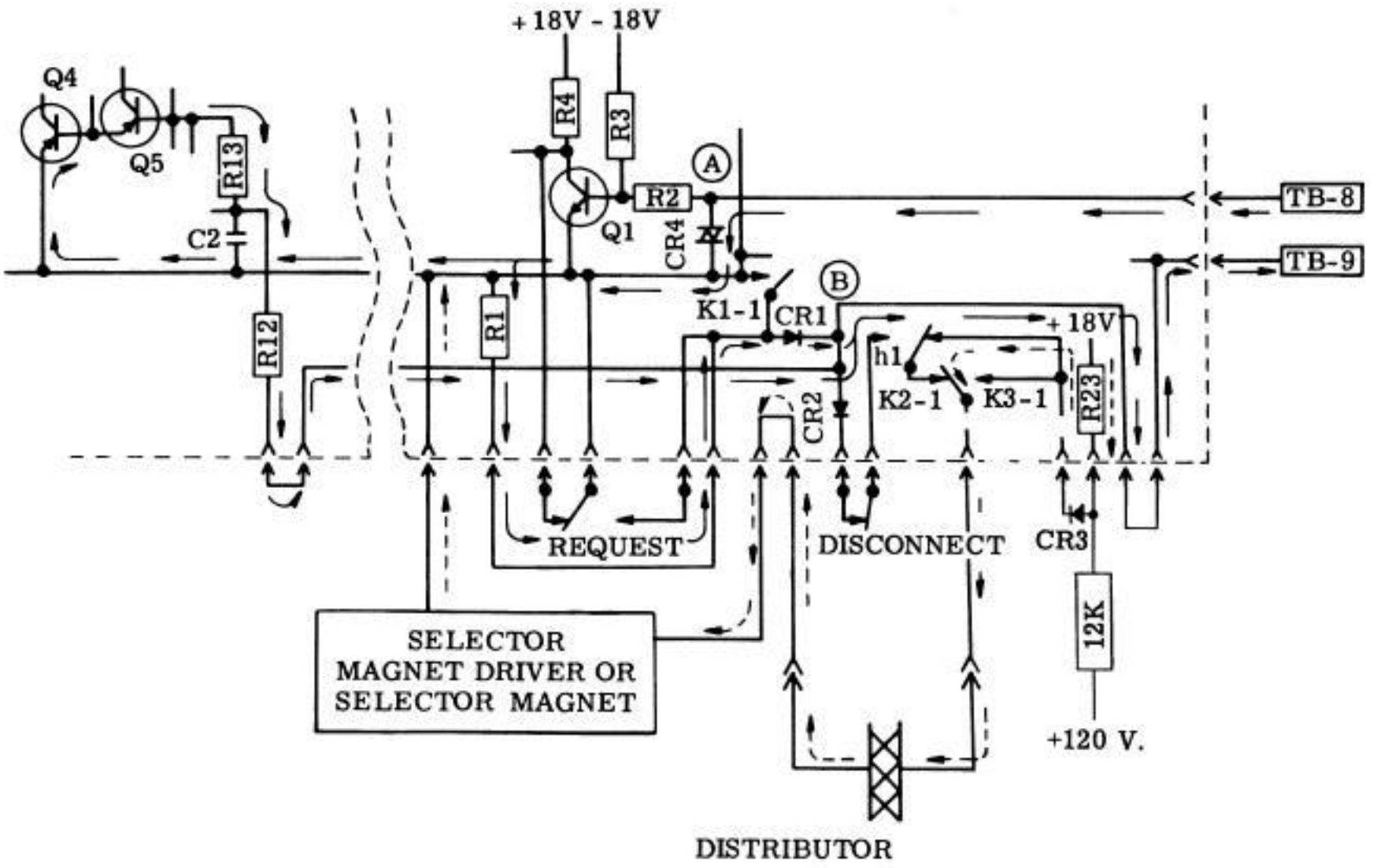



Figure 19 - Control Circuits in Idle Condition

5.41 If the REQUEST pushbutton is released at any time before the connect circuit is turned on, the teletypewriter will revert to the idle line condition.

J. Call Connection (Figures 18 and 20)

5.42 If a call is initiated locally, current in the loop is 0.060 ampere. When the loop polarity is reversed by the exchange, current flow is from TB9 to TB8. Diode CR1 becomes reverse-biased, stopping any current flow except that through R12 and R13. This current flow turns off Q4 and turns on the connect circuit. With Q6 in conduction, the K2 relay operates and the CONN lamp lights. The transfer contacts K2-1, then switch and allow loop current of 0.060 ampere to flow through the distributor and selector magnet driver as shown in Figure 20. The loop current then flows from TB9 through CR2, the contacts of K2-1 and K3-1, keyboard signal generator and distributor, the selector magnet driver, and CR4 to TB8.

5.43 With Q6 in conduction, CR15 is forward-biased and will turn on the output transistor (Q2) of the motor delay timer. The motor control relay operates, closing contacts K4, turning on the motors. Q4 is cut off and its collector is negative. Feedback from the collector of Q4 to the base of Q2, through R15, turns off the request circuit. The K1 relay releases and the REQUEST lamp extinguishes. The K1-1 contact opens, but does not have any effect upon loop current flow, since it is not in the current loop. The junction of R37 and R38 is held near neutral from the collector of Q6 through CR14 and prevents operation of the local circuit.

K. Remote Connection (Figures 18, 19 and 20)

5.44 The teletypewriter may be connected remotely when it is in the idle line or local condition. The incoming call causes the exchange to reverse the loop polarity from that shown in Figure 19. This causes the potential at the junction of CR1 and CR2 to change

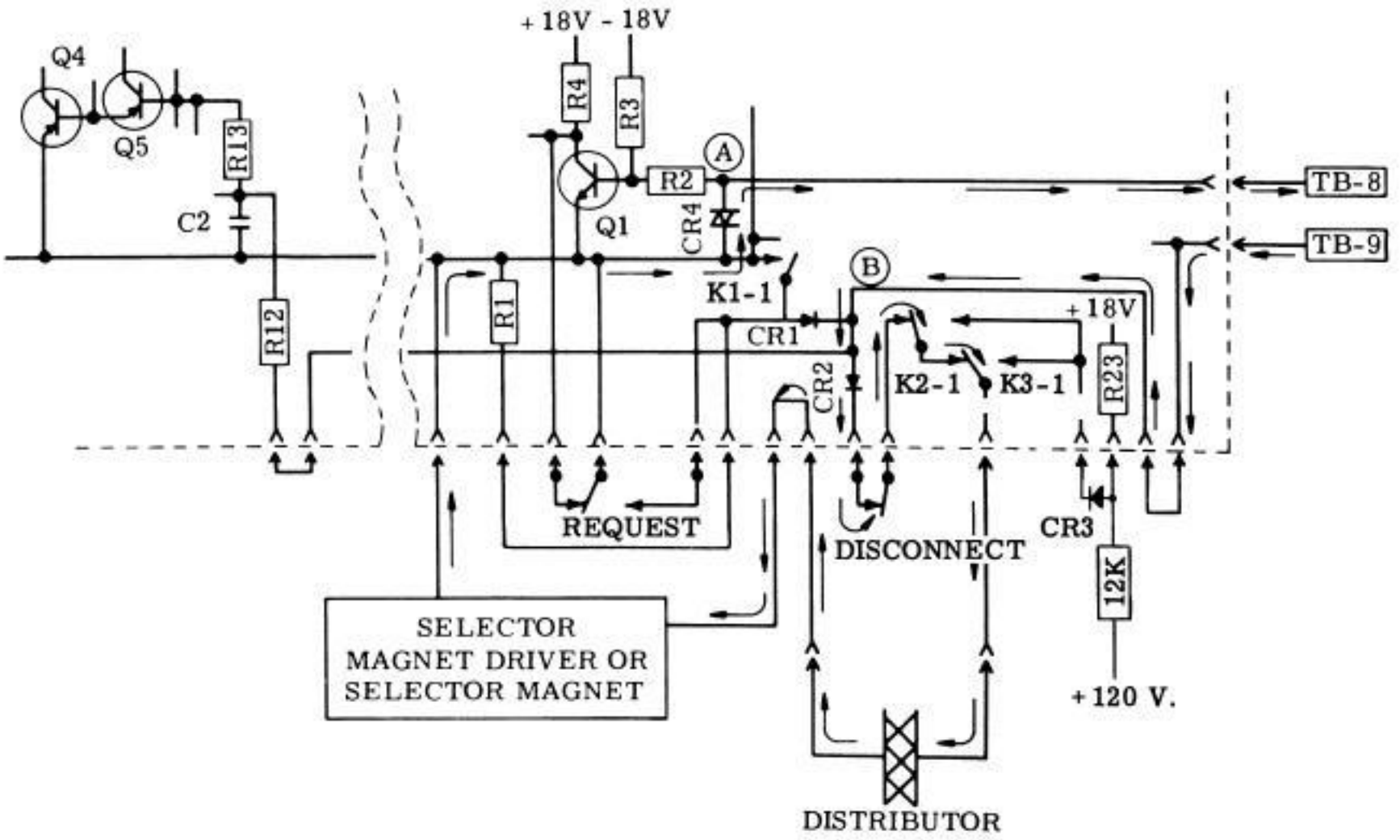



Figure 20 - Control Circuits in Connected Condition

from -200 volts to approximately +200 volts. This potential causes the connect circuit to operate as described above.

5.45 If the paper in the teletypewriter becomes low and the low paper contacts operate, the junction of R12 and R13 is not allowed to become positive. Q4 may not be turned off and a connection cannot be made. If low paper occurs during a call, the teletypewriter remains in the connected state since zero potential at the junction of R12 and R13 will not affect the connect circuit. A disconnect occurs in the normal manner, since CR3 will be back-biased to a negative potential at the junction of R12 and R13.

5.46 When a call is initiated locally and a low paper condition exists, the normal sequence of events occur until a connection is attempted. When the exchange cannot connect, it reverses the loop polarity and the teletypewriter returns to the idle condition.

L. Call Disconnect (Figures 18 and 19)

5.47 Operation of the DISCONN pushbutton while in the connect condition, opens the signal loop. When the exchange recognizes the break, it reverses the loop polarity. The reverse polarity is blocked by CR2 and current flows through CR1 along the same path shown in Figure 19. At point (B) -200 volts is developed by current flow as described in 5.35. This potential causes the connect circuit to turn off. The CONN lamp is extinguished and the K2 relay releases. The K2-1 contacts return to the blinded condition and the teletypewriter stops running open. The input to the motor delay timer is negative and the timer times out. After 0.550 second the motor control relay releases and the motor turns off. This delay period allows the teletypewriter clutches to latch.

M. Remote Disconnect

5.48 The operation of the circuits and the loop paths are the same as those described in 5.47. The DISCONN pushbutton is not depressed

locally, but the signal conditions appear identical to the call control unit.

N. Local Offline Operation

5.49 If the teletypewriter is in the idle line condition, operation of the LCL pushbutton causes the local circuit to operate (Q8 turns on). If the unit is in either the request or connect condition, CR13 or CR14 prevents operation of the local circuit. When the local circuit operates, the K3 relay operates and the LCL lamp will light. Contact K3-1 of the relay shorts out contacts K2-1 in the signal loop. Current in this loop will then flow through R23, K3-1, the keyboard and the selector magnet driver, to neutral. CR16 is forward-biased, causing the output transistor of the motor delay timer to turn on. The motor control relay operates and the motor starts. The associated apparatus are now ready for offline operation.

5.50 To revert back to the idle line condition, the DISCONN pushbutton is depressed. Contact S3-2 opens and turns off the local circuit as previously described. A call may then be initiated in the local condition in the usual manner. When the REQUEST pushbutton is depressed, contact S1-2 opens and turns off the local circuit in the same manner as when the DISCONN pushbutton is depressed.

5.51 If an incoming call is received while the teletypewriter is in the local condition, the action of the circuit is the same as that described in 5.42 and 5.44. The K2 relay operates to shunt the line through the sending components of the set and the selector magnet driver, but this operation cannot be accomplished, since the K3-1 contact has shorted the K2-1 contact out of the circuit. Operation of the K2-2 contact completes the 117 volt ac circuit to the buzzer causing it to sound.

5.52 With the connect circuit on, the collector of Q6 is near neutral. This causes the timer to start. At the end of a 2.3 second period, a positive pulse from the timer is coupled to the base of Q9, through C10 and CR17. This pulse causes the local circuit to turn off. The LOCAL lamp is extinguished and the K3 relay is released. The K3-1 contact shorts the signal loop through the sending and receiving apparatus of the set. The K3-2 contact opens and the buzzer turns off. The teletypewriter is now in the connect condition.