TP177010 SELECTOR MAGNET DRIVER

DESCRIPTION AND PRINCIPLES OF OPERATION

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1. GENERAL

1.01 The TP177010 electronic selector-magnet driver is a solid-state device which couples a signal line to a receiving teletypewriter and repeats the line signals in a form that will effectively operate the teletypewriter's selector mechanism. It is designed specifically to drive one 28 selector magnet or one 15 selector holding magnet. When used in place of a line relay (such as the Western Electric 255A) to drive the specified selector magnets, it will provide improved operation, greater reliability and reduced maintenance. However, it is not intended as a general purpose driver for all types of selectors, nor as a replacement for relays in general.

2. DESCRIPTION (Figure 1)

2.01 The driver includes a dc power supply and an etched circuit card which are mounted on a small chassis (Figure 1). The power supply consists of an isolation transformer, a full-wave rectifier and single-capacitor filter. Various electrical components including five transistors are mounted on the circuit card which is supported by three posts. Power and signal cables equipped with spade lugs provide for electrical connections to the driver.

3. FEATURES

3.01 With different strapping arrangements, the driver will accept neutral signals of either 0.020 or 0.060 ampere or polar signals of up to 0.030 ampere. The output is 0.060 ampere regardless of input.

Prepared for American Telephone and Telegraph Company by Teletype Corporation

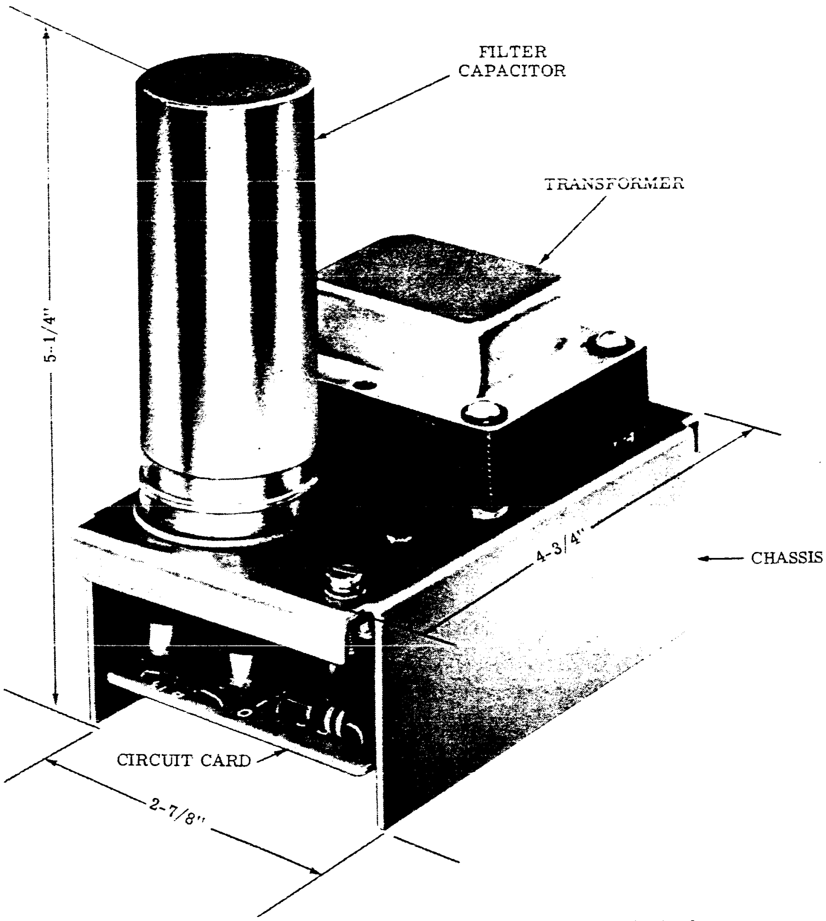


Figure 1 - TP177010 Electronic Selector Magnet Driver

TABLE 1

TECHNICAL DATA

DIMENSIONS (Overall)	
Length	4-3/4 inches
Width	2-7/8 inches
Height	5-1/4 inches
ELECTRICAL	
Power Source	117 v ac ± 10% 50-60 cps
Max Power Consumption	12 watts
Input Signals	0.020 a. or 0.060 a. ± 10% neutral or up to 0.030 a. polar
Output Signals	0.060 a.
Signalling Speed	Up to 200 wpm
Wiring Diagram	4445WD
ENVIRONMENTAL REQUIREMENTS	
Operating Temperatures	0° C (+32° F) to +65° C (+149° F) at specified power and input requirements
Storage Temperature	Max +85° C (+185° F)

3.02 The driver may be strapped so that, when used in conjunction with external contacts, the selector does not receive (is blinded to) certain incoming messages and does receive (is unblinded to) others.

3.03 Strapping arrangements can be changed by removing and/or soldering bare wire between terminal posts on the circuit card. The posts are accessible so that the card need not be removed for this procedure.

3.04 Since its input is essentially resistive rather than inductive, the driver permits the inclusion of additional receiving units on a teletypewriter loop without introducing signal distortion.

4. MOUNTING

4.01 The driver can be mounted in any vacant position on the 28-type electrical service units and in the position provided for the line relay on the 15-type bases. Mounting hardware is provided with the driver.

Note: The TP177015 modification kit is required to mount the driver on 15-type equipment.

5. GENERAL PRINCIPLES OF OPERATION

5.01 This section explains the operation of the selector magnet driver. It is based on the schematic wiring diagram in the section entitled "TP177010 Selector Magnet Driver - Wiring Diagram." Basically the driver operates as follows: Neutral or polar teletypewriter signals are applied to its input. These signals are repeated at its output in a form that will effectively operate the selector of a receiving teletypewriter. Direct current for the driver's circuits is provided by an internal power supply.

5.02 Terms: The transistors as used in the driver either do not conduct or conduct into saturation. They do not operate at intermediate stages. Thus throughout this discussion they are referred to as being either "on" (conducting) or "off" (not conducting).

5.03 Signals: The driver is specifically designed to receive teletypewriter, start-stop signals. These signals are explained in detail in the appropriate sections. For this explanation, it is sufficient to say that each signal element (or pulse) may occur in either of two conditions — marking or spacing. For neutral operation, current flows in the signal line circuit during the marking condition, and no current flows during the spacing condition. For polar operation, current flows during both conditions, but the polarity is reversed to differentiate between marking and spacing.

6. GENERAL DESCRIPTION OF CIRCUITS

BIAS VARISTORS

6.01 The elements referred to as "bias varistors" (CR1 through CR5) are used in the circuit to develop transistor bias voltages and low-voltage references that set the input switching level. They consist of two diffused-junction, silicon diodes mounted in opposite directions side by side. They have a forward diode characteristic in either direction and thus their voltage drop varies slightly with the current. At 0.10 a. the drop is 0.8 v. Stabistors CR6, CR7 and CR13 have characteristics similar to varistors, but pass current in only one direction.

INPUT CIRCUIT

6.02 The input circuit receives the teletypewriter signals and determines when the driver shifts from marking to spacing. It includes R1 through R3, bias varistors CR1 through CR5, and transistor Q1. In neutral operation, it keeps the driver spacing or marking until the line current rises above or drops below the switching value. In polar operation it does the same until the current rises above or drops below zero.

6.03 Resistor R1 protects transistor Q1 from high current surges that might damage it. It samples the current flowing into Q1's base, and, if the current exceeds a value of approximately 0.100 a., the voltage developed across R1 and the base-emitter junction exceeds the forward drop of CR1 and CR2, and most of the excess current is shunted around Q1. Since the bias varistors are bidirectional, Q1 is protected for inputs of either polarity.

6.04 For 0.020 ampere neutral operation, R2 is disconnected by removing the strap at terminals 1 and 2, and R3, CR3, CR4 and CR5 are all left in the circuit. For 0.060 ampere neutral operation, R2, R3, CR3, CR4 and CR5 are all left in the circuit. For polar operation up to 0.030 a., R2 is disconnected by removing the strap at terminals 1 and 2; CR3, CR4, and CR5 are shunted out by placing a strap across points 3 and 4; and R3 alone is left in the circuit.

SWITCHING CIRCUIT

6.05 Transistors Q2, Q3 and associated components form a snap-action trigger circuit. In the marking condition, Q2 is off and Q3 is on. The opposite exists for the spacing condition. The change from one state to the other occurs at the midpoint value of the input current and is very rapid regardless of the slope of the input waveform.

OUTPUT CIRCUIT

6.06 The output circuit, which includes Q4, Q5 and associated components, controls the current in the selector magnet coils. During the space to mark transition, it places essentially the full supply potential across the coils and causes the current to rise rapidly to the operating value of 0.060 a. This rapid rise provides quick selector armature pickup. Once the operating value is reached, the circuit adds resistance to maintain the operating current. During the mark to space transition, a controlled discharge circuit, which includes CR9 and Q2, rapidly dissipates the coil's energy without developing any high reverse voltage transients that might cause transistor damage.

POWER SUPPLY

6.07 The power supply provides dc for the driver's circuits. It includes an isolation transformer, a full-wave rectifier, and single capacitor filter. It operates from a 117 v, 50-60 cps, ac source, and provides a nominal dc voltage of -40 v. This value provides a safety factor against transistor breakdown under the most unfavorable circumstances of high temperature, high line voltage and maximum line signaling frequency.

Note: The actual potential of the negative side of the power supply relative to ground depends on where the signal line is grounded. Relative to the local earth ground, it can have almost any value in the range of +120 v to -120 v.

7. SPACING CONDITION

7.01 In the spacing condition transistors Q1, Q3 and Q5 are off; Q2 and Q4 are on; and no current flows in the selector magnet coils.

7.02 In neutral operation, no current flows in the signal line during spacing. Thus, the base of Q1 is connected to the positive side of the power supply either through R3 alone (for 0.020 a. operation) or through R3 and R2 in parallel (for 0.060 a. operation). Internal current through varistors CR3, CR4 and CR5 places a -2.4 v bias on the emitter of Q1 and keeps it off. In polar operation (R3 alone in circuit and CR3, CR4 and CR5 shunted), TP1 is positive and TP6 is negative during spacing. Thus the signal line through R1 drives the base of Q1 positive and keeps it off.

7.03 The base of Q2 is driven negative with respect to its emitter through resistors R4 and R5 and resistors R7 and R8. Thus Q2 is on, and the voltage drop from its emitter to collector is very small — less than 0.1 v.

7.04 The output of Q2 is applied to the base of Q3 through germanium diode CR11. The current flow through CR11 and R6 to the negative side of the power supply causes a maximum drop of 0.4 v across CR11. Thus the base of Q3 is at most -0.5 v with respect to the emitter of Q2. Resistor R12 permits sufficient current to flow through CR7 so that the latter's voltage drop is at least 0.6 v. Q3's emitter is more negative than its base; thus Q3 is off.

7.05 CR10 prevents current from flowing from the collector of Q2 through the selector coils, CR8 and R4 to the negative side of the power supply. Therefore, the selector magnet is not energized in the spacing condition.

7.06 The collector of Q2 is connected to the emitter of Q4 and to one side of CR13. The negative side of the power supply through R9 makes the base of Q4 negative in relation to its emitter and keeps it on. A 0.1 v drop across Q4 is applied to the base of Q5. Because of the voltage drop across CR13 caused by the current flow through CR13 and R13, the emitter of Q5 is at least 0.55 v more negative than the emitter of Q4. Thus there is a 0.45 volt back bias across Q5 which remains off.

8. MARKING CONDITION

8.01 In the marking condition, Q1, Q3 and Q4 are on; Q2 and Q5 are off; and a current of 0.060 a. flows in the selector magnet.

8.02 In both neutral and polar operation, the marking signal places a negative potential on the base of Q1 and keeps it on. Current flows from its collector to the negative side of the power supply through R5 and R4 and through R8 and R7. Current also flows through CR6, CR7 and R12 to the negative side of the supply. A drop of at least 0.65 v across CR6 is applied to the emitter of Q2. The base of Q2, which is connected directly to the collector of Q1, is about -0.1 v with respect to the emitter of Q1. Therefore, Q2 has a back bias of 0.55 v and is off.

8.03 Since Q2 is cut off, it does not back bias Q3 as it did in the spacing condition (Paragraph 7.04). The negative side of the supply through R6 puts a negative potential on the base of Q3 and keeps Q3 on. Current flows from the collector of Q3 through CR8 and R4 to the negative side of the supply, and through CR10 and the selector coils to the junction of Q4's emitter and CR13. Since the base of Q3 is only about -0.4 v with respect to its emitter, the drop of almost 5 v across Q3, CR10, and the selector coils back biases diode CR11. Q2 is unaffected since it is off and its collector is negative with respect to its base.

8.04 Q4 is on and Q5 is off as described in Paragraph 7.06.

9. SPACE TO MARK TRANSITION

9.01 In neutral operation, varistors CR3, CR4 and CR5 place -2.4 v on Q1 keeping it turned off during spacing Paragraph 7.02). As the signal line changes from spacing to marking, current begins to flow in the input line and a negative potential is developed across the input resistor(s) (R3, or R3 and R2). Q1 remains off until this current exceeds its midpoint value of 0.010 a. for 0.020 a. or 0.030 a. for 0.060 a. operation. This midcurrent value is detected when a voltage slightly greater than -2.4 v is developed at the base of Q1 turning it on.

9.02 In polar operation R3 alone is in circuit and CR3, CR4 and CR5 are shunted. As soon as the current moves slightly beyond zero in the marking direction, it places a negative voltage on the base of Q1 and turns it on.

9.03 Q3 turns on, and Q2 turns off under the conditions described in Paragraphs 8.02 and 8.03 above. Q2 and Q3 form a trigger circuit which utilizes positive feedback. The collector of Q2 is connected to the base of Q3, and the collector of Q3 is connected to the base of Q2. Q2 through CR11 switches Q3, and Q3 then feeds back to Q2 through CR8 controlling the resistor network of R4 and R5. As the signal changes from spacing to marking, Q1 turns on and causes Q2 to begin to turn off. Q2 in turn causes Q3 to begin to turn on. The collector of Q3 drives the junction of R4 and R5 positive. Less base current is supplied to Q2 which turns off even more. This trigger action removes any point of uncertainty and prevents the driver from being damaged by locking up on an intermediate point or going into oscillation as the input switching level is crossed.

9.04 Initially, the induced voltage of the magnet coil opposes the current flow from the collector of Q3 through the coils to the negative side of the supply. This prevents current from flowing through CR13 and Q4 (which was on during spacing). The collector of Q4 and the base of Q5 move toward the negative supply potential. Q5 is off and its collector is at the negative supply potential. Since its base and collector are negative, the emitter of Q5 also moves toward the negative supply potential.

9.05 A short time later, the voltage drop across the coils decreases, and current begins to flow in the coils, increasing nearly linearly with time. The negative terminal of the coils begins to move toward the positive supply potential. The emitters of Q4 and Q5 begin to go positive. Since the negative potential on the collector of Q4 is applied to the base of Q5, the latter turns on as its emitter goes positive and Q4 turns off.

9.06 Since R11 is small and Q5 is on, essentially the full supply potential is placed across the coils. The coils' current, limited only by R11 and the small resistance of the coil, increases rapidly. (It aims at point much higher than the desired 0.060 a. operating current.) Thus the operating current is reached very quickly, and effects a fast pickup of the selector magnet armature.

9.07 During the spacing condition, Q4 was on and its base was no more than -0.6 v with respect to its emitter. As described above, during the space to mark transition, the current flow through Q4 drops to almost zero, and its emitter goes toward the negative supply potential. Capacitor C1 holds Q4's base at the conducting potential which is positive with respect to the emitter, and Q4 turns off. Q5 is still on. The base potential of Q4 drops exponentially toward the negative supply as C1 discharges through R9.

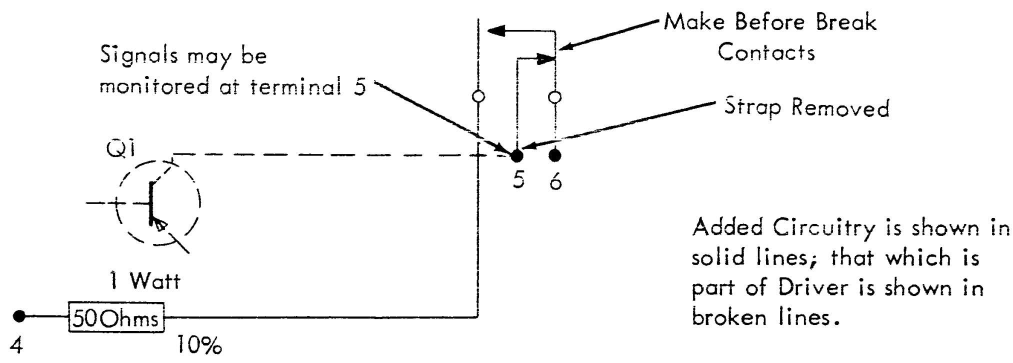


Figure 2 - Blinding Arrangement to Permit Signal Monitoring

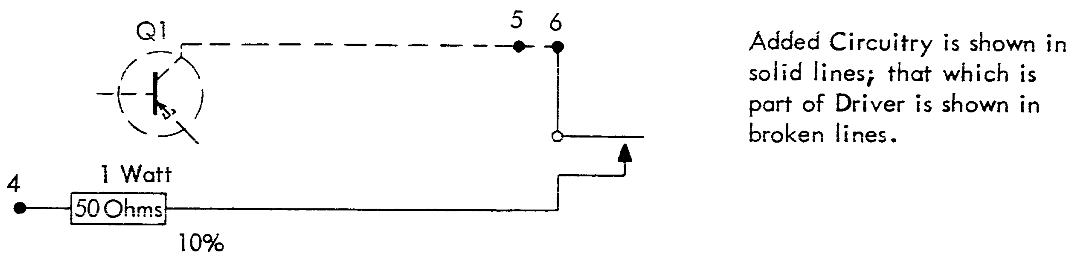


Figure 3 - Simple Blinding Arrangement

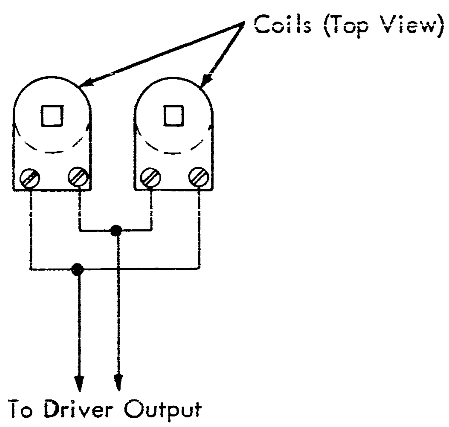


Figure 4 - Selector Coils Connected in Parallel

9.08 Normally the voltage divider network of R7 and R8 places a potential of +10 v with respect to the negative supply on the anode of CR12 which is back biased. However, during the space to mark transition period, the base potential of Q4 drops exponentially toward the negative supply. When it gets just below the divider's voltage, CR12 becomes forward biased and clamps the base to this value.

9.09 As the current begins to flow through the coils, Q4's emitter drops from the negative supply potential until it is more positive than its base, and Q4 turns on. Its collector potential becomes nearly the same as its emitter and is applied to the base of Q5 which turns off. CR12 is again back biased, and the current to Q4's base is supplied through R9 as before. The current flow from the coil to the negative supply is now through Q4 and R10 which limits it to the operating value of 0.060 a. R9 and R13 are essentially in parallel with R10 and help to determine the current's value.

9.10 The voltage divider network of R7 and R8 determines the current value at which Q5 turns off and Q4 turns on. The closer the potential on the anode of CR12 approaches the negative supply, the sooner Q5 turns off. Current through the divider network always flows to the positive side of the supply either through the collector of Q1 or the base of Q2. CR12 remains backbiased except for the brief period described above during the space to mark transition.

10. MARK TO SPACE TRANSITION

10.01 As the signal changes from marking to spacing, Q1 and Q3 turn off and Q2 turns on under the conditions described in Paragraph 7.02 through 7.05. The operation of the trigger circuit of Q2 and Q3 is the opposite of that described in Paragraph 9.03. Q4 remains on and Q5 remains off as described in Paragraph 7.06.

10.02 When Q3 turns off, it no longer supplies current to the selector coils. The coils resist a drop in their current by developing a negative voltage transient at their normally positive end. This transient is passed by CR10, blocked by CR8 and blocked by CR9 until it exceeds the negative supply potential at which time CR9 conducts. CR9 insures that the voltage rating of Q3 is not exceeded by clamping it at about -40 v.

10.03 Q2 holds the normally negative end of the coil at near positive supply potential when Q3 turns off. A constant potential of about 35 v is thus placed across the coils. The rate at which the current through the coil decreases is constant.

11. BLINDING

11.01 A receiving teletypewriter is "blinded" when it does not respond to the line signals, ie it does not print or perforate the information being transmitted on the line. To effect blinding, the selector is kept steadily marking regardless of the line signals. Blinding can be accomplished in a number of ways depending on the specific application, but may be considered in two categories based on whether or not it is necessary to monitor the signal line while the equipment is blinded.

MONITORED SIGNALS

11.02 If it is necessary to monitor the line signals, the driver can be blinded as follows. The collector of Q1 is disconnected from the base of Q2 by removing the strap between terminals 5 and 6. Terminal 6 is then connected (by relay contacts, etc) to the positive side of the power supply at terminal 4 through a 50 ohm resistor (see Figure 2). Because of the drop across CR3, CR4, CR5, CR6 and CR7, a back bias of about 3.2 v is placed on Q2. Thus Q2 is off, Q3 is on, and the driver is locked in the marking condition regardless of the line signals (see Paragraph 8). By auxiliary circuits not part of the driver, the line signals can still be monitored at terminal 5. Normal operation of the driver can be restored by externally reconnecting terminals 5 and 6 and disconnecting the 50 ohm resistor between terminal 6 and the positive side of the power supply.

11.03 Blinding can be accomplished either manually or automatically. For example, the stunt box of a page printer (which would be receiving the line signals through its own selector) could be arranged so that its contacts would blind the driver of a reperforator at the receipt of a certain character sequence, and would unblind it at the receipt of another sequence. Thus the reperforator could be made to ignore certain traffic.

UNMONITORED SIGNALS

11.04 If it is not necessary to monitor the line signals, a simpler method of blinding may be used. Terminal 6 is connected to the power supply (signal line) at terminal 4 through a 50 ohm resistor and the strap between 5 and 6 is not removed (see Figure 3).

11.05 This approach is feasible providing that the reduced input resistance will not disturb external circuits that operate into the driver.

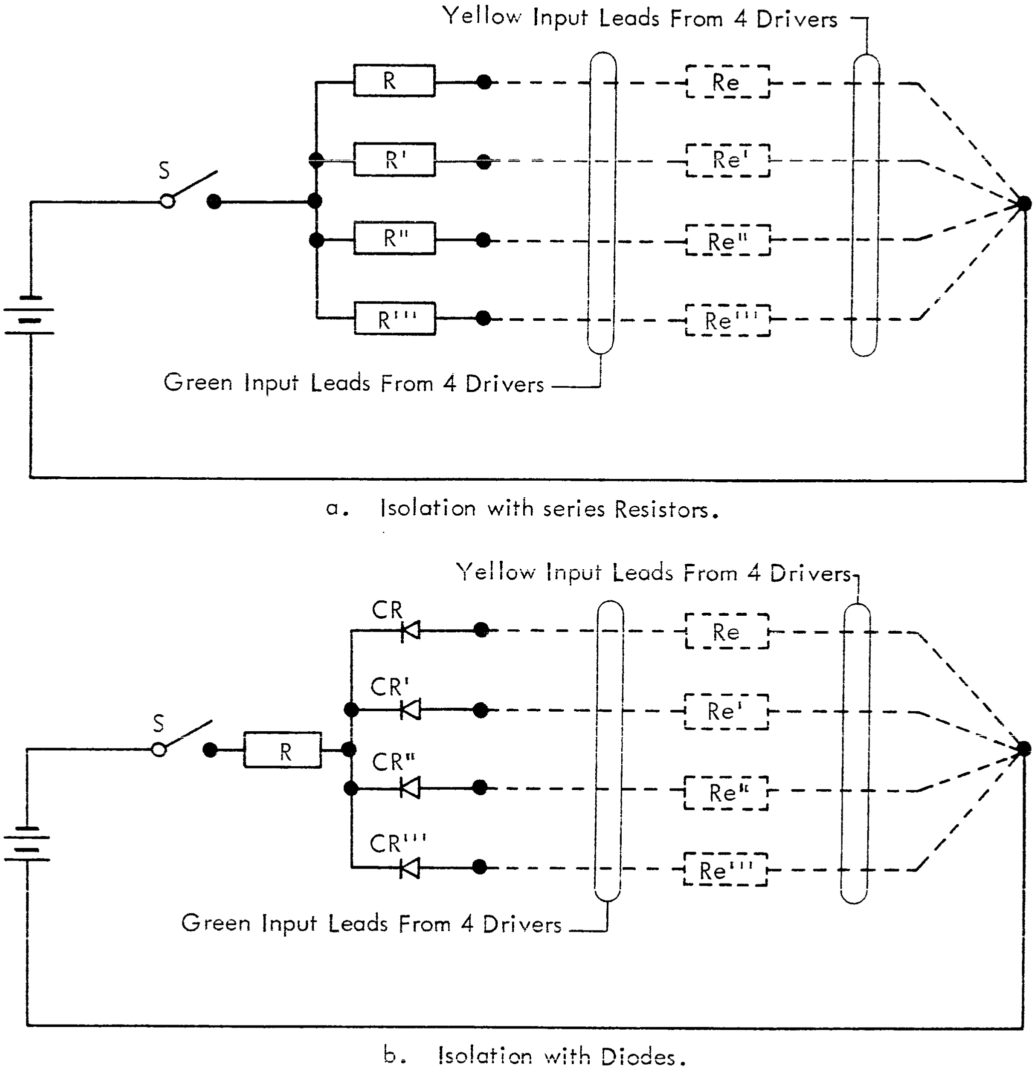
PURPOSE OF 50 OHM RESISTOR

11.06 The 50 ohm, 1-watt resistor connected between terminals 6 and 4 prevents damage to Q1 in the event the signal line current exceeds the value for which the input resistors are strapped.

12. VARIATIONS

SELECTOR MAGNET CONNECTIONS

12.01 The circuits of the driver are designed for connecting the two selector coils in parallel to reduce required dc voltage and to



R, R', R" & R''' - Current Limiting Resistors
Re, Re', Re", Re''' - Drivers' Equivalent Input Resistance.
CR, CR', CR" & CR''' - Isolation Diodes
S - Keying Contacts

Circuitry that is part of Driver is shown in broken lines. Additional Circuitry is shown in solid lines.

Figure 5 - Additional Circuitry for Parallel Operation of Four Drivers

reduce the overall self-induced voltage when the coils' current is increasing or decreasing. Operation with the coils in series will not harm the driver, but will reduce signal margins. It is not recommended. A typical parallel connection is shown in Figure 4.

INPUT RESISTANCE

12.02 For the signal line, the input resistance of the driver varies in accordance with the polarity and magnitude of the input current. For example, the input resistors of 124 and 249 ohms are in parallel for 0.060 a. operation and have an effective measured value of 83 ohms. This is the input resistance for the signal line as long as the line current is below the switching level, ie the level where Q1 turns on (0.030 a.).

12.03 When Q1 does turn on, however, the voltage across the 83 ohms is held at approximately 2.9 v by the clamping action of Q1, CR3, CR4 and CR5 even though the current is increasing. Thus the resistance is decreasing: eg at 0.060 a. the actual effective value is 48 ohms, or about one-half of the measured value of 83 (2.9 v/0.060 a. = 48 ohms). The corresponding effective resistance for 0.020 a. operation is 145 ohms.

12.04 This variation in input resistance can lead to discrepancies between the computed and actually required values of signal line series resistance. For example, assume a ten-station teletypewriter loop, 0.060 a. operation, 120 v line battery, and ignore the resistance of the signal line itself. Basing the values on ohmmeter or bridge measurement, the total resistance in the circuit would thus be 83 x 10 or 830 ohms. The total required resistance would be 120/0.060 or 2000 ohms. The battery station would thus require 2000-830 or 1170 ohms of series resistance. However, in light of Paragraph 12.03, actually the effective value of the input resistance at the marking current value is approximately one-half of the measured value, or 480 ohms. If 1170 ohms, as computed above, is used at the battery station, the total effective line resistance will be 1170 + 480 or 1650 ohms, and the resulting line current will be 120/1650 or 0.073 a. Thus the series resistance actually required at the battery station to give 0.060 a. of line current is 2000-480 or 1520 ohms.

12.05 If line resistance is checked with line current of reversed polarity as in polar operation, a similar discrepancy appears. Since Q1 does not conduct when the polarity is reversed, the input resistance seems to be higher. Consequently, it is difficult to obtain equal current for marking and spacing on polar circuits, unless each is set independently of the other.

12.06 With the driver strapped for polar operation, the computed input resistance for marking is R1 + (0.4 v)/0.030 a. or 10 + 13.3 = 23.3 ohms. (0.4 v is the Q1 emitter to base drop.) For spacing, the computed input resistance is 1.6 v, the drop across CR1 and CR2, divided by 0.030 a. or 53 ohms.

13. SPECIAL MODES OF OPERATION

13.01 The drivers are designed to operate in the conventional manner with their inputs in series. Paralleling the inputs of several drivers is not recommended, because the first to go marking holds the input voltage at its threshold value and prevents it from rising higher to turn on the other drivers. However, several modifications of the input circuit can be made to meet special requirements.

13.02 Parallel operation is often used to permit several circuits to be operated from a single keyer, although series operation can usually accomplish this end. When conditions make parallel operation desirable — as in hub circuits — additional circuitry must be provided to isolate the drivers from each other. Resistors can be used for this purpose as shown in Figure 5a, or diodes as shown in Figure 5b.

13.03 The input terminals can be shorted to make the driver go spacing. CR1 and CR2 are placed in parallel with CR3, CR4 and CR5. Since CR1 and CR2 have a lower voltage drop, all the current flows through them to the emitter of Q1 instead of through CR3, CR4 and CR5. The resultant voltage drop through CR1 and CR2 applies a negative bias to the emitter of Q1 which keeps Q1 shut off.