

NICK CARTER

INSTRUCTION BOOK
for
REGENERATOR
MODEL SFO
MODEL SFO-2

THE TECHNICAL MATERIEL CORPORATION

Mamaroneck, New York

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SECTION 1

GENERAL DESCRIPTION

1. PURPOSE AND BASIC PRINCIPLES.

Teletypewriter Regenerator Model SFO (hereafter referred to as Regenerator) is capable of accepting teletypewriter signals in audio (on/off) form or in direct current form (polar and neutral) having up to 45% bias distortion and regenerating the signal to have less than 5% bias distortion at the output.

a. Two Regenerators may be used to receive a Duplex teletype signal. One Regenerator will produce the leading duplex signal at its output regenerated to standard simplex timing. The other Regenerator will produce the lagging duplex signal at its output regenerated to standard simplex timing.

b. Each Regenerator will operate on 60, 75, or 100 wpm teletype signals.

c. Regeneration of the teletype signal in the Regenerator is accomplished by electronic means. Sampling pulses are generated in the Regenerator to synchronize with the center of each teletype pulse. If a sampling pulse coincides with a mark, the pulse operates a relay circuit to produce a regenerated mark at the Regenerator output. If the sampling pulse coincides with a space, the relay circuit will produce a space of proper duration at the Regenerator output.

2. DESCRIPTION OF UNITS.

The Regenerator Model SFO is illustrated in Figure 1-1. The panel is 3/16" thick by 19" long by 8-3/4"

high, and is finished in ocean gray enamel. The chassis extends 10" behind the panel and is supported to the panel on each side by brackets. The controls most often used are located on the Regenerator panel. Seldom used controls and fuses are located behind an access door in the center of the panel. Input, output and power connections are located at the rear of the Regenerator chassis. All vacuum tubes and relay are readily accessible from the rear of the Regenerator and are mounted in a vertical position. On Duplex reception the inputs of two Regenerators are connected in parallel and the outputs operate two teletypewriters. A separate power supply to operate the teletypewriter printer is required as the output of the Regenerator is in the form of relay contacts.

3. REFERENCE DATA

a. Input: 60, 75, or 100 wpm teletype signals.

b. Input keying: tone — 500 to 3,600 cps, 30 ma. polar, 60 ma. neutral, simplex or duplex; DC keying may be positive or negative with respect to ground on mark, tone keying may be either normal or inverse.

c. Output: Relay contacts in series with a 310 ohm resistor, contacts closed on mark during operation or during any steady input state.

d. Acceptable input distortion: 45% mark or space bias.

e. Output distortion: less than 5%.

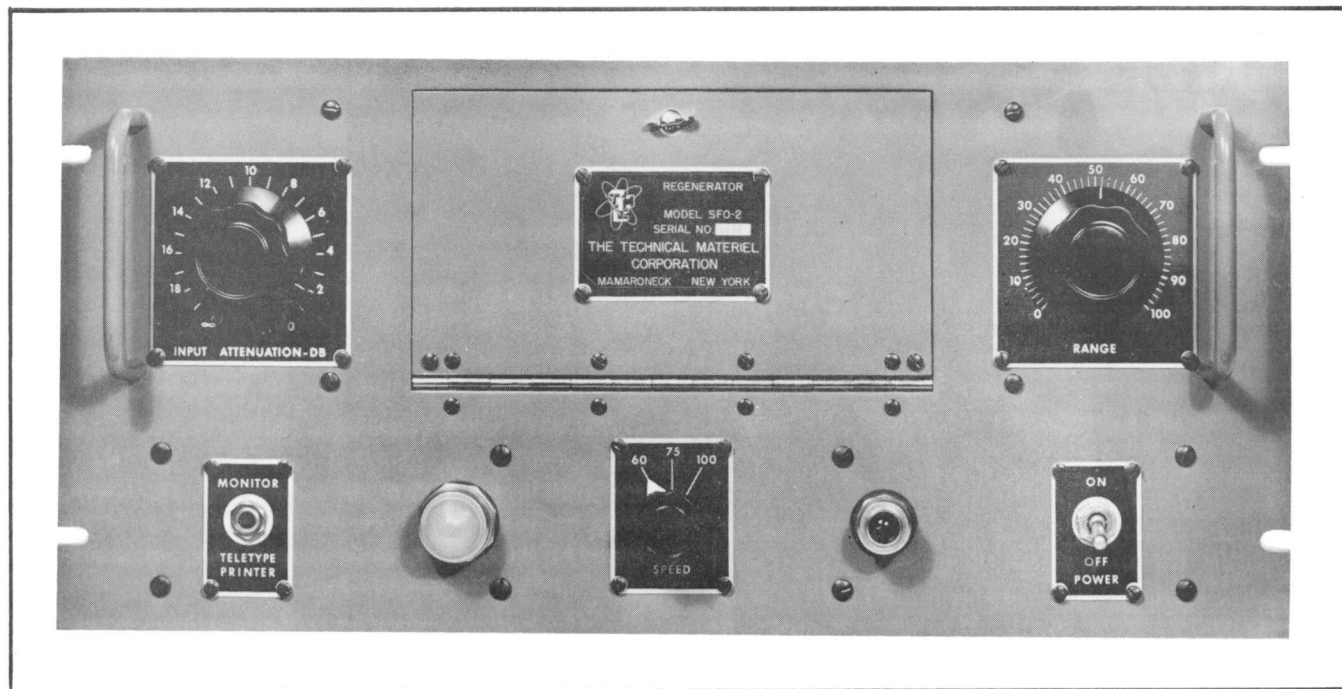


Figure 1-1. Regenerator Model SFO

- f. Tone input level: ---20 DBM to 0 DBM.
 g. Power requirements: 105 to 125 V, 50 to 60 cyc, 85 watts.
 b. Visual operation indicator: Neon lamp on front panel.

- i. Power Supply: Built in on each Regenerator.
 j. Monitor Tel typewriter: Front panel jack for monitor teletypewriter.

TABLE 1-1. VACUUM TUBE COMPLEMENT

SYMBOL	TYPE	CIRCUIT
V1	JAN6SN7GT	AUDIO AMPLIFIER
V2	JAN6H6	SERIES LIMITER
V3	JAN6H6	SIGNAL FULL WAVE RECTIFIER
V4	JAN6SN7GT	TRIGGER
V5	JAN6SN7GT	ONE SHOT MULTIVIBRATOR
V6	JAN6SN7GT	ONE SHOT MULTIVIBRATOR
V7	JAN6SN7GT	GATED MULTIVIBRATOR
V8	JAN6SL7GT	COINCIDENCE GATE
V9	JAN6SN7GT	ONE SHOT MULTIVIBRATOR
V10	JAN5U4G	FULL WAVE RECTIFIER
VR1	JAN OD3/VR150	VOLTAGE REGULATOR
VR2	JAN OA3/VR75	VOLTAGE REGULATOR
VR3	JANOD3/VR150	VOLTAGE REGULATOR
VR4	JAN OA3/VR75	VOLTAGE REGULATOR
V11	JAN 6SN7GT	CONTROL

SECTION 2

THEORY OF OPERATION

1. GENERAL DESCRIPTION OF CIRCUITS.

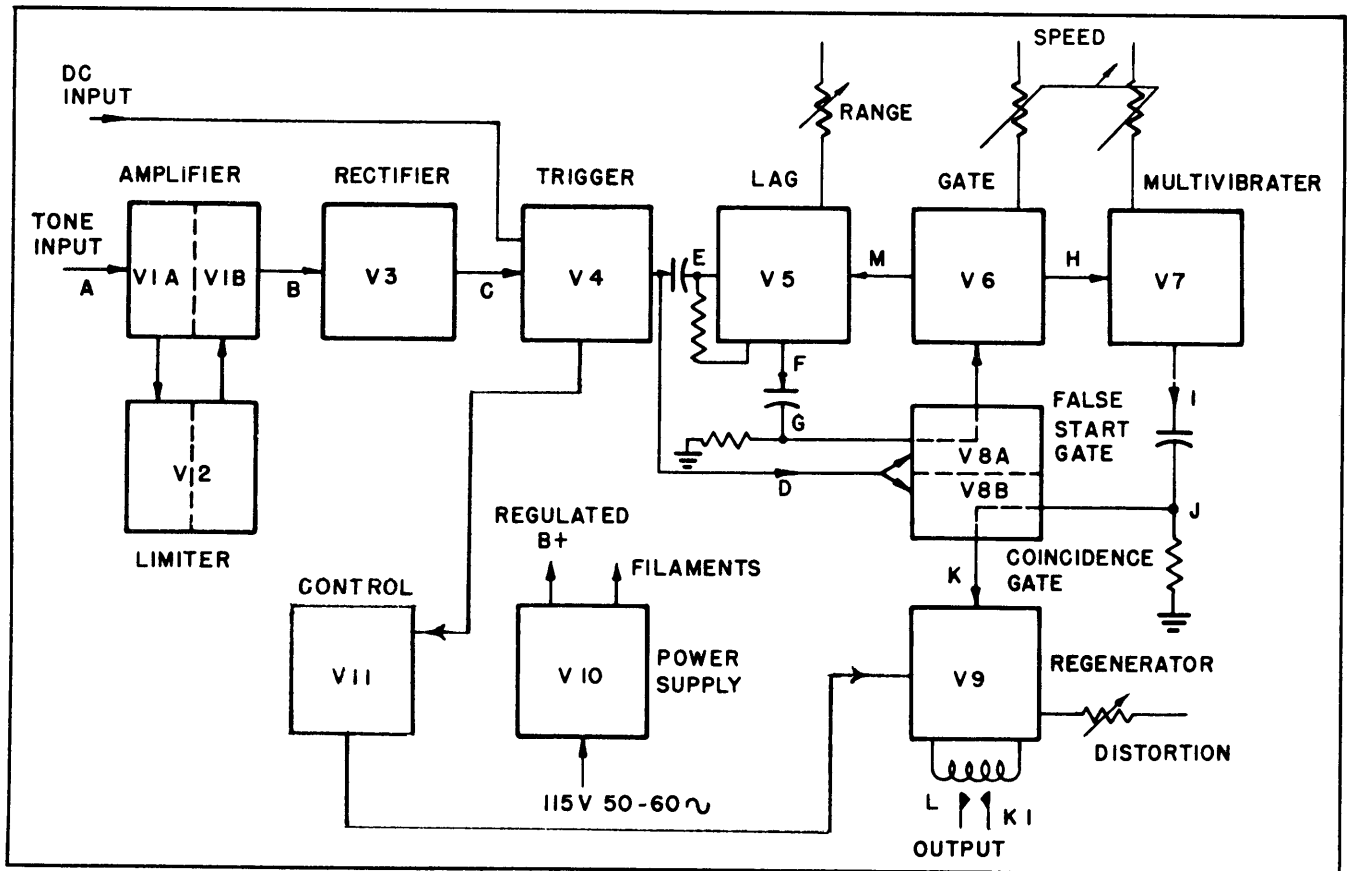
(1) Figure 2-2 illustrates a block diagram of the Regenerator showing routing of signal from input to output. Figure 2-1 is a Functional drawing showing wave shapes of the signal at pertinent points of the circuit on a time base. The time base is for 60 WPM operation, but similar circuit function occurs at 75 and 100 WPM so these time bases are not shown. A speed switch not shown on the Block Diagram changes timings in tube V5, V6, V7 and V9 to permit circuit operations to synchronize with either 60, 75 or 100 WPM operation.

(2) Constant reference will be made during the following discussion to tubes, points or lines designated by letters in Figures 1-2 and 2-2. Readers' reference to these Figures should be made when necessary without further direction.

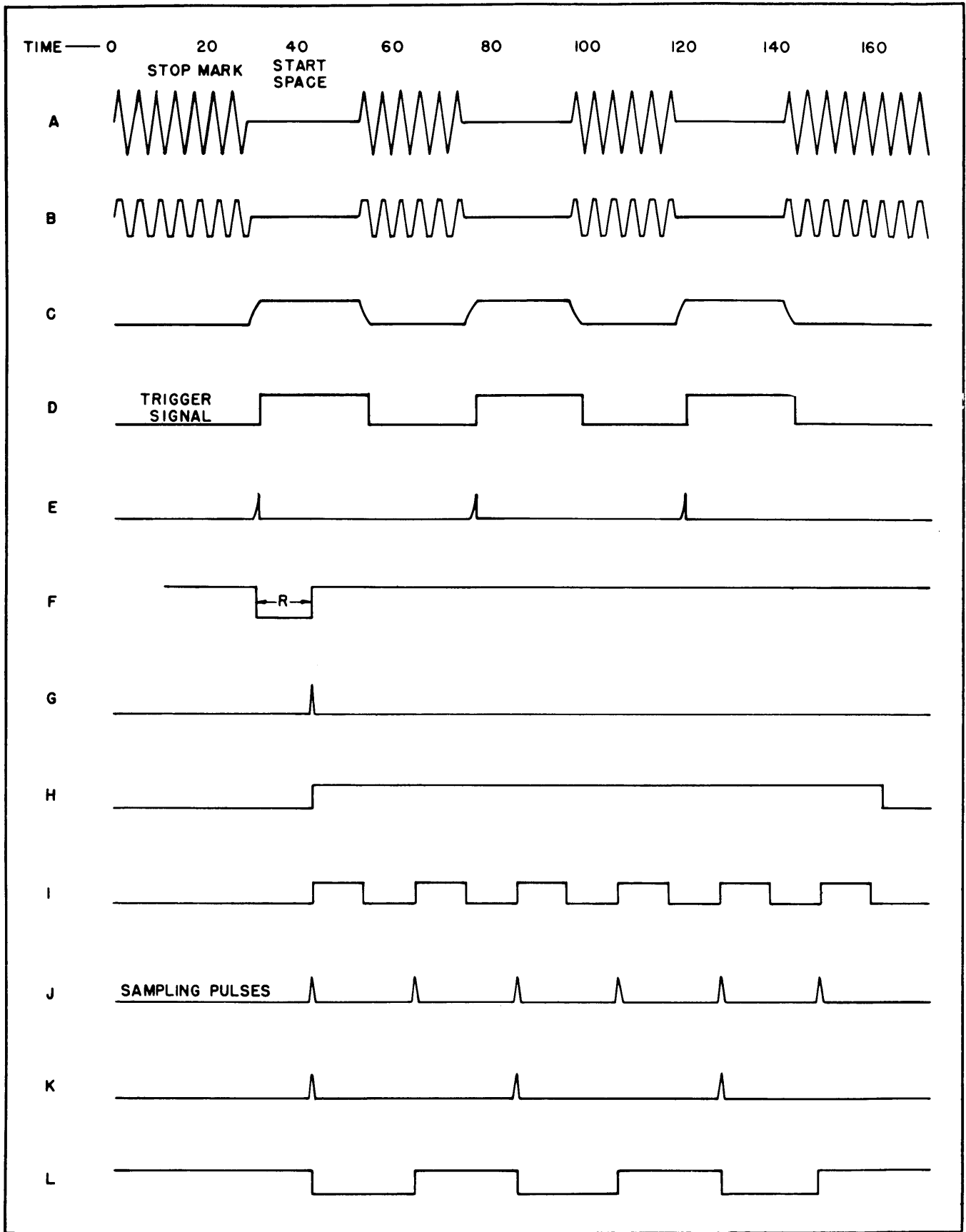
(3) It will be assumed that a keyed tone teletype signal is applied to the input of the Regenerator. A signal for the character Y is illustrated in the Functional Drawing Figure 2-1 where tone is on for the stop mark and off for the start space.

(4) The tone signal is amplified by triode V1A, limited by dual diode V2 to allow operation on varying line levels, and again amplified by triode V1B. This signal (line B, Fig. 2-1) and (point B Fig. 2-2) is then applied to a full wave rectifier tube V3, the output of which is illustrated in line C. The curve on the rise and decay time of voltage is due to filtering after the rectifier. The output of V3 is applied to trigger tube V4 as is the DC input voltage when polar or neutral DC keying is applied to the Regenerator, instead of tone keying.

(5) Trigger tube V4 performs the function of giving a square wave positive voltage output. See line D. Output from V4 is applied to both sections of the dual triode gate tube V8. Output from V4 is also differentiated and the resultant positive pulse (line E) is used to trigger the one shot multivibrator Lag tube V5. The operating time of this tube (line F, Fig. 2-1 and point F, Fig. 2-2) is adjustable by means of the RANGE control and is normally set for 11 ms on 60 WPM teletype so that the tube will trigger off at the time center of the start space. Output from V5 is differentiated and the resultant positive pulse is applied to the False Start Gate



Figur 2-1. Block Diagram

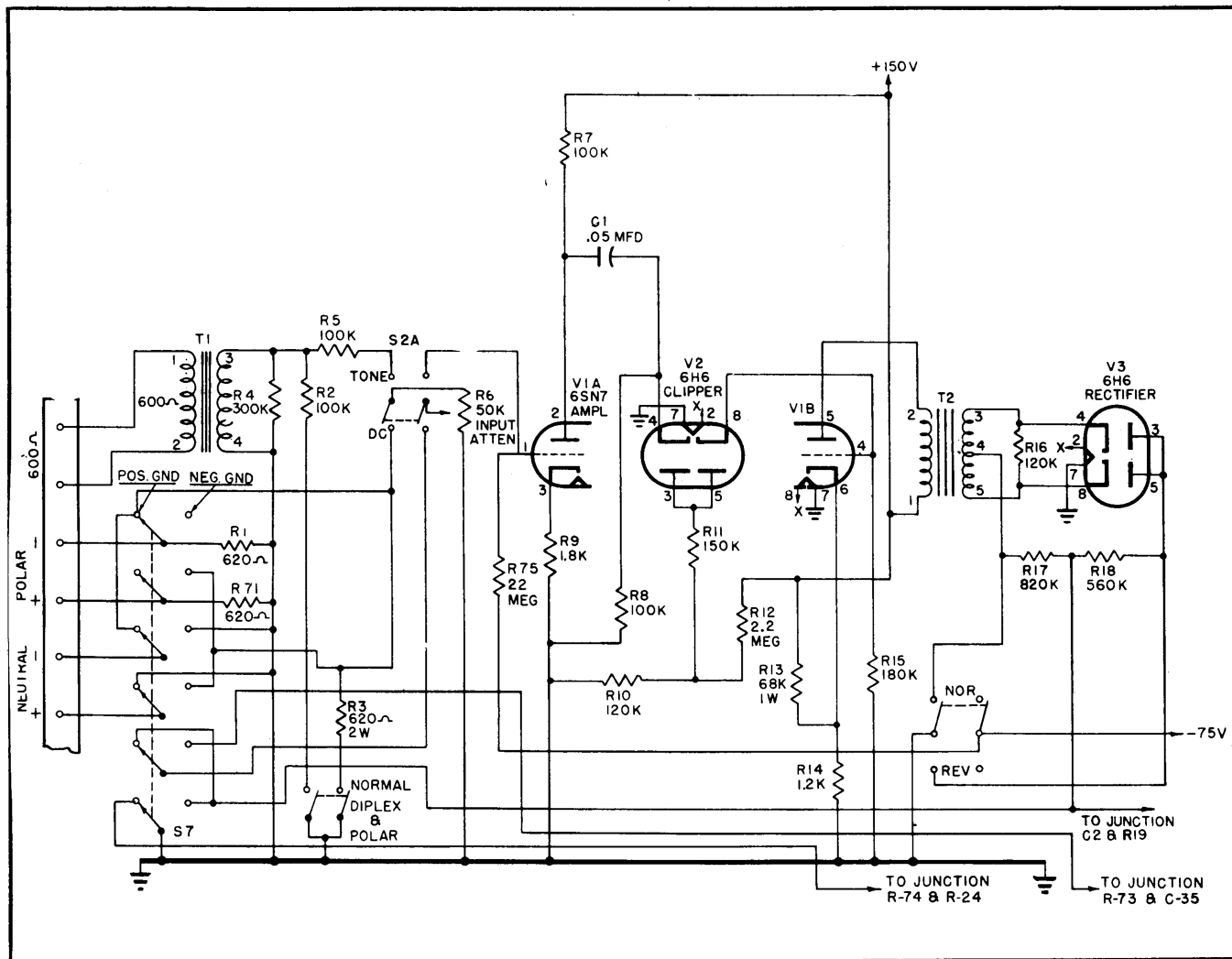


Figur 2-2. Functi nal Diagram

tube V8A. This triode tube is gated by the Trigger Signal so that if the differentiated pulse from V5 coincides in time with the Trigger signal, the pulse will appear at output of V8A and operate Gate tube V6. If the differentiated pulse from V5 does not coincide with a Trigger signal, no pulse will appear at the output of V8A. Assuming a start pulse of 8 ms length due to noise or some other random condition, the pulse from V5 will occur 11 ms after the start of the 8 ms trigger signal, will not coincide with the Trigger signal and no pulse will occur at the output of V8A. Under normal conditions the pulse applied to the input of V8A will appear at its output and the one shot multivibrator gate tube V6 will be triggered to its operating condition. Tube V6 remains in its operating condition for 121 ms (line H) during which time it performs two operations: (1) Lag tube V5 is biased off (connection M on the Block Diagram) so that additional pulses after the start pulse will not trigger this tube, (2) Multivibrator tube V7 is turned on for 5½ cycles of operation and then off. See line I. The multivibrator output is differentiated to produce

a positive sampling pulse for each of the six 22ms teletype pulses. See Line J. These sampling pulses are about 1 ms wide. A SPEED control consisting of a ganged variable resistor permits adjustment of the multivibrator frequency so that a sampling pulse occurs exactly at the center of each teletype pulse.

(6) The sampling pulses are applied to Coincidence Gate tube V8B which operates in similar fashion to False Start Gate tube V8A. When a sampling pulse occurs in coincidence with the Trigger signal, the sampling pulse appears at the output of V8B, and when the sampling pulse does not coincide with a Trigger signal, the sampling pulse does not appear at the output of V8B. Line K illustrates the signal at the output of V8B. Pulses at the output of V8B are applied to Regenerator tube V9 which is a one shot multivibrator with relay K1 connected in the output plate circuit. The operating time of tube V9 plus the operating characteristics of relay K1 produces the final output signal which is secured when the relay contacts are connected in series with a local battery supply to operate a teletypewriter. The output signal is illustrated in line L



Figur 2-3. Input and Amplifier Circuit

showing a negative line voltage on mark. A variable resistor (DISTORTION control) which varies the timing of V9, is normally adjusted for minimum output Distortion. This is necessary so as to take care of variations of speed, tube V9, and relay characteristics.

(7) Since the sampling pulse at the center of each 22ms teletype pulse is about 1 ms wide, it is possible for the input signal to have mark bias distortion extending 10 ms into the space signals and still have the sampling pulse sample correctly. Output from the Regenerator will be correct and undistorted as long as sampling is correct. Similarly, space bias distortion may extend 10 ms into the mark signals without faulty operation. Thus 45% bias distortion may be tolerated by the Regenerator without producing faulty output. Speed adjustment of the Regenerator must, of course, be perfect to secure operation at 45% bias distortions.

2. CIRCUIT ANALYSIS.

Circuit analysis for the Regenerator will be divided into sections of the circuit which accomplish specific individual functions. These functions are combined to produce the overall regenerative function.

a. INPUT AND AMPLIFIER CIRCUITS.—The input and amplifier circuits are illustrated in Figure 2-3. Tubes V1, V2 and V3 are utilized in the amplifier circuit to secure a DC voltage to properly operate the following trigger circuit from tone inputs of —20DBM to 0 DBM. The DC input circuits provide suitable impedances to the DC input lines.

(1) TONE INPUT.—Switch S7, located at rear of Chassis, should always be in POSITIVE GROUND POSITION for all tone input keying. Keyed tone input to the Regenerator is applied to the primary of the input transformer T1 which has a nominal impedance of 600 ohms. Resistors R2, R4, and R5 form a fixed attenuating network at the secondary of T1 so that amplifier tube V1A is not overloaded when 0 DB input is applied to the Regenerator and Input Attenuator R6 is set for zero attenuation. Switch S2 must be set to TONE during tone input operation so that the output from T1 is connected through S2 and Input Attenuator R6 to the grid of amplifier tube V1A. For Diplex operation, switch S1 is thrown to DIPLEX thus opening resistor R2 from across the secondary of T1. This reflects an impedance of 1200 ohms to the primary so that when two Regenerators are connected in parallel for tone input, the impedance is again 600 ohms and the operating level of the Regenerators is relatively unchanged over that for Simplex operation. Tubes V1A and V1B provide amplification of the tone signal so that inputs of -20 DB will properly operate the Regenerator. Output from V1A is capacitively coupled through capacitor C1 to the series limiter tube V2. Tube V2 is a dual diode series limiter which

provides relative uniform output from the front end with changing input levels from -20 DB to 0 DB. Tube V2 operates to clip the top off each side of the sine wave input at a predetermined level as follows: The plates of V2 are returned to a slightly positive point (junction of R10 and R12) through resistor R11 so that current flows in both sections of the tube and the tube conducts. Signals of relatively small amplitude applied to the input cathode (pin 4) of V2 are then passed to the output cathode (pin 8) without clipping. As the signal level is increased, a certain amplitude will be reached where the voltage on the positive peaks of the sine wave applied to the input cathode exceeds the static plate to cathode voltage. When this amplitude is reached, the tube ceases to conduct and clipping on the positive half of the wave results. When the signal voltage swings negative beyond the static value of plate to cathode voltage applied to the output section of the tube, this diode does not conduct and clipping on the negative half of the signal results. By proper selection of R8, R11, and R15, symmetrical clipping of the positive and negative halves of the signal is achieved. Output from limiter tube V2 is further amplified by triode V1B which is transformer coupled to rectifier tube V3. Tube V3 is a full wave rectifier whose function is to supply a DC voltage to operate the following trigger tube V4. Resistor R16 loads the secondary of T2 to reduce phase shift through the transformer. Keying switch S3A connected so as to secure either positive or negative output from tube V3. In the NORMAL position of S3, the center tap of transformer T2 secondary is grounded and a negative output at the junction of R17 and R18 is secured to operate the trigger tube. In the REVERSE position of S3 the plates of V3 are grounded and a positive output at the junction of R17 and R18 is secured. Capacitor C2 provides filtering of the rectified signal.

(2) DC INPUT.—When polar or neutral DC keying is applied to the Regenerator instead of tone input, switch S2 must be set to DC and switch S7 located in rear of Chassis next to terminal block, set to its proper position for positive or negative ground. The NORMAL-REVERSE switch located on front panel should be in NORMAL for all DC keying. The Input Attenuator R6 is then connected between the input line and the input to trigger tube V4. For neutral simplex operation switch S1 connects resistor R3 in parallel with resistor R1 across the DC input terminals to present an impedance of 310 ohms. For diplex neutral operation, the DC inputs of two Repeaters are connected in parallel and switch S1 is set to DIPLEX opening resistor R3. The input impedance of each unit is now 620 ohms and the paralleled impedance is 310 ohms. For polar simplex operation, resistor R1 and R71 present a 1240 ohm input balanced to ground. When two Regenerator inputs are connected in parallel,

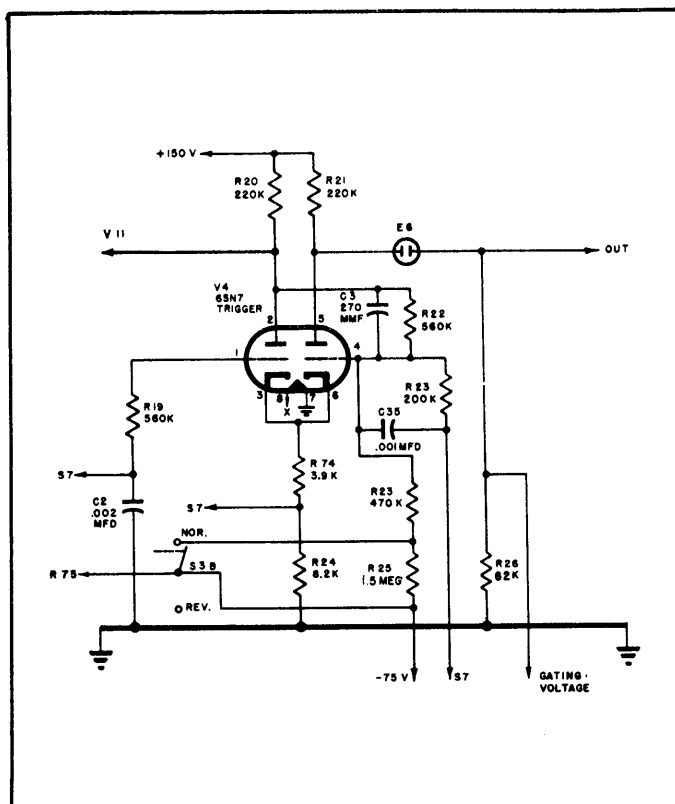


Figure 2-4. Trigger Circuit

the polar input impedance is 620 ohms balanced to ground. Input attenuator R6 provides a means of adjusting the level to the following trigger tube V4 for either tone or DC input to the Regenerator.

b. TRIGGER CIRCUIT.—The trigger circuit illustrated in Figure 2-4 is provided to accept the DC input signals from either the rectifier tube V3 or directly from the DC inputs and provide a stable square wave DC teletype signal voltage at the trigger output. A uniform square wave voltage is essential for optimum operation of the following sampling pulse generating circuits and gating circuits. Trigger tube V4 utilizes a direct coupled flip-flop circuit to secure a square wave voltage across the output load resistor R26. Threshold action is secured in V4 as random input voltages below a certain critical level necessary to trigger the tube will have no effect on the circuit. If there is considerable noise on the input signal, input to the trigger tube should be adjusted to provide about 6 DB more signal input than will just trigger V4. If the input signal is varying in amplitude, however, input to the trigger tube must be adjusted to provide enough signal above the trigger point of V4 that the varying level never falls below the trigger point.

(a) Operation of the trigger circuit is as follows: Keying switch S3 shorts out resistor R25 when set for NORMAL keying. This puts the grid of V4B at a negative potential, the plate draws no current and neon lamp E6 is on. Voltage (about 18 volts) is

now developed across resistor R26. When signal is applied to the Regenerator as during the stop mark, a negative voltage is applied to the grid of V4A. This reduces the plate current causing the plate of V4A and the grid of V4B (coupled to the plate through R22) to swing positive. Plate current is drawn in V4B, the plate voltage drops below the operating potential required for neon lamp E6 and the voltage across R26 drops to zero. Since application of a negative voltage to the grid of V4A causes an increase in the plate current of V4B, the current through the common cathode resistor R24 increases, causing the cathode bias voltage to increase. This effect on V4A is in the same direction as the application of the initial negative voltage to the grid so that a regenerative action results and a very steep drop off in voltage across R26 results. Upon removal of the negative voltage to the grid of V4A, the circuit flops back to its original state very rapidly due to the regenerative cathode coupling and neon lamp E6 is turned on instantly. Capacitor C3 speeds up the action of the trigger circuits so that the rise and decay time of voltage developed across R26 is very small (less than .25 ms).

(b) When keying switch S3 is set to REVERSE, resistor R25 is inserted in the grid circuit of V4B so that V4B normally draws current. The voltage at the plate of V4B is below the operating potential of E6 and no voltage is developed across R26. Switch S2 also connects a positive output voltage from rectifier tube V3 to the grid of V4A. The inverse tone input signal will now have tone during the start pulse so that a positive D.C. voltage will be applied to the grid of V4A. The plate current of tube V4A will increase causing the voltage at the plate of V4A (and the grid of V4B) to swing in a negative direction. Tube V4B is thus biased off causing the voltage at the plate to swing positive. Neon lamp E6 turns on and a voltage is developed across load resistor R26. The common cathode coupling of V4A and V4B causes regenerative action and sharp rise and decay time of voltage across R26 as before. The keying switch S3 thus provides the same output keying across R26 regardless of whether the tone input is normal or inverse. The output keying across R26 is inverse (ON during the start period) and is used to operate the following circuit. When DC input keying is applied to the Regenerator, the input may be either positive or negative on stop mark.

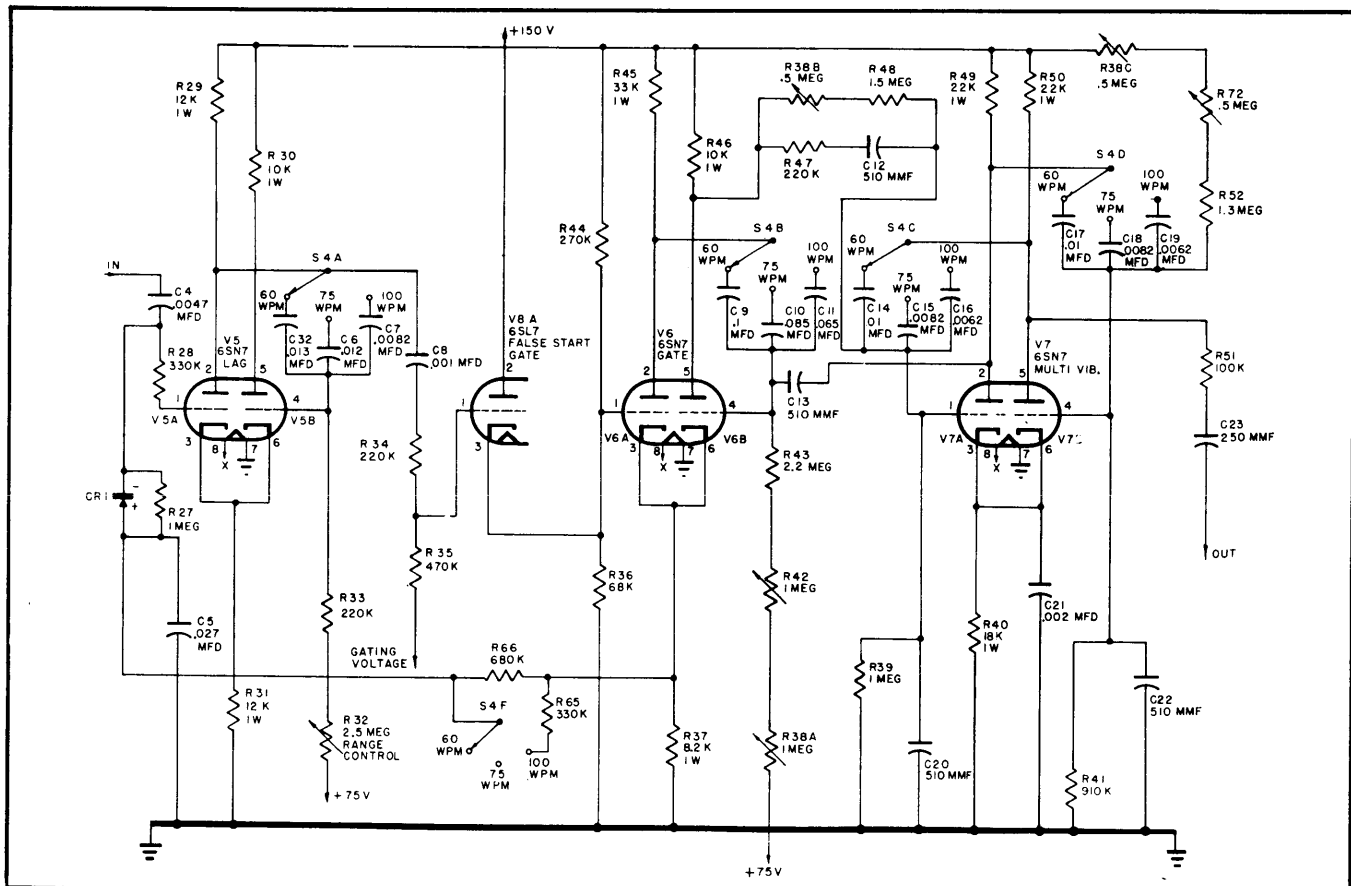
c. SAMPLING PULSE GENERATING CIRCUITS.—The six one ms pulses required for sampling the six 22 ms teletype pulses are generated and adjusted for timing in tubes V5, V6 and V7. See Figure 2-5. Tubes V5 and V6 are one shot multivibrators of the cathode coupled type. Tube V7 is a free running multivibrator when it is gated on by tube V6. The sampling pulses are secured by differentiating the output of V7. The SPEED control varying the frequency of V7 deter-

mines the spacing between sampling pulses (nominally 22 ms for 60 WPM operation). Gate tube V6 determines the number of sampling pulses. Tube V5 and associated RANGE control varies the position of the sampling pulses in respect to the teletype signal pulses.

(1) LAG CIRCUIT.—The trigger output signal developed across load resistor R26 is differentiated by capacitor C4 and resistor R27 to provide a positive pulse to trigger the grid of lag tube V5A. The plate of tube V5B normally draws current due to the connection of its grid through resistor R32 and R33 to a positive voltage. Tube V5A is then biased off due to the voltage developed across the common cathode resistor R31. When a positive pulse of sufficient amplitude is applied to the grid of V5A, the circuit triggers into a state where V5A draws current and V5B does not. After a time interval dependent mainly on the capacitance of C32 and resistance of R32 and R33, the circuit triggers back to its normal state with V5B drawing current. The voltage at the plate of V5A drops to about 100 volts when the circuit is triggered, and suddenly shifts back to the B+ value at the end of the cycle. The change of voltage in a positive direction is differentiated by capacitor C8 and resistor R34 plus R35 to supply a trigger pulse of proper amplitude to trigger gate tube V6. This trigger pulse is gated by

tube V8A (as described in Section 2-2C) before being applied to the grid of tube V6A. RANGE control R32 is a variable resistor in the timing circuit of V5 and functions to change the operating time of tube V5. Thus the delay between the leading edge of the start pulse and the position of the first sampling pulse is made adjustable from about 2 ms to 20 ms. For operation at 75 and 100 wpm switch S4A connects appropriate values of capacitors (C6 or C7) into the timing circuit of V5 so that operation of the RANGE control is approximately the same for 60, 75, or 100 wpm teletype signals.

(2) GATE CIRCUIT.—Gate tube V6 utilizes a one shot multivibrator circuit similar to that of tube V5 except that its operating time (121 ms for 60 wpm) is much longer than that of tube V5. Tube V6 accomplishes two major functions (a) Multivibrator tube V7 is turned on for 5½ cycles of operation and off, (b) Lag tube V5 is rendered inoperative after the start pulse and is kept inoperative until the following stop mark. The operating time of tube V7 is determined primarily by capacitor C9 and resistors R43 plus R42 plus R38A. For 75 or 100 wpm operation switch S4B connects capacitors C10 or C11 into the timing circuit of tube V7 to provide proper operation of the circuit at different teletype speeds. Variable resistor R38A is part of a three gang variable resistance SPEED



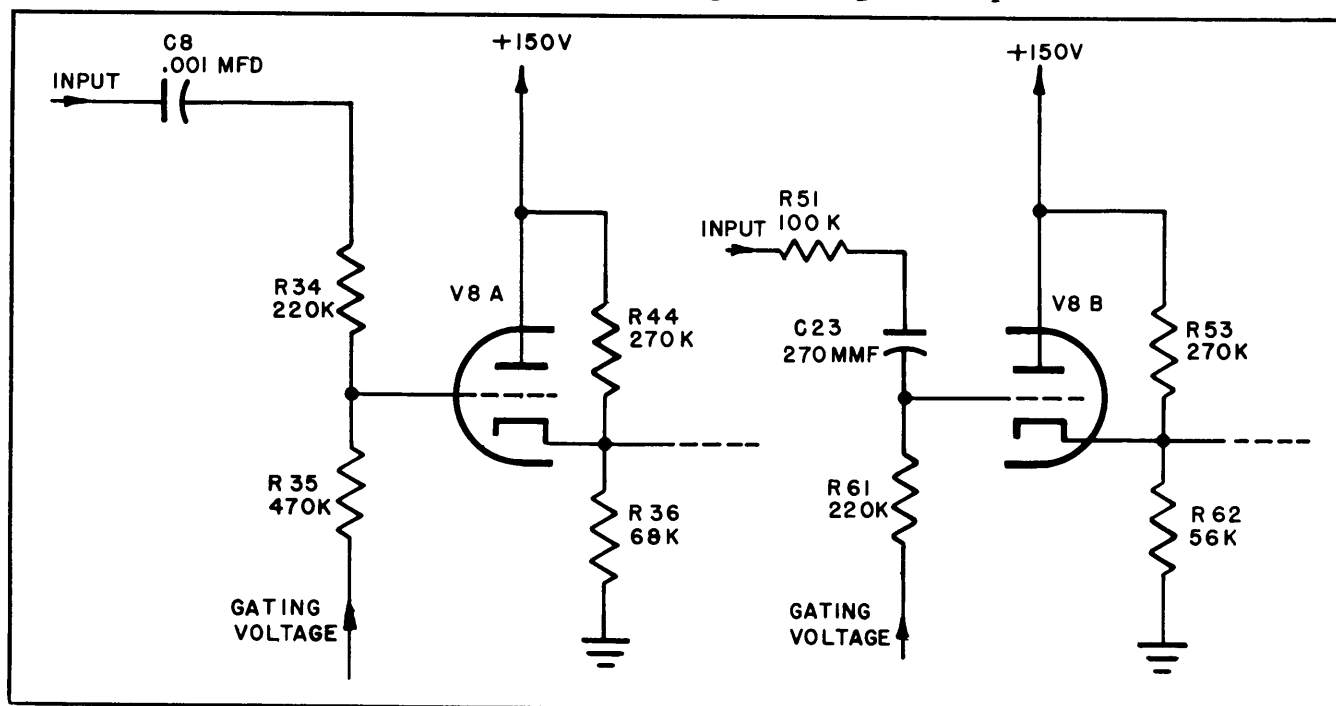
Figur 2-5. Sampling Puls G n rating Circuits

control and smoothly varies the timing of V7 about $\pm 10\%$. Sections R38B and R38C of the SPEED control vary the frequency of multivibrator tube V7 in unison with the timing of gate tube V6 so that for any setting of the SPEED control, only $5\frac{1}{2}$ cycles of the multivibrator occur. The SPEED control nominally provides for $\pm 10\%$ variations in speed from the speeds of 60, 75 or 100 wpm selected by switch S4. Variable resistor R42 provides a fine adjustment of the timing of V6 so that variable resistor R38A tracks properly (gates only $5\frac{1}{2}$ cycles) with R38B and R38C.

(a) Multivibrator tube V7 is turned on for $5\frac{1}{2}$ cycles and off by gate tube V6 as follows: Multivibrator tube V7 utilizes a symmetrical multivibrator circuit with the exception of the connection of resistor R46 between R38B and B+. Neglecting resistor R46, resistors R38B, R48 and R39 form a divider network between B+ and ground with the grid V7A connected to the junction of R48 and R39. An equal resistor network from B+ to ground consisting of R38C, R52 and R41 has the grid of V7B connected to the junction of R52 and R41. Equal plate resistors R49, R50 and equal coupling capacitors C14, C17 provide a symmetrical circuit which will multivibrate at 45.45 cps (nominal for 60 wpm setting) if gate tube V6 is out of the circuit. When gate tube V6 is in the circuit, V6B draws current due to the connection of its grid to +150 volts through resistors R43, R42 and R38A. The voltage at the plate of V6B is then below 100 volts due to the voltage drop across plate resistor R46. The voltage at the grid of V7A is now considerably below the voltage at the grid of V7B, since the resistor divider network connected to the grid of V7A connects at its B+ end to less than 100 volts, while the resistor divider network at the grid of V7B connects at

its B+ end to 150 volts. Under these conditions V7B will draw considerable current causing sufficient voltage drop across the common cathode resistor R40 to bias off tube V7A, and V7 will not oscillate. At the moment tube V6 is triggered by a pulse from lag tube V5, the output section of V6 (V6B) ceases to draw current and multivibrator tube V7 starts to oscillate. To make sure that oscillation starts immediately in tube V7, capacitor C12 and resistor R47 apply a pulse from the plate of V6B to the grid of V7A at the moment of starting. Capacitor C13 applies positive pulses at each half cycle point from the plate of V7A to the grid of V6B. At the time of the sixth positive pulse, the voltage at the grid of V6B is nearly to the point where the tube will trigger back to its stable state with V6B drawing current. The sixth positive pulse causes this triggering action to occur so that V6 always triggers off at the $5\frac{1}{2}$ cycle point of the multivibrator's operation and in turn shuts the multivibrator off until the gate tube V6 is again triggered on by the lag tube V5. Capacitors C20, C21 and C22 in the multivibrator circuit help to stabilize the frequency of oscillation. Capacitors C15 and C18 provide the proper frequency of operation of tube V7 for 75 wpm teletype speeds. Capacitors C16 and C19 provide the proper frequency of operation of tube V7 for 100 wpm teletype speeds.

(b) Lag tube V5 is rendered inoperative by gate tube V6 after the start pulse in the following manner: The grid of V5A is returned to the cathode of V6 through resistors R28, R27 and R66. When tube V6 is in its off state (V6B drawing current), a positive voltage is developed across the cathode resistor R37. A greater voltage is developed across the cathode resistor



Figur 2-6. Gat Circuits

of V5 so that the grid of V5A is just biased off. Under these conditions, a positive pulse of normal amplitude will be sufficient to trigger the grid of V5A. When V6 is triggered from V5, V6A draws current while V6B does not. Since the plate resistor of V6A is much higher in value ($R45 = 33,000$ ohms) than the plate resistor of V6B ($R46 = 10,000$ ohms), the voltage across the cathode resistor R37 will be much less when gate tube V6 is in the on cycle than when in the off period. Thus the grid of V5A will be returned to a much more negative point (with respect to its cathode) when the gate is on than when the gate is off. Under these conditions the pulses following the start pulse, although applied to the grid of V5A are not of sufficient amplitude to trigger the circuit. About 20 ms after the gate turns off (V6B draws current), the lag tube V5 is again capable of being triggered by the first pulse applied to the grid. The 20 ms delay is caused by capacitor C5 and resistor R66. At 100 wpm speed the delay is reduced by shunting R66 by R65 to reduce the RC time constant. The purpose of the delay is to permit the Regenerator to recover quickly if a start pulse is missing and the gate cycle is started by a following pulse.

d. COINCIDENCE GATE CIRCUITS.—The coincidence gate circuits are illustrated in figure 2-6. Tube V8A performs the function of preventing random noise pulses at the Regenerator input from triggering the gate circuit providing the noise pulses are somewhat shorter than one half the normal start pulse duration. Tube V8B provides the circuit in which the teletype signal pulses are sampled by the one ms pulses from the multivibrator and thus determines whether a mark or a space is to be produced at the output of the Regenerator.

(1) FALSE START GATE.—Tube V8A is one half section of a 6SL7GT tube which is connected as a cathode follower. The tube is normally biased far beyond cut-off by cathode resistor R36 and resistor R44 connected between cathode and B+. The grid of V8A is connected through resistor R35 to the gating voltage (developed at the output of tube V4) and also receives pulses from lag tube V5 through capacitor C8 and resistor R34. At the time of the teletype start pulse the gating voltage (plus 17 volts) is applied to the grid of V8A so that the tube is biased just beyond cut-off. A pulse now applied through capacitor C8 and resistor R34 to the grid will cause plate current to flow and the pulse will appear at the cathode. If the pulse is applied to the grid of V8A when there is no gating voltage, tube V8A will be biased so far beyond cut-off that the amplitude of the pulse will not be sufficient to cause plate current to flow and the pulse will not appear at the cathode. Assuming a random pulse of 8 ms duration is applied to the Regenerator, this pulse will cause a gating voltage of eight ms duration to be applied to the grid of V8A. The pulse to the grid of V8A through capacitor C8 under normal setting of the

RANGE control at 60 wpm operation will not occur until 11 ms after the start of the eight ms gating pulse. The pulse through capacitor C8 will thus occur three ms after the gating voltage has ceased and will not appear at the cathode of V8A to trigger the following gate tube V6. As long as tube V6 is not triggered, no output can be secured from the Regenerator.

(2) SAMPLING GATE.—Tube V8B is connected in a similar circuit to that of tube V8A. Cathode to ground resistor R62 and cathode to B+ resistor R53 normally bias V8B far beyond cut-off. The output from multivibrator tube V7 is differentiated and applied to the grid of V8B through capacitor C23. Gating voltage to the grid of V8B is applied through resistor R61 so that when the plus 17 volts is on (as during the start pulse) the positive differentiated multivibrator pulse causes plate current to flow in tube V8B and a positive pulse appears at the cathode to drive Regenerator tube V9. Resistor R61 prevents the differentiated multivibrator pulse from feeding back into the source of the gating voltage (across resistor R26 in Figure 2-3) with sufficient amplitude to cause any interlocking in operation. When there is no gating voltage applied to tube V8B, the pulse from the multivibrator is not of sufficient amplitude to cause plate current to flow and the pulse will not appear at the cathode. Resistor R51 limits the amplitude of the multivibrator pulse to secure the desired operation.

e. REGENERATOR CIRCUIT.—The Regenerator circuit provides the output teletype signals in normal keying form and with less than 5% distortion. The one shot multivibrator Regenerator circuit employing tube V9 and relay K1 is illustrated in Figure 2-7. Relay K1 is connected in the output section of V9 (V9B) and is normally excited and has its contacts closed during any steady input condition to the Regenerator. When a teletype signal is applied to the Regenerator, a positive pulse will be impressed on the grid of tube V9A from the cathode of Sampling Gate Tube V8B every time a space pulse occurs. With normal adjustments for 60 wpm operation, tube V9 will trigger into its unstable state upon application of the positive trigger pulse and remain in this state for about 19 ms before triggering back to the stable state. This operating time interval is determined primarily by the values of capacitor C24 and resistors R55 plus R54. Resistor R54 is the DISTORTION control and permits adjustment of this time by at least $\pm 10\%$. At the instant V9A is triggered by the pulse from tube V8B, tube V9B ceases to draw current and the relay K1 opens within two ms. Assuming there is no space pulse following the start pulse, the current will not be applied to the relay again for 19 ms and the relay coil characteristic is such that the contacts will not close for five ms after the current has been applied. The total time the relay contacts will be open can be calculated from the following formula:

$$\text{Contact open time} = \text{circuit operating time}$$

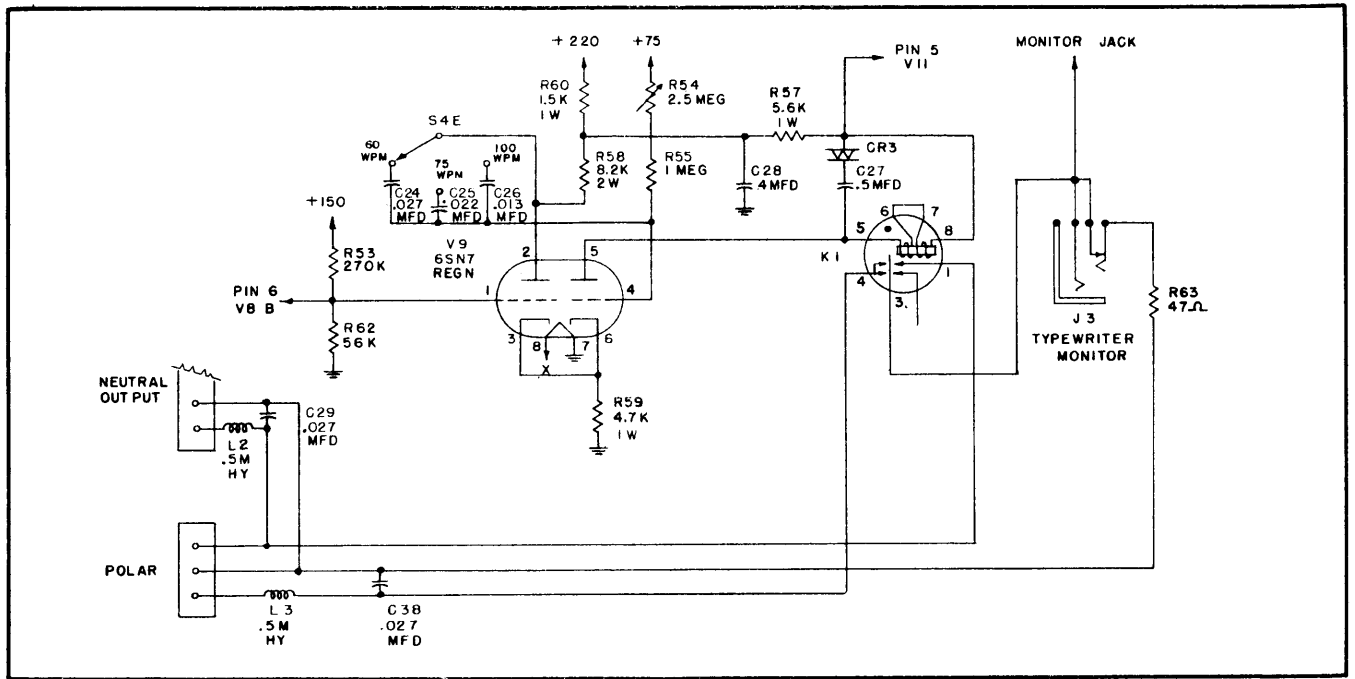


Figure 2-7. SFO-2 Regenerator Circuit

— time for contacts to open + time for contacts to close.

The relay contact open time thus can be evaluated at $19 - 2 + 5$ or 22 ms which is the correct time of a space signal. If the start space of the teletype signal is followed by another space, a second pulse 22 ms after the first pulse will trigger tube V9 from the sampling

gate tube V8B. There will be a three ms period when the relay coil is energized under these conditions (22 ms between pulses to circuit — 19 ms operating time of circuit), but since the relay requires five ms to close after being energized, the contacts will not close at all and a 44 ms space will result from the relay contacts. In this fashion the relay will produce undistorted teletype signals at the contacts depending only on the

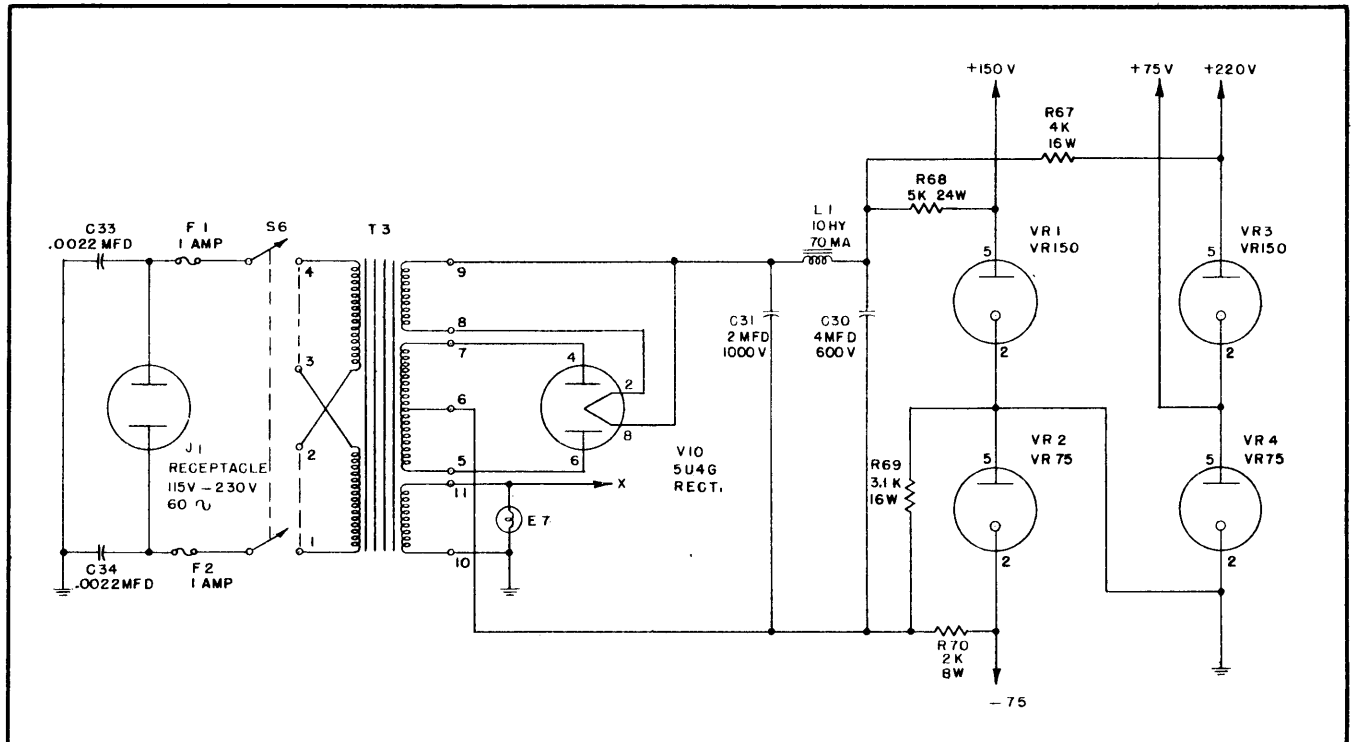


Figure 2-8. SFO-2 Power Supply Circuit

regenerator tube V9 receiving the 1 ms driving pulses from the sampling gate circuit. Capacitors C25 and C26 are selected by speed switch S4E to provide proper circuit timings at 75 or 100 wpm operation. Capacitor C27 and resistor R56 determine to some extent the operating time characteristics of relay K1. Capacitor C28 and resistor R60 form a decoupling network in the B+ supply to tube V9. More uniform operation of the circuit is thereby achieved. Jack J3 provides connection of a monitor teletypewriter. Resistor R63 replaces the resistance of the teletypewriter when its connection is removed from the jack. Capacitor C29 and RF choke I2 prevent radiation of excessive noise voltages generated by the contacts of relay K1.

f. POWER SUPPLY CIRCUIT.—The power supply circuit is illustrated in Figure 2-8. A single power transformer T3 supplies filament and plate power for all tubes in the Regenerator. Tube V10 is a full wave rectifier whose output is filtered by reactor L1 and capacitors C31 and C30. All DC voltages used in the Regenerator are regulated. Regulating resistor R68 and tube VR1 provide plus 150 volts. Regulating resistor R67 and tubes VR3 and VR4 provide plus 225 volts and plus 75 volts. A regulated minus 75 volts is secured by connecting resistor R69 between the center tap of the high voltage winding and ground to secure a minus 117 volt drop, and regulating to 75 volts with series resistor R70 and tube VR2. Power switch S6 breaks both sides of the line are fused by F1 and F2. Capacitors C33 and C34 bypass either side of the AC line to ground to prevent radiation of noise voltages into the line.

g. OSCILLOSCOPE MONITOR SWITCH CIRCUIT.—The oscilloscope monitor switch circuit shown in Figure 2-9 indicates the various circuits to which

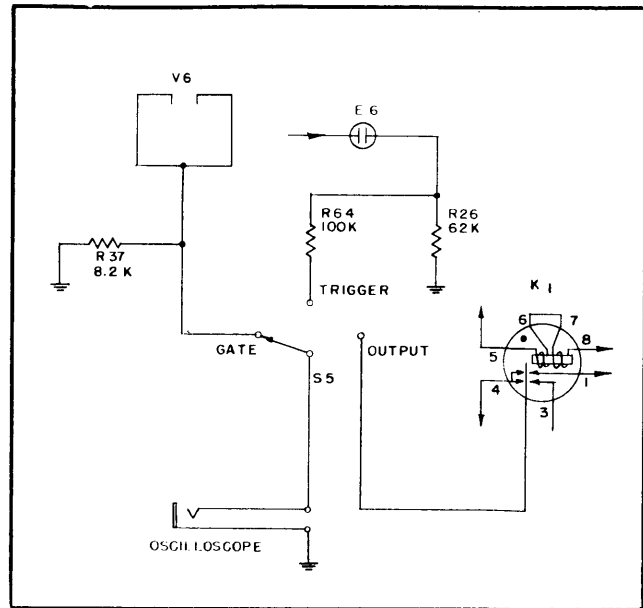


Figure 2-9. SFO-2 Oscilloscope Monitor Switch Circuit

the oscilloscope is connected when the switch is set to different positions. In the GATE position of the switch, the oscilloscope connected to jack J2 is connected to the cathode of gate tube V6 to view the gate cycle. In the TRIGGER position of the switch, the voltage across load resistor R26 is viewed. The gating voltage for the coincidence gate tubes plus the sampling pulses are seen at this point. In the OUTPUT position of the switch, the output voltage to the teletypewriters is seen. This voltage can be observed only when a power supply is connected in the output circuit to operate the teletypewriters.

SECTION 3 INSTALLATION

1. INSTALLATION.

a. A power supply suitable to operate the teletype-writers must be connected in series with the output. If the equipment is located in a position where radiated noise may be troublesome to receivers, the output lines from the equipment should be shielded and the shielding grounded to the GND output terminal on the Regenerator terminal board. Since one connection of the output from the Regenerators is connected to ground, a single shielded cable may be used for connecting the output from each Regenerator to the respective teletypewriter. In this case the shield should be grounded at the GND output connection and the shielded wire should connect from the other Regenerators output connection to one side of the teletypewriter input relay. The other teletypewriter input relay connection would return to ground through the power supply. A suitable variable series resistor may be necessary in the output circuit to each teletypewriter for securing the optimum operating current.

b. In making input wiring to the equipment the following considerations should be observed:

(1) Neutral or Polar DC inputs may be either positive or negative with respect to ground and Switch S7 should be set accordingly. When Switch S7 is in Positive ground position the side of the line connected to the negative terminal board connection must be negative during the mark signal. The positive Neutral input connection to the Regenerator is ground. The positive Polar input connection to the Regenerator is 620 ohms to ground as is the negative terminal. Inputs that are balanced to ground are thus provided for polar operation when Neutral positive is grounded. When Switch S7 is in Negative ground position the negative Neutral input connection is ground. The positive Neutral and positive Polar are connected together and are 620 ohms to gnd. The Negative Polar input connection is 620 ohms to ground. Inputs that are balanced to ground are thus provided for polar operation when Neutral negative is grounded.

(2) Tone input to the Regenerator is normally 600 ohms balanced to ground but one of the Tone input terminals may be grounded to provide unbalanced input if desirable. Switch S7 located at rear of chassis must be on POSITIVE GROUND position for all tone keying.

(3) For diplex operation the inputs of the two Regenerators to which the signal is fed are wired in parallel (plus to plus and minus to minus for DC inputs).

(4) Input lines should be shielded if there is

much chance of noise pick-up by the leads or if there is noise radiation from the leads.

2. INITIAL ADJUSTMENTS.

After the Regenerator has been installed and the Regenerator wired in accordance with Section 3-1, each Regenerator should be operated and checked. Adjustments should be made only if checks indicate such a need.

a. INITIAL CHECK.—Make an initial check on the Regenerator as follows:

(1) Turn the Power switch to ON. The pilot lamp should light immediately and the neon lamp should light within a few seconds.

(2) Flip the toggle switch labeled NORMAL—REVERSE to REVERSE. The neon lamp should now be off. Return the switch to the NORMAL position. These checks determine that the equipment is powered and that the trigger circuit is operating.

b. OPERATIONAL CHECK AND ADJUSTMENTS.—An operational check should be performed on each Regenerator after installation to make sure the equipment is properly adjusted for operation.

(1) Allow the Regenerator to operate for at least fifteen minutes to warm up and stabilize.

(2) Determine the speed (60, 75 or 100 wpm) of the incoming signal which will operate the Regenerator. Set the front panel SPEED selector switch to the correct position.

(3) Determine the type of teletype signal for which the Regenerator is connected at the input (DC Neutral or Polar, or Tone), and set the three keying switches behind the front panel access door and S7 located on rear of Chassis for operation on the input signal used. The toggle switch with NORMAL and REVERSE designations should always be at NORMAL unless a tone input with inverse keying (tone off during stop mark) is connected to the keyer. The TONE—DC switch is set for either tone or DC inputs. The SIMPLEX NEUTRAL—DIPLEX, POLAR switch, is set to SIMPLEX NEUTRAL for either tone or DC simplex signals and to DIPLEX POLAR for any diplex or DC polar inputs. SWITCH S7 should always be in POSITIVE GROUND POSITION FOR ALL TONE KEYING.

(4) Connect an oscilloscope having a low frequency sweep to the oscilloscope jack behind the access door. An oscilloscope similar to the OS-8/U is suitable. See Figure 3-1 for the oscilloscope connections.

(5) Apply a teletype signal to the Regenerator. The neon lamp should blink when the signal is applied,

If it does not, advance the INPUT ATTENUATOR clockwise until a point is reached where the neon lamp just begins to blink. Advance the INPUT ATTENUATOR six steps clockwise (6DB) beyond the trigger point.

(6) Set the SPEED switch on the front panel to the speed of the incoming signal.

(7) Set the rotary OSCILLOSCOPE switch located above the jack on the subpanel to the TRIGGER position.

(8) Apply an undistorted repeated character telegraph test signal to the Regenerator. Operate and adjust the oscilloscope to see the trigger signal. The lowest frequency sweep of the oscilloscope will usually be the sweep to use to see one complete teletype character. This is a DC teletype signal on which should be seen a sampling pip for each of the teletype pulses except the stop pulse. See Figure 3-2 for a typical pattern for the character Y.

(9) Adjust the front panel RANGE control forward and backward and observe that the sampling pips move forward and backward across the teletype pulses. It should be possible to adjust the RANGE control so that a sampling pip coincides with the exact center of each of the teletype pulses.

(10) Set the RANGE control so that the first sampling pip coincides with the center of the start pulse. The last sampling pip should now coincide with the center of the last intelligence pulse. If it does not, the variable SPEED control located on the sub-panel is in need of adjustment and step (11) should be performed.

(11) After the setting of the RANGE control to center the first sampling pip on the start pulse, adjust slowly with a screwdriver the SPEED control until the last sampling pip is exactly centered on the last intelligence pulse. A sampling pip should now be visible at the exact center of each of the six teletype pulses. This represents the correct adjustments for the RANGE and SPEED controls.

(12) Set the OSCILLOSCOPE selector switch to the OUTPUT position and observe the output signal from the Regenerator. This signal will be seen only if the output circuit to the remote teletypewriter and series power supply is connected and operating. If there is any discernible bias distortion on the output signal (mark and space pulses not equal), adjust slowly with a screw driver the DISTORTION control until mark and space pulses are equal in length.

(13) Connect a teletype printer to the MONITOR jack on the Regenerator panel and check operation of the printer. Change the undistorted test character to a test message. It should be possible to rotate the RANGE control over its full range without causing faulty printer operation.

(14) Rotate the Range control clockwise to 100. If the monitor printer prints errors, there is mark bias distortion (the mark signals are elongated).

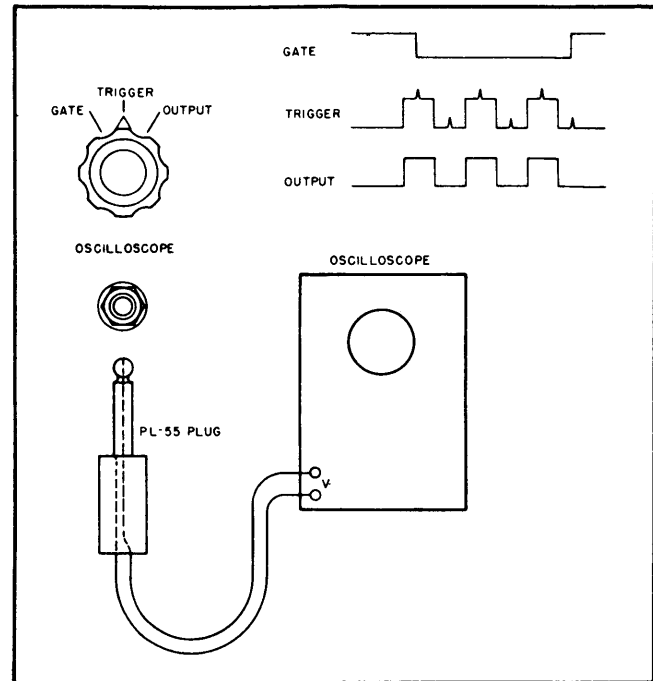


Figure 3-1. Oscilloscope Connections and Patterns

(15) Rotate the Range control counter-clockwise to zero. If the monitor printer prints errors, there is space bias distortion on the signal. If the SPEED adjustment was not made correctly, an indication of bias distortion on the signal when the RANGE control is rotated to its extreme limits may be false. Accurate speed adjustment of the Regenerator is necessary before the RANGE control can be varied over its full range on a signal free of bias distortion.

NOTE

After any SPEED adjustment is made on the Regenerator, an adjustment of the output DISTORTION control is necessary for optimum operation of the equipment.

The final setting of the RANGE control should be that which centers the sampling pips on the teletype signal pulses as seen on the oscilloscope. This setting should be at approximately 50 on the RANGE control.

(16) After these installation checks, the equipment is ready for normal operation.

(17) If it is desired to send a keyed tone over a line from the Regenerator, a tone generator may be connected in series with the ungrounded Regenerator output terminal and one side of the line. The grounded output terminal should connect to the other side of the line. Capacitor C29 (See Figure 7-2 for the location of capacitor C29) must be disconnected from the circuit for this type of operation and perform an operational check on the Regenerator as outlined in Section 3-2b. The Regenerator is now ready for normal operation.

SECTION 4 OPERATION

1. INTRODUCTION.

The Regenerator should seldom require attention from the operator after the equipment is installed, checked, and adjusted as outlined in Section 3-3. While the adjustments of the Regenerator are very important to secure optimum performance, it should not be necessary for the operator to readjust the equipment unless another type of signal input is connected to the Regenerator, or unless the speed or amplitude of the input signal changes.

2. CAPABILITIES AND LIMITATIONS.

The Regenerator is specifically designed to correct for bias distortions in teletype signals and when properly adjusted, mark or space bias distortions of 45% are corrected to less than 5% at the Regenerator output. There are conditions which will cause faulty operation of the Regenerator. These conditions are most often found in signals from radio circuits.

a. If there is a missing start pulse due to a fading signal, the Regenerator will be started by a following intelligence pulse and will print errors for a few characters until the Regenerator corrects itself.

b. If the start pulse is too short in duration (less than 10 ms for 60 wpm operation), it will be treated

as noise and intercepted by the Regenerator so that a following intelligence pulse longer than 10 ms will act as the start pulse and errors will be printed for a few characters.

c. If there is a missing intelligence pulse or if there is a split or knock-out in one of the intelligence pulses at the point sampling occurs, an error will be printed.

d. If the speed of the incoming signal changes, the amount of bias distortion that can be accepted by the Regenerator will be reduced. Since the change in speed would appear as an increase in distortion to the operator, periodic speed checks should be made on the Regenerator as outlined in Section 5-1.

3. OPERATION OF EACH FUNCTION.

The Regenerator is intended to perform two general functions. The first is to regenerate single channel teletype signals before operating a teletype printer. The second is to regenerate duplex teletype signals to single channel form for the operation of a teletype printer.

a. OPERATION ON SINGLE CHANNEL CIRCUITS.—The following steps are required to put the Regenerator into operation after an input signal is applied to the unit and the remote output power supply is connected and powered.

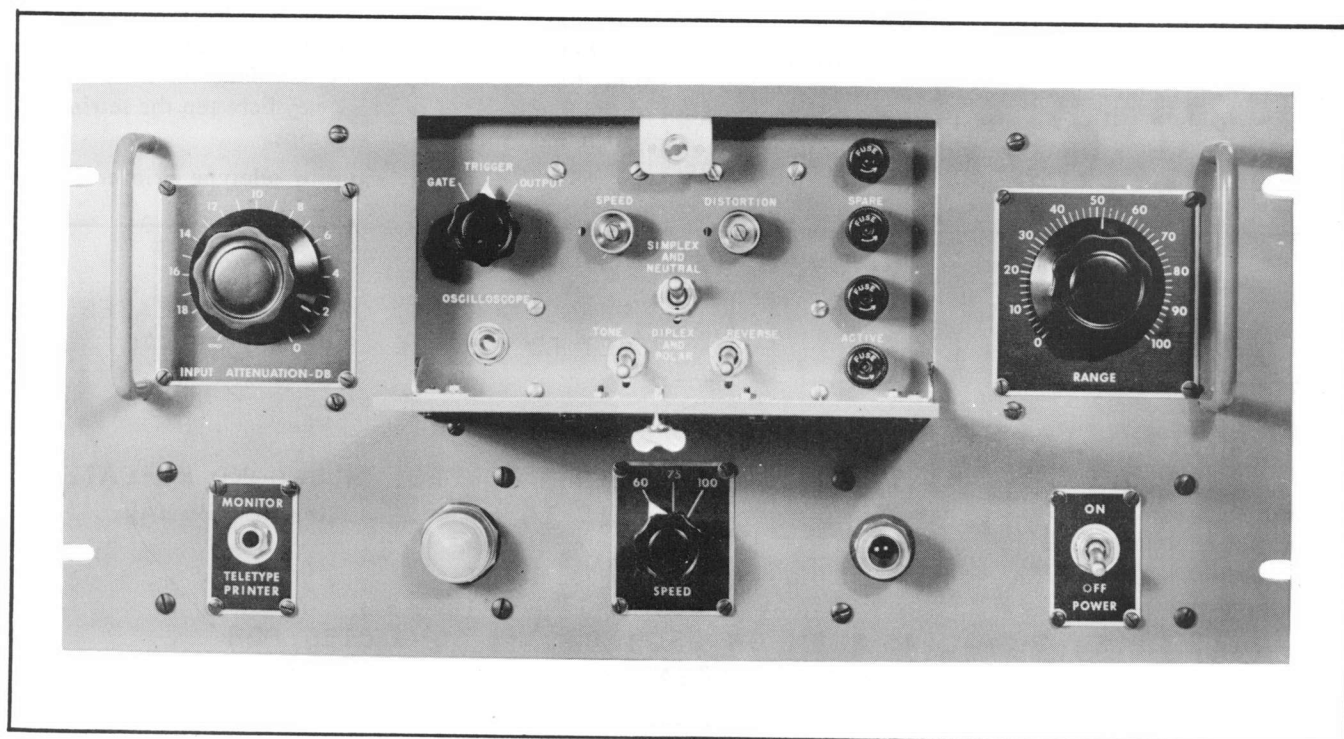


Figure 4-1. Panel and Sub Panel Controls

(1) Turn the POWER switch to ON. Allow fifteen minutes for warm up of the equipment.

N †

The Regenerator is designed for continuous operation and should normally be powered continuously after first being turned on unless there will be long intervals (a week or more) when there will be no signals applied to the Regenerator input.

(2) Rotate the INPUT ATTENUATOR counterclockwise to the last position (∞). Advance the INPUT ATTENUATOR clockwise until a step is reached where the front panel neon lamp first begins to blink. This is the trigger point. Rotate the INPUT ATTENUATOR six steps further in a clockwise direction beyond the trigger point. If the INPUT ATTENUATOR reaches 0 before six steps can be made, set to 0. If tone input signals which are known to vary considerably in amplitude are operating the Regenerator, more secure operation may be had by advancing the INPUT ATTENUATOR 10 or 12 steps beyond the trigger point.

(3) Set the RANGE control of the Regenerator to 50. The remote teletype printer to which the Regenerator is connected should now be operating. If this teletypewriter is too distant for observation, connect a monitor teletype printer to the MONITOR jack on the panel of the Regenerator and check that the monitor teletypewriter is printing correctly. If it is not printing correctly, the installation was faulty and the steps outlined in Section 3-2b should be repeated.

(4) Rotate slowly the RANGE control of the Regenerator to 0 and to 100. Check if the teletypewriter prints correctly at all settings of the RANGE control. If the teletypewriter begins to print errors at any particular setting of the RANGE control, make the final

setting of the RANGE control half way between the settings at which errors begin.

EXAMPLES: If the teletypewriter makes errors above 80 on the RANGE control, the final setting of the RANGE control should be 40. If the printer makes errors above 70 and below 10 on the RANGE control, the final setting of the RANGE control should be 40.

Note

If the RANGE control causes printing errors when set to 0, it is probable that the sub-panel SPEED adjustment is incorrect. The SPEED adjustment should be checked as outlined in Section 3-2b.

b. OPERATION ON DIPLEX CIRCUITS.—Operation of the Regenerator for diplex signals is similar to that for simplex signals with the exception of the adjustment of the RANGE controls. Adjustments on the two Regenerators connected for diplex operation are as follows:

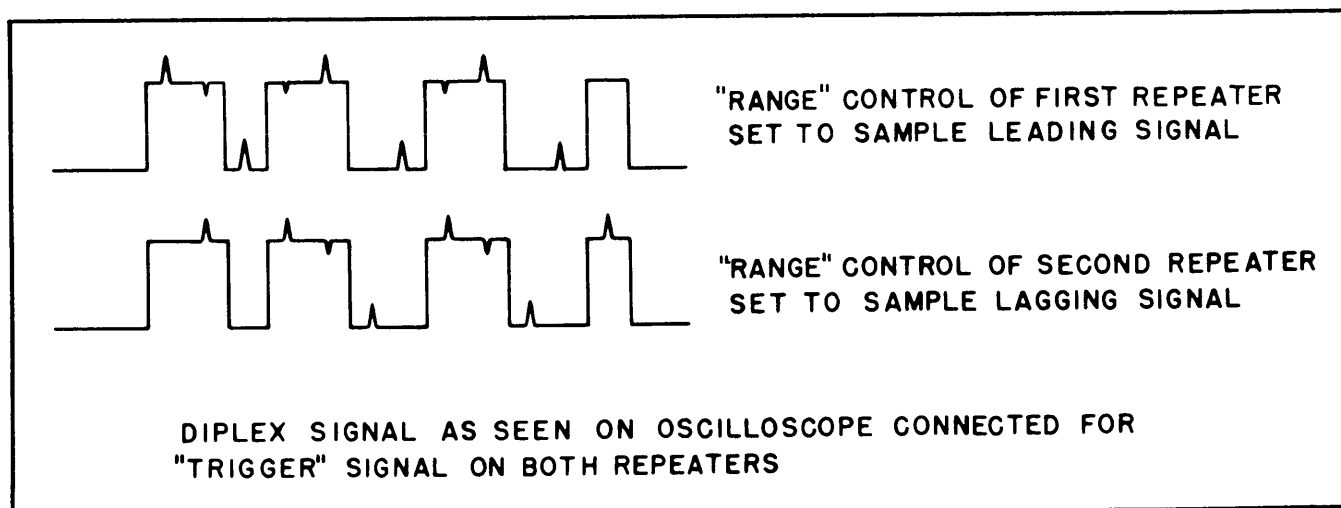
(1) Perform the first two steps as in Section 4-3a on each of the Regenerators. Make sure the keying switches behind the access door are properly set as outlined in Section 3-2b (3).

(2) Set the RANGE control of one Regenerator to 25 to secure operation on the leading diplex signal.

(3) Set the RANGE control of the second REGENERATOR to 75 to secure operation on the lagging diplex signal.

(4) Connect a monitor teletype printer to the MONITOR jack of the first Regenerator. Observe that printing is correct. Rotate the RANGE control of the first Regenerator from 0 to 60 and observe at what settings incorrect printing begins. Make the final setting of the RANGE control half way between the settings at which incorrect printing begins.

(5) Connect the monitor teletype printer to the



Figur 4-2. Oscilloscop Patterns, Diplex Operation

MONITOR jack of the second Regenerator. Observe that printing is correct. Rotate the RANGE control of the second Regenerator from 40 to 100 and observe at what settings incorrect printing begins. Make the final setting of the RANGE control half way between the settings at which incorrect printing begins.

(6) Perform the following check using an oscilloscope with a low frequency sweep (such as the OS-8/U) if difficulty is experienced in securing operation on diplex signals or if operation of the Regenerator is restricted to less than 30 points on the RANGE control.

(a) Connect the oscilloscope to the OSCILLOSCOPE jack behind the access door of the first Regenerator. Figure 3-2 illustrates this connection.

(b) Set the OSCILLOSCOPE selector switch to the TRIGGER position and adjust the oscilloscope to observe the trigger signal. Figure 4-2 illustrates typical patterns where one Regenerator is adjusted to sample the leading diplex signal and the second Regenerator is sampling the lagging diplex signal.

(c) Adjust the RANGE control of the Regenerator from 0 to 50 and observe the movement of the sampling pulses on the signal pulses. It should be possible to adjust the sampling pips to the exact center of the leading diplex signal pulses. If it is not possible to do this, set the RANGE control so that the second sampling pip is centered with the first intelligence diplex pulse and make a slight adjustment of the sub-panel SPEED control so that the last sampling pip coincides with the center of the last leading diplex intelligence pulse.

(d) Set the OSCILLOSCOPE selector switch to the OUTPUT position and check the output signal for equal mark to space ratio. Adjust the DISTORTION control for correction if necessary.

(e) Repeat the above steps (a), (b), (c) and (d) for the second Regenerator except in this case adjusting the RANGE control from 50 to 100 while observing the sampling pips on the lagging diplex signal

pulses. Make final RANGE and SPEED adjustments to center the sampling pips on the lagging diplex signal pulses.

4. ADJUSTMENTS FOR CHANGING SPEEDS.

If the Regenerator is to be operated at a speed different than that for which it was originally adjusted, the following steps must be performed:

a. Set the front panel SPEED selector switch of the Regenerator to coincide with the speed of the incoming signal.

b. Operate the Regenerator as outlined in Section 4-4a. It is probable that slight readjustments of the sub-panel SPEED control and DISTORTION control will be necessary as outlined in Section 3-2b. Control R72, located adjacent to R42 under side of chassis is used to adjust the range of the speed control. This is necessary due to the 20% tolerance of the triple section speed control. Only a slight adjustment of this control will be necessary as it has been properly adjusted by the manufacturer.

5. SUMMARY OF OPERATION.

The following summary describes briefly the operation of the Regenerator.

a. Turn POWER switch to ON. Allow 15 minutes warm up.

b. Advance INPUT ATTENUATOR clockwise from the infinity (∞) position until the front panel neon lamp first begins to blink. Advance the INPUT ATTENUATOR clockwise six steps beyond this point.

c. Set the RANGE control to 50 for normal simplex operation.

d. For diplex operation set the RANGE control of one Regenerator to 25 and the RANGE control of the second Regenerator to 75.

e. For operation at a different speed, set the front panel SPEED control to coincide with the speed of the incoming signal.

f. Turn the POWER switch of the Regenerator to OFF to stop the unit.

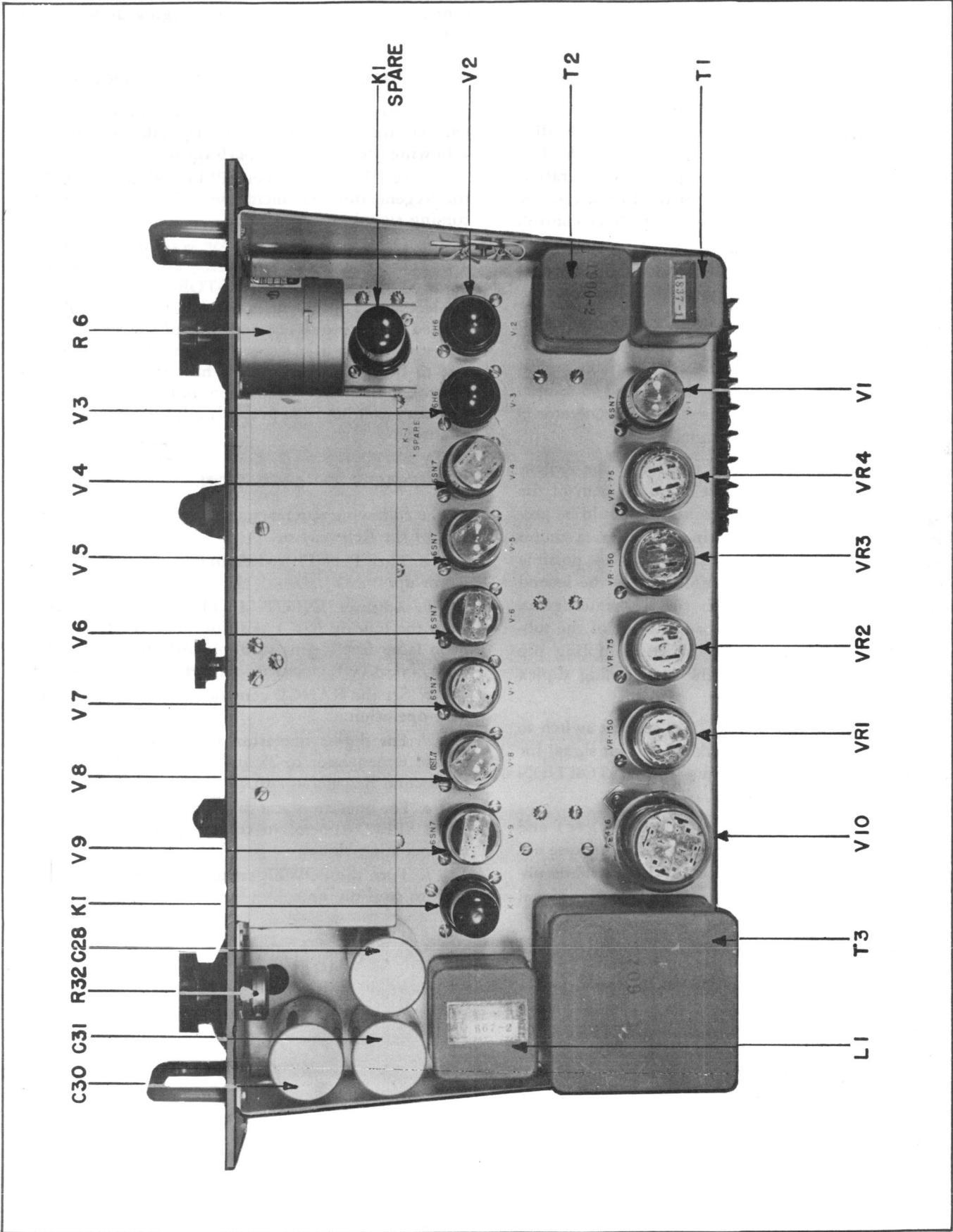


Figure 5-1. Tube Location

SECTION 5

OPERATOR'S MAINTENANCE

1. ROUTINE CHECK-CHART.

Table 5-1 illustrates routine checks which should be made on the Regenerator daily using an oscilloscope with a low frequency sweep, similar to the OS-8/U.

Such checks will assure that the Regenerator is in optimum adjustment. They will also disclose the quality of the signals applied to the Regenerator and delivered from the Regenerator.

TABLE 5-1. ROUTINE CHECK CHART

WHAT TO CHECK	HOW TO CHECK	PRECAUTIONS
Waveform at Trigger position of Oscilloscope selector switch.	Connect oscilloscope to sub-panel jack. Set selector switch to TRIGGER.	SAMPLING PIPS should fall on the center of the teletype pulses.
Waveform at OUTPUT position of Oscilloscope selector switch.	Connect oscilloscope to sub-panel jack. Set selector switch to OUTPUT.	Output signals should have equal mark and space pulses.

2. EMERGENCY MAINTENANCE.

a. NOTICE TO OPERATORS.

Operators shall not perform any of the following emergency maintenance procedures without proper authorization.

b. REPLACEMENT OF TUBES, FUSES AND RELAY.

(1) REPLACEMENT OF FUSES.

WARNING

Never replace a fuse with one of higher rating unless continued operation of the equipment is more important than probable damage. If a fuse burns out immediately after replacement, do not replace it a second time until the cause has been corrected.

(a) Fuse failure in an individual Regenerator would normally be indicated by failure of the pilot lamp to be on when the power switch is turned on. Vacuum tubes in the Regenerator would not be lighted. The two 1½ ampere ACTIVE fuses behind the access

door of the Regenerator panel should be checked in this event. Two 1½ ampere SPARE fuses are located directly above the active fuses on the sub-panel.

(2) REPLACEMENT OF TUBES AND RELAY.

(a) The location of all tubes and relay is indicated in Figure 5-1 for an individual Regenerator. Tubes may be checked visually to see if they are lighted, or for warmth. Failure of the front panel neon lamp to blink when signal is applied to the Regenerator may be caused by defective tubes V1, V2, V3 or V4 or a defective neon lamp E-6. The neon lamp may be removed from the front of the Regenerator by unscrewing the jewel and unplugging the bayonet type lamp.

If the neon lamp does blink when signals are applied to the input of the Regenerator, and all tubes are lighted, the relay K-1 may be replaced by the spare relay mounted on the Regenerator chassis behind the Input Level control. All tubes and relays in the Regenerator plug in to standard octal sockets.

(b) All electron tubes in the Regenerator are accessible from the rear. One tube clamp is used in each Regenerator to hold the rectifier tube V-10. Pressure on this clamp may be relieved by finger or screw driver to remove the 5U4G tube from its socket.

WARNING

If tubes are removed from the Regenerator for testing, they should not all be removed at one time and replaced indiscriminately. Remove, test and replace one tube at a time in its respective socket. Changing some tubes may necessitate slight readjustment to the Regenerator controls. The control R72, located adjacent to R42 under side of chassis, may need a slight adjustment. This adjustment affects the range of speed control R38 and should be used in making adjustments outlined in sections 3-2b and 4-3b.

SECTION 6

PREVENTIVE MAINTENANCE

1. ROUTINE MAINTENANCE CHECK-CHART.

Table 6-1 illustrates checks which should be made at intervals as indicated. There are no lubrications or mechanical parts to check in the equipment.

TABLE 6-1. ROUTINE MAINTENANCE CHECK CHART

WHAT TO CHECK	WHEN TO CHECK	HOW TO CHECK	PRECAUTIONS
Waveform at TRIGGER position of Oscilloscope selector switch.	Daily	Connect oscilloscope to sub-panel jack. Set selector switch to TRIGGER.	Sampling pips should fall on center of teletype pulses.
Waveform at OUTPUT position of Oscilloscope selector switch.	Daily	Connect oscilloscope to sub-panel jack. Set selector switch to OUTPUT.	Output signals should have equal mark and space pulses.
Waveform at GATE position of Oscilloscope selector switch.	Weekly	Connect oscilloscope to sub-panel jack. Set selector switch to GATE.	Gate signal should be uniform in length on each repetition.
Input Attenuator	Semi-annually	Rotate above trigger point while watching TRIGGER signal.	No erratic behavior of trigger signal should be observed.
Range Control	Semi-annually	Rotate while watching TRIGGER signal.	Sampling pips should move evenly across teletype pulses.
Tubes	Semi-annually	Check one at a time in tube checker.	Replace tubes in same sockets from which removed. Check adjustment of controls if new tubes are put in Repeater.

SECTION 7

CORRECTIVE MAINTENANCE

1. SYSTEM TROUBLE SHOOTING.

a. INPUT CIRCUITS.—If the neon lamp on the front panel of the Regenerator does not blink when the Regenerator is properly adjusted and powered for operation, there is probably a defect in the input line or in the equipment supplying input signals to the Regenerator. The input voltage to the Regenerator should be checked with an oscilloscope or suitable meter.

b. OUTPUT CIRCUITS.—If there is input signal to the Regenerator and the neon lamp is blinking, the teletype printer to which the Regenerator is connected should be printing. If it does not print, make the following checks:

(1) Check that the teletype printer is in operating condition.

(2) Check the signal voltage at the output terminals of the Regenerator with an oscilloscope or DC meter. If no signal voltage is found here, the Regenerator is defective.

2. UNIT TROUBLE SHOOTING AND REPAIR.

a. TROUBLE SHOOTING.

(1) TROUBLE SHOOTING CHART.—A chart showing probable troubles, symptoms and corrections for the Regenerator is illustrated in Table 7-1. Trouble shooting chart represents primarily a signal tracing procedure wherein the signal is traced from the input of the equipment to the output by means of an oscilloscope. The Schematic Diagram, Figure 7-5, which illustrates wave forms at various points of the circuit is used for reference.

(2) CIRCUIT CONSTANTS.

(a) All circuit components mentioned in Table 7-1 are illustrated in Figures 7-2 and 7-3 which represent the Part Locations Below Chassis and Part Locations Behind the Sub-panel. All parts shown on the Schematic Diagram, Figure 7-5 may be found in either Figures 7-2 or 7-3. The bottom plate must be removed from the chassis to gain access to the parts under the chassis. The dust cover behind the sub-panel must be removed to gain access to parts in this location.

(b) All tube pin connections at which measurements are made by means of an oscilloscope, voltmeter or ohmmeter are illustrated in Figure 7-4, Voltage and Resistance Chart. The values of voltage and resistance tabulated in Figure 7-4 are nominal and may vary

within 10%. All measurements are from socket pin to ground and made with a 20,000 ohm per volt meter using the appropriate scale for the reading taken.

b. REPAIR.

(1) ELECTRICAL ADJUSTMENTS.—The adjustments of all front panel and sub-panel controls of the Regenerator are described in Section 3-2b. Failure to secure proper operation of the Regenerator when all circuit components, voltages and signals appear normal is probably due to misadjustment of sub-panel controls or to improper setting of variable resistor R42 and R72 located below the chassis. See Figure 7-2.

(a) Sub-panel controls may be correctly set using the procedure outlined in Section 3-2b.

(b) Improper setting of variable resistor R42 will be in evidence if more, or less than six sampling pips are observed on the oscilloscope during the adjustment of the sub-panel SPEED control. If there are only five sampling pips seen (none for the last intelligence pulse), the shaft of variable resistor R42 should be rotated clockwise by means of a screw driver a few degrees beyond the point where the sixth pip first appears. If there are seven sampling pips (one in the stop mark), R42 should be rotated counter-clockwise slightly beyond the point where the seventh pip has disappeared.

(2) MECHANICAL ADJUSTMENTS.—There are no mechanical devices in the Regenerator which require adjustment.

(a) REMOVAL AND REPAIR.—Since nearly all small parts in the Regenerator are mounted under the chassis on terminal boards, the replacement of these parts is readily performed.

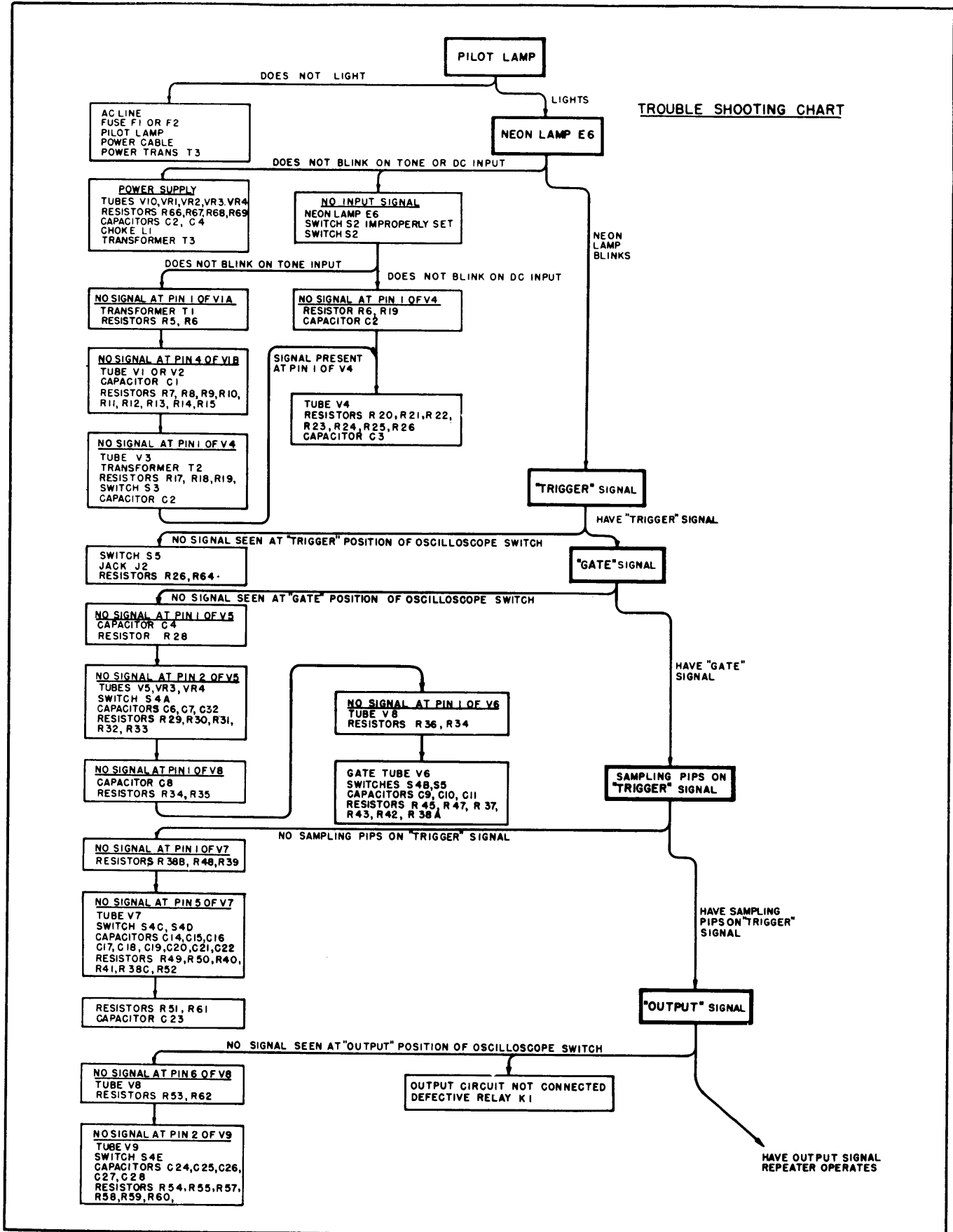
(3) COMPONENT CHARACTERISTICS.

(a) ELECTRON TUBES.—Normal operating currents and voltages of all tubes in the Regenerator are illustrated in Table 7-2. Table 7-3 illustrates the Tube Characteristics for tubes used in the Regenerator.

(b) RELAY CHARACTERISTICS.—Characteristics of the Western Electric relay K-1 used in the Regenerator are illustrated in Table 7-4.

(4) DRAWINGS.

(a) SCHEMATIC DIAGRAM.—The Schematic Diagram of the Regenerator is illustrated in Figure 7-5. Voltage measurements, resistance values and waveforms are listed on this diagram for convenient servicing.



Tabl 7-1. Tr ubl Sh ting Chart

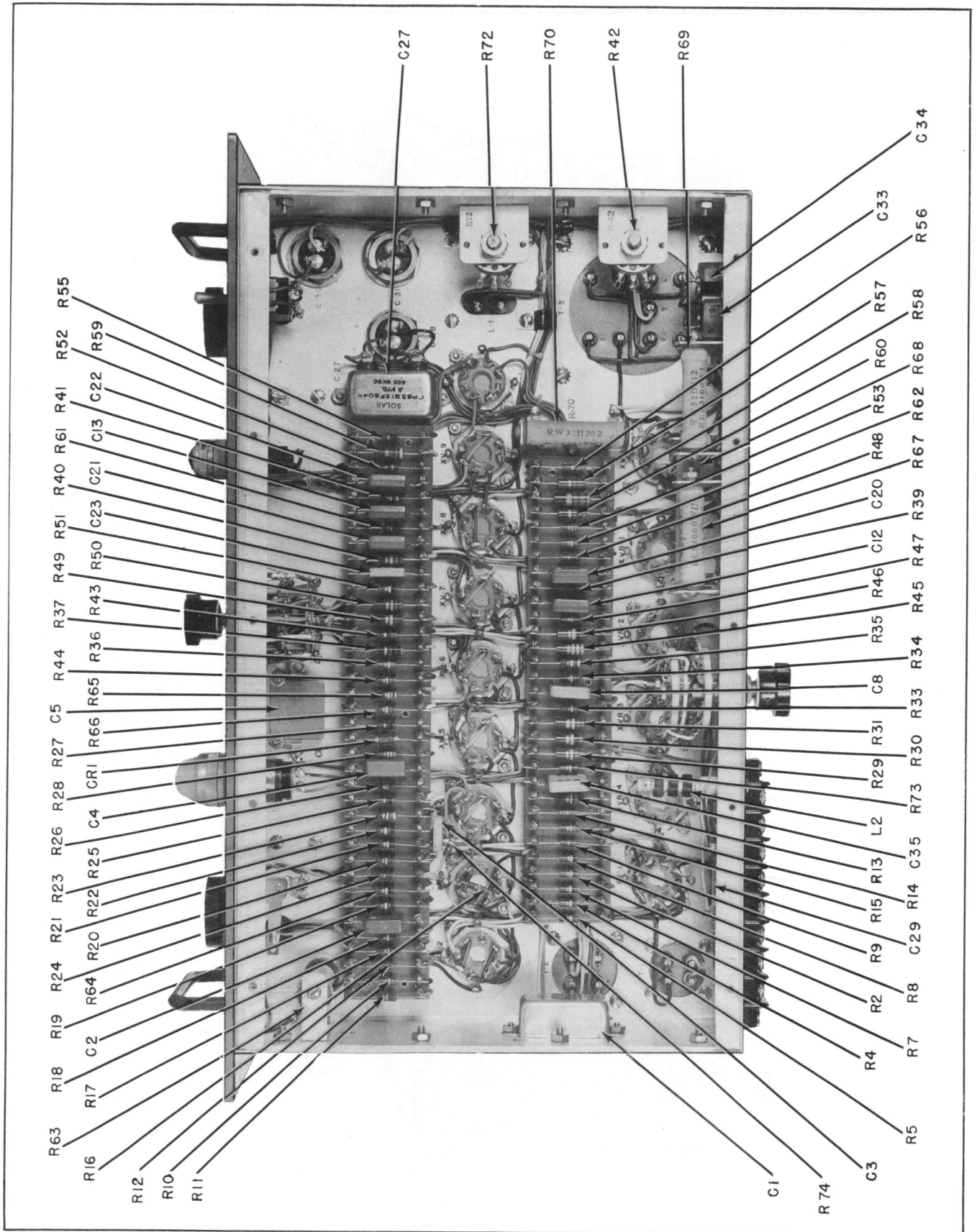


Figure 7-1. Part Location Below Chassis

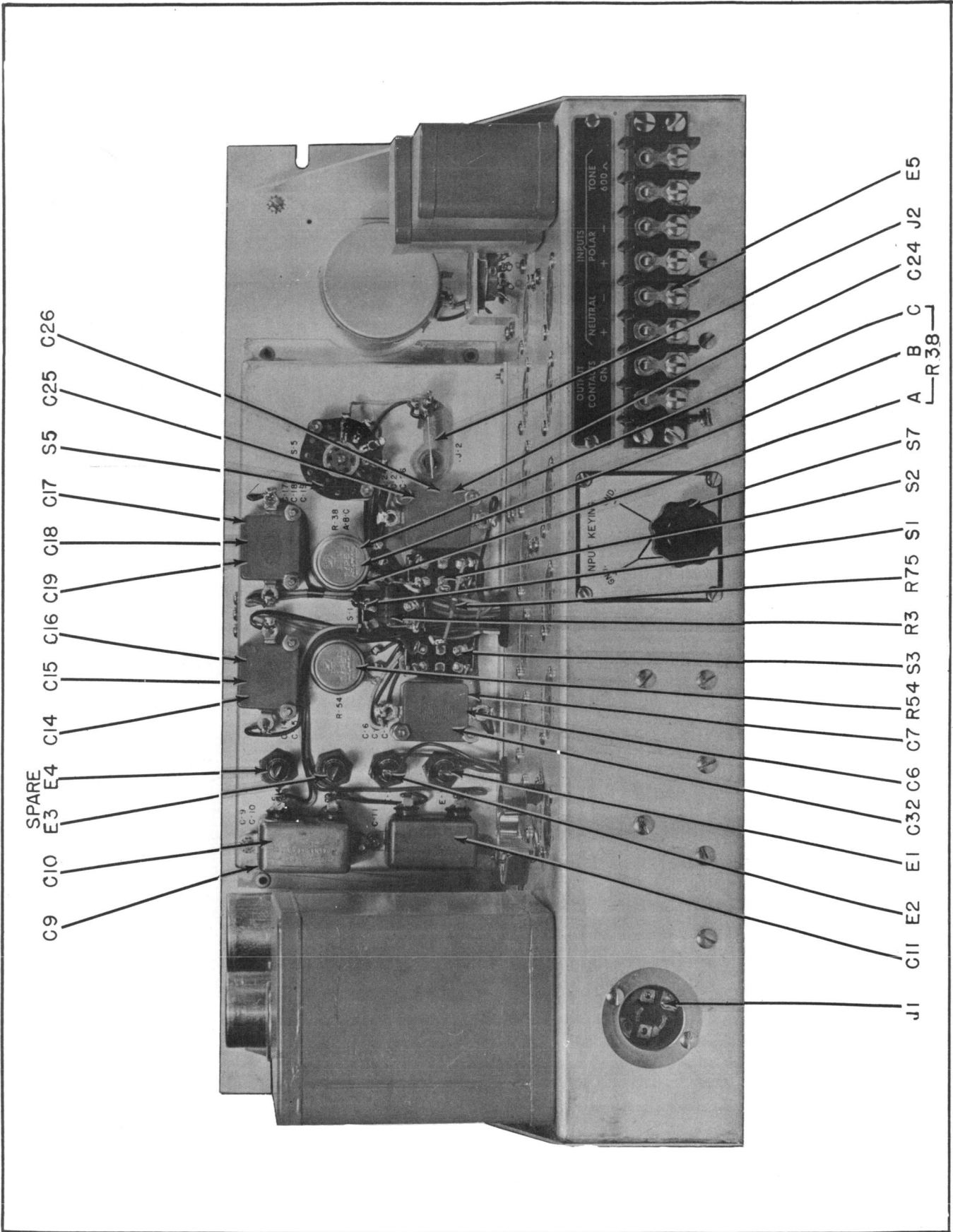


Figure 7-2. Part Location Behind Sub-Panel

TUBE LAYOUT

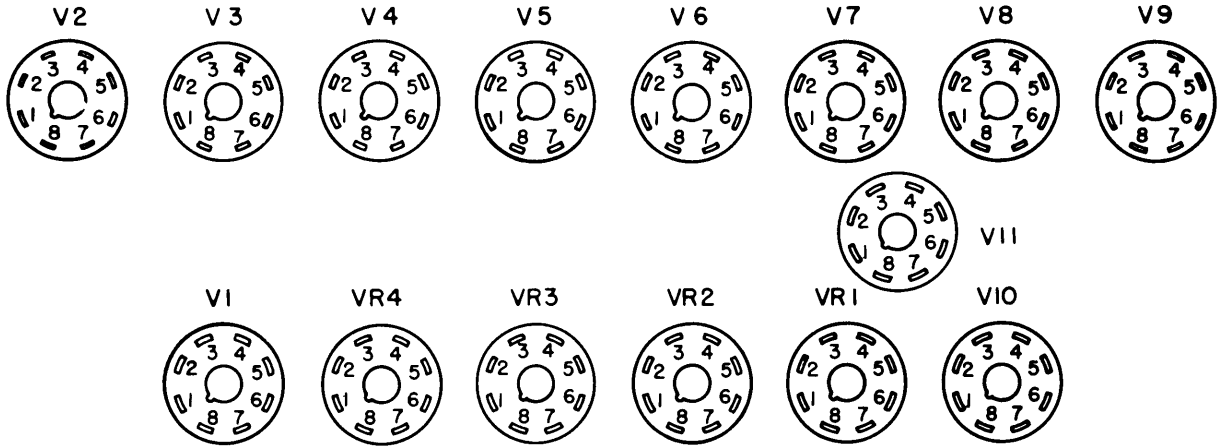


TABLE																	
TUBE	PIN 1		PIN 2		PIN 3		PIN 4		PIN 5		PIN 6		PIN 7		PIN 8		TUBE TYPE
	V	R	V	R	V	R	V	R	V	R	V	R	V	R	V	R	
V1	0	36K	50	150K	1.7	1.8K	.75	180K	146	48K	6.1	1.2K	0	0	6.3*	0	6SN7GT
V2	0	0	6.3*	0	.76	270K	.70	100K	.76	270K	0	∞	0	0	.70	180K	6H6
V3	0	0	6.3*	0	-.36	1.4M	0	310	-.36	1.4M	0	∞	0	0	0	320	6H6
V4	0	1.4M	35	220K	1.35	3.9K	-17	310K	75	280K	1.35	3.9K	0	0	6.3*	0	6SN7GT
V5	21	1.4M	147	60K	52	12K	52	∞	110	60K	52	12K	0	0	6.3*	0	6SN7GT
V6	28	60K	146	80K	42	8.2K	39	3.0M	97	60K	42	8.2K	0	0	6.3*	0	6SN7GT
V7	22.5	650K	147	70K	52	18K	50	610K	81	70K	52	18K	0	0	6.3*	0	6SN7GT
V8	12	520K	147	50K	28	56K	14	290K	147	50K	24	56K	0	0	6.3*	0	6SL7GT
V9	24	50K	215	67K	39	4.7K	12	∞	125	70K	39	4.7K	0	0	6.3*	0	6SN7GT
V10	0	∞	325	55K	0	∞	4.00**	3.5K	0	∞	400**	3.5K	0	∞	325	55K	5U4G
VR1	0	∞	0	0	0	∞	0	∞	147	50K	0	∞	0	∞	0	∞	VR 150
VR2	0	∞	-75	5.3K	0	∞	0	∞	0	0	0	∞	0	∞	0	∞	VR 75
VR3	0	∞	75	∞	0	∞	0	∞	220	58K	0	∞	0	∞	0	∞	VR 150
VR4	0	∞	0	0	0	∞	0	∞	75	∞	0	∞	0	∞	0	∞	VR 75
VII	-25	680K	140	65K	GND	0	-.6	180K	120	60K	GND	0	6.3*	0	GND	0	6SN7GT

NOTES-

1. MEASUREMENTS MADE WITH 20,000 OHMS PER VOLT METER
2. TONE- DC SWITCH S2 SET TO "TONE"
3. NORMAL- REVERSE SWITCH S3 SET TO "NORMAL"
4. ALL MEASUREMENTS MADE TO GROUND
5. * AC VOLTAGE
6. ** MEASUREMENT MADE TO C.T. (TERM NO. 4) OF POWER TRANSFORMER
7. K = X 1000
8. M = X 1,000,000

Figur 7-3. Voltag and R sistanc Chart

TABLE 7-2. TUBE OPERATING VOLTAGES AND CURRENTS

TUBE TYPE	FUNCTION	PLATE (E)	PLATE (MA)	CATHODE (E)	GRID (E)	HEATER (E) AC
6SN7GT V1	1st Audio Amplifier 2nd Audio Amplifier	50 146	.90 2.60	1.7 6.1	0 .75	6.3
6H6 V2	Series Clippr (Input sec.) (Output sec.)	.76 .76	0 0	.7 .7		6.3
6H6 V3	Full Wave Rectifier	.36	0	0		6.3
6SN7GT V4	Trigger (Input Sec.) (Output Sec.)	35 75	.30 0	1.75 1.75	0 -17	6.3
6SN7GT V5	Lag (Input Sec.) (Output Sec.)	147 110	0 3.7	52 52	24 52	6.3
6SN7GT V6	Gate (Input Sec.) (Output Sec.)	146 97	0 4.3	42 42	28 39	6.3
6SN7GT V7	Multivibrator (Input Sec.) (Output Sec.)	147 81	0 2.4	52 52	22.5 50	6.3
6SL7GT V8	False Start Gate Coincidence Gate	147 147	0 0	28 24	12 14	6.3
6SN7GT V9	Regenerator (Input Sec.) (Output Sec.)	215 125	0 7.4	39 39	24 12	6.3
5U4G V10	Full Wave Rectifier	*400 *400	57.0 57.0			5.0
OD3/ VR150	Voltage Regulator VR1	147	12.0			
OA3/ VR75	Voltage Regulator VR2	0	19.0			
OD3/ VR150	Voltage Regulator VR3	220	13.0			
OA3/ VR75	Voltage Regulator VR4	75	13.0			
6SN7GT VII	Control (Input sec.) (Output sec.)	140 120	1.0 13.0	0 0	-14 -.6	6.3 6.3

* AC Volts

TABLE 7-3. TUBE CHARACTERISTICS

TUBE TYPE	FILA- MENT VOLT- AGE (V)	FILA- MENT CUR- RENT (A)	PLATE VOLT- AGE (V)	GRID BIAS (V)	PLATE CUR- RENT (A)	A-C PLATE RESIST- ANCE (OHMS)	VOLT- AGE AMPLI- FICA- TION FAC- TOR (MU)	TRANSCON- DUCTANCE (MICROMHOS)		EMISSION	
								NOR- MAL	MINI- MUM	IS (MA)	TEST V LTS
6SN7GT Each Sect.	6.3	0.6	250	-8	9	7700	20	2600	2000	40	30
6H6 Each Sect.	6.3	0.3	150 AC Max.		8.0 Max.					15	20
6SL7GT Each Sect.	6.3	0.3	250	-2	2.3	44000	70	1600	1200	40	30
5U4G Each Sect.	5.0	3.0	450 AC Max.		225 Max.					225	75
OD3/ VR150			150		5 Min. 30 Max.						
OA3/ VR75			75		5 Min. 30 Max.						

TABLE 7-4. RELAY CHARACTERISTICS

RELAY TYPE	PRIMARY RESIST- ANCE (OHMS)	SECOND- ARY RESIST- ANCE (OHMS)	OPERATE CURRENT WINDINGS SERIES AIDING	RELEASE CURRENT WINDINGS SERIES AIDING	CONTACT RATING (WATTS)	MOUNTIN
275-C	700 ±10%	3300 ±10%	.008	.0035	20	Octal Socket — Vertical Position

ADDENDUM

REGENERATOR MODEL SFO-2

1. SFO-2 is a modification of SFO regenerator which has a tube V11 added, with associated circuits, in order to allow an open circuit (no signal) at the input of the regenerator to appear as an open circuit at the relay output contacts to the teletype machine. The serial numbers have -2 added. An additional modification is the removal of all grounds from the contact circuit of K-1 relay which permits operation into an ungrounded teletype system.

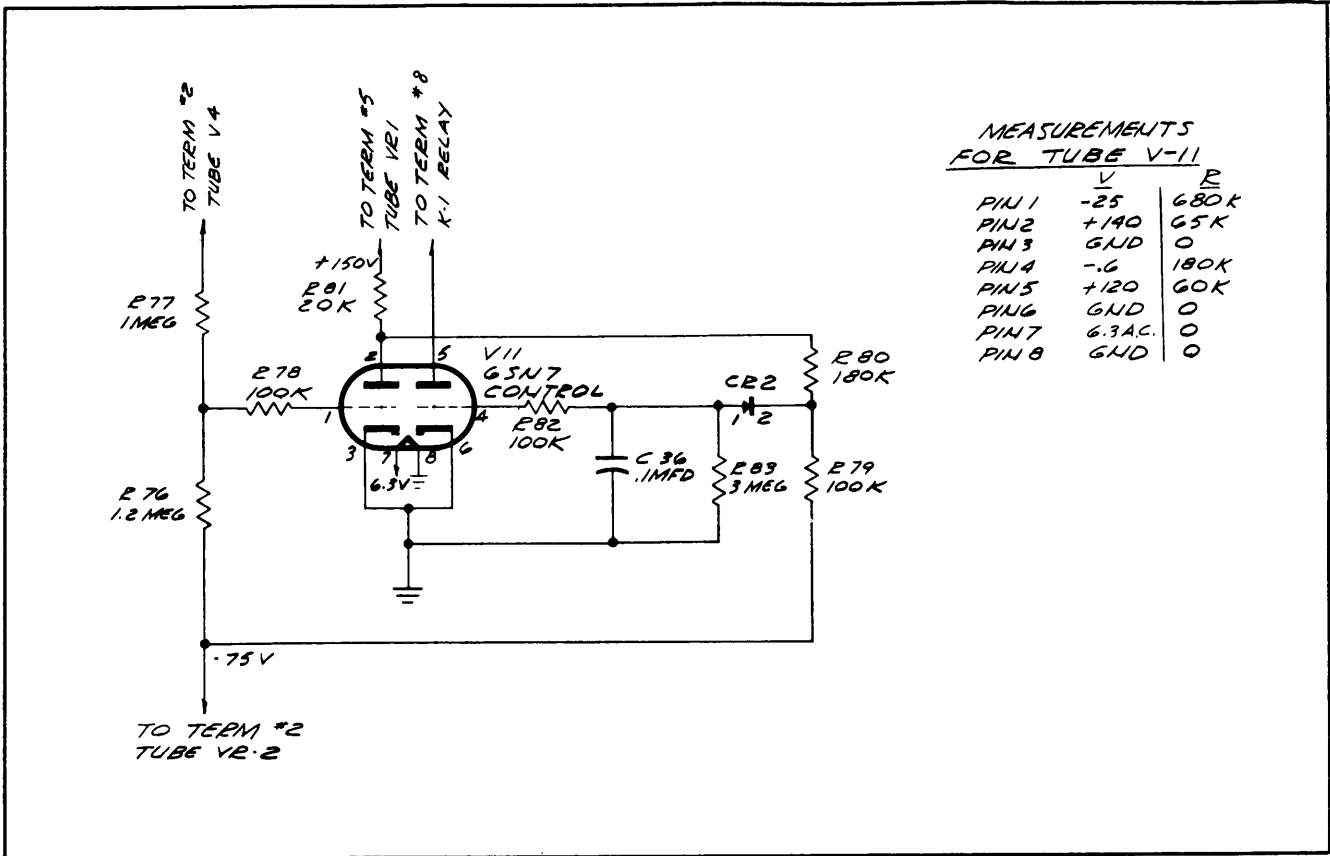
2. Purpose of modification and circuit function.

(a) This circuit is added in order to allow an open circuit (no signal) at the input of the regenerator to appear as an open circuit at the relay output contacts to the teletype machine. To accomplish this, a type 6SN7GT dual-triode tube V11 and associated resistors and capacitors are added as shown in schematic diagram for SFO-2. The Circuit functions in the following manner: The first section of V11 is controlled by voltage appearing in the plate circuit of tube V4. A coupling network composed of resistors R-76, R-77, and R-78 establishes operating bias for the first section of tube V11 and also transfers the plate potential changes of tube V-4 to tube V11. The inverted signal appearing in the plate circuit section one, tube V11 is coupled through a delay network to the grid of section two, tube V11, which is biased so that the grid voltage swings from 0 to -24 volts. Varistor CR-2, capacitor C-36, and resistors R-79, R-80, and R-83 are so arranged as to normally maintain negative bias at the grid of section two, tube V11, during condition of keyed input, since short duration keyed pulses are rectified by Varistor CR-2 and stored in capacitor C-36 as a fixed negative voltage somewhat past the plate current cut-off point of the type

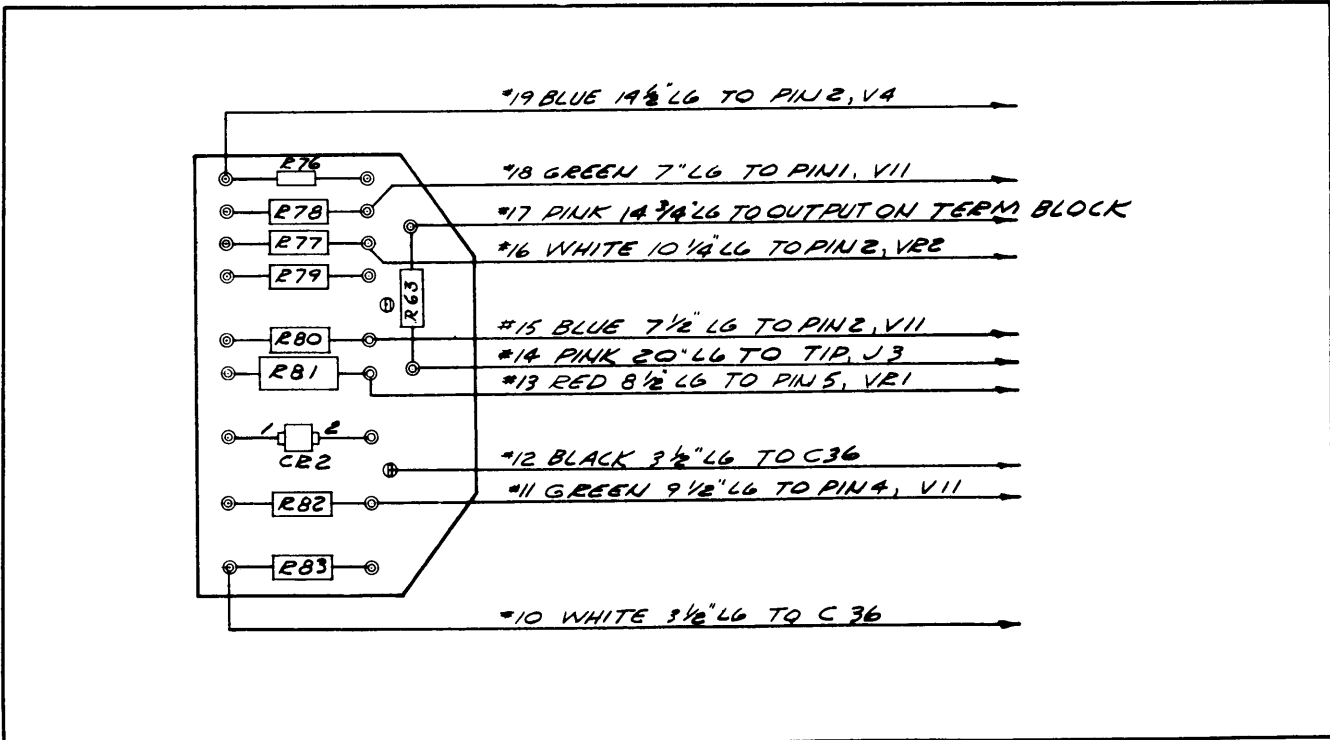
6SN7GT tube, thus preventing plate current of section two, tube V11, from affecting normal operation of relay K-1. A time delay of about 300 milliseconds is obtained by the combination of capacitor C-36, resistor R-83, and the reverse shunting resistance of Varistor CR-2. During a condition of no input to the regenerator (input open), the first section of tube V-4 becomes conductive and the corresponding reduction in plate voltage is reflected through resistors R-76, R-77, and R-78 as a higher negative bias on the grid of section one, tube V11. The corresponding increase in plate voltage of section one, tube V11, coupled through resistor R-80, counteracts the negative bias normally established on the grid of section two, tube V11. This causes section two, tube V11, to become conductive and draw plate current through resistor R-57. The consequent reduction of plate potential available to tube V9 through resistor R-57 and the winding of relay K-1 renders V9 inoperative, thus causing the relay contacts to remain open.

(b) An additional modification of the SFO regenerator permits operation into an ungrounded teletype system. All grounds from the contact circuit of relay K-1 are lifted. Oscilloscope monitoring of the keyed waveform of the output circuit is obtained by observing the voltage drop appearing across R63. Some conditions may occur where the bias distortion control will be more readily adjusted by connecting the oscilloscope directly across the output contacts on the rear of the chassis. J3 monitor jack was changed to a Yaxley 703B microphone jack and a three way plug supplied with each unit. Only the tip and ring connections are used thus keeping the monitoring circuit above ground.

REFER TO MODEL SFO FOR ROUTINE
INFORMATION



Tube V11 Control Circuit, SFO-2



Terminal Board for V11 Components, SFO-2

MODEL SFO-2 REGENERATOR REFERENCE DATA

a. Input: 60, 70, or 100 wpm teletype signals.
b. Input keying: tone-500 to 3,600 cps, 30 ma. polar, 60 ma. neutral, simplex or duplex; DC keying may be positive or negative with respect to ground on mark, tone keying may be either normal or inverse.

c. OUTPUT.

1. WITH V11 TUBE REMOVED FROM ITS SOCKET: Relay contacts in series with a 47 ohm resistor, contacts closed on mark during operation or during any steady state input.

2. WITH V11 IN PLACE relay contacts in series with 47 ohm resistor. An open circuit (no signal) at the input of the regenerator appears as an open circuit at the relay output contacts to the teletype machine.

INVERSE TONE KEYING WILL NOT OPERATE WITH V11 IN ITS SOCKET.

3. POLAR OUTPUT. A 3 terminal Jones

strip on rear of chassis supplies connections for Polar Output.

OUTPUT RELAY CONTACTS ARE NOT GROUNDED.

d. Acceptable input distortion: 45% mark or space bias.

e. Output distortion: less than 5%

f. Tone input level: -20 DBM to 0 DBM.

g. Power requirements: 115 V or 230 V, 50 to 60 cyc, 85 watts. Regenerators are wired for 115 V. For 230 V consult Schematic Diagram.

h. Visual operation indicator: Neon lamp on front panel.

i. Power Supply: Built in on each Regenerator.

j. Monitor Teletypewriter: Front panel jack for monitor teletypewriter.

FOR ALL TONE KEYING, SWITCH S7, LOCATED AT REAR OF CHASSIS, MUST BE IN POSITIVE GROUND POSITION

FOR ALL D.C. KEYING THE NORMAL - REVERSE SWITCH ON FRONT SUB PANEL SHOULD ALWAYS BE IN NORMAL POSITION.

1. ELECTRICAL PARTS LIST

SYM	DESCRIPTION	FUNCTION	TMC PART NUMBER
C1	CAPACITOR, fixed: paper; .05 mfd, ±10%; 600 wvdc.	V2 coupling	CP53B1EF503K
C2	CAPACITOR, fixed: mica; 2,000 mmfd ±5%; char C; 500 wvdc.	V3 output filter	CM35C202J
C3	CAPACITOR, fixed: mica; 270 mmfd ±10%; char A; 500 wvdc.	Coupling V4	CM25A271K
C4	CAPACITOR, fixed: mica; 4700 mmfd, ±10%; char. C; 500 wvdc.	Coupling V5	CM35C472K
C5	CAPACITOR, fixed: mica; .027 mfd, ±5%; char B; 600 wvdc.	Delay V5	CM50B273J
C6	CAPACITOR, fixed: mica; .012 mfd, ±5%; char. B; 600 wvdc.	Timing V5	CM50B123J
C7	CAPACITOR, fixed: mica; .0082 mfd, ±5%; char. B; 600 wvdc.	Timing V5	CM45B822J
C8	CAPACITOR, fixed: mica; .001 mfd, ±10%; char. C; 500 wvdc.	Coupling V5	CM30C102K
C9	CAPACITOR, fixed: paper; .1 mfd, ±10%; 600 wvdc.	Timing V6	CP53B1EF104K
C10	CAPACITOR, fixed: paper; .085 mfd, ±5%; 600 wvdc.	Timing V5	CP-100-2
C11	CAPACITOR, fixed: paper; .065 mfd, ±5%; 600 wvdc.	Timing V6	CP-100-1
C12	CAPACITOR, fixed: mica; 510 mmfd, ±5%; char C; 500 wvdc.	Coupling V6-7	CM35C511J
C13	CAPACITOR, fixed: mica; 510 mmfd, ±5%; char C; 500 wvdc.	Coupling V6-7	CM35C511J
C14	CAPACITOR, fixed: mica; .01 mfd, ±5% char. B; 500 wvdc.	Timing V6	CM45B103J
C15	CAPACITOR, fixed: mica; .0082 mfd, ±5%; char. B; 500 wvdc.	Timing V7	CM45B822J
C16	CAPACITOR, fixed: mica; .0062 mfd, ±5%; char. B; 500 wvdc.	Timing V7	CM45B622J
C17	CAPACITOR, fixed: mica; .01 mfd, ±5%; char. B; 500 wvdc.	Timing V7	CM45B103J
C18	CAPACITOR, fixed: mica; .0082 mfd, ±5%; char. B; 500 wvdc.	Timing V7	CM45B822J
C19	CAPACITOR, fixed: mica; .0062 mfd, ±5%; char. B; 500 wvdc.	Timing V7	CM45B622J

SYM	DESCRIPTION	FUNCTION	TMC PART NUMBER
C20	CAPACITOR, fixed: mica; 510 mmfd, $\pm 5\%$; Char. C; 500 wvdc.	Grid load V7	CM35C511J
C21	CAPACITOR, fixed: mica; .002 mfd, $\pm 5\%$; char. C; 500 wvdc.	Cathode bypass V7	CM35C202J
C22	CAPACITOR, fixed: mica; 510 mmfd, $\pm 5\%$; char. C; 500 wvdc.	Grid load V7	CM35C511J
C23	CAPACITOR, fixed: mica; 270 mmfd, $\pm 10\%$; char. A; 500 wvdc.	Coupling V7-V8	CM25A271K
C24	CAPACITOR, fixed: mica; .027 mfd, $\pm 5\%$; char. B; 600 wvdc.	Timing V9	CM50B273J
C25	CAPACITOR, fixed: mica; .022 mfd, $\pm 5\%$; char. B; 600 wvdc.	Timing V9	CM50B223J
C26	CAPACITOR, fixed: mica; .013 mfd, $\pm 5\%$; char. B; 600 wvdc.	Timing V9	CM50B133J
C27	CAPACITOR, fixed: paper; .5 mfd, $\pm 10\%$; 600 wvdc.	K1 coil shunt	CP53B1EF504K
C28	CAPACITOR, fixed: paper; 4 mfd, $\pm 10\%$; 600 wvdc.	Decoupling V9	CP41B1EF405K
C29	CAPACITOR, fixed: mica; .027 mfd, $\pm 5\%$; char. B; 500 wvdc.	K1 Noise suppressor	CM50B273J
C30	CAPACITOR, fixed: paper; 4 mfd; $\pm 10\%$; 600 wvdc.	Filter B+	CP41B1EF405K
C31	CAPACITOR, fixed: paper; 2 mfd; $\pm 20, -10\%$; 1000 wvdc.	Input filter B+	CP41B1FG205K
C32	CAPACITOR, fixed: mica; .013 mfd, $\pm 5\%$; char. B; 500 wvdc.	Timing V5	CM50B133J
C33	CAPACITOR, fixed: mica; .0022 mfd, $\pm 10\%$; char. B; 500 wvdc.	RF filter	CM30B222K
C34	CAPACITOR, fixed: mica; .0022 mfd, $\pm 10\%$; char. B; 500 wvdc.	RF filter	CM30B222K
C35	CAPACITOR, fixed: mica; .001 mfd, $\pm 10\%$; char. C; 500 wvdc.	Coupling	CM30C102K
C36	CAPACITOR, fixed: paper; .1 mfd; $\pm 10\%$; 600 wvdc.	Time constant V11	CP53B1EF104K
C37	CAPACITOR, fixed: paper; .5 mfd; $\pm 10\%$; 600 wvdc.	Filter V11	CP53B1EF504K
C38	CAPACITOR, fixed: mica; .027 mfd, $\pm 5\%$; char. B; 500 wvdc.	Relay contact noise suppressor	CM50B273J

SYM	DESCRIPTION	FUNCTION	TMC PART NUMBER
CR1	CRYSTAL UNIT: rectifying; germanium; 40 ma max fwd current	R27 negative pulse shunt.	IN43
CR2	RECTIFIER, metallic: selenium; 360V AC RMS.	Bias rectifier V11	RX-102
CR3	RECTIFIER, metallic: silicon carbide; 14000 ohms res per arm, 1 ma.	Peak suppressor	RX-101
E1	HOLDER, fuse: extractor post type; for single AGC fuse.	F1 holder	FH-100-3
E2	HOLDER, fuse: extractor post type; for single AGC fuse.	F2 holder	FH-100-3
E3	HOLDER, fuse: extractor post type; for single AGC fuse.	F3 holder	FH-100-3
E4	HOLDER, fuse: extractor post type; for single AGC fuse.	F4 holder	FH-100-3
E5	BOARD, terminal: general purpose, eight brass N.P. 8-32 BH screw terminals.	Input - output connections	TM-111-8
E6	LAMP, glow: 105/125V AC, 1/4 watt.	V4 output switch	NE-16
E7	LAMP, incandescent: 6-8V; 1 watt.	Power or indicator	BI-101-47
E8	BOARD, terminal: general purpose, 3 brass 6-32 binder head screws	Polar output connection	TM-100-3
F1	FUSE, cartridge: 1 1/2 amp.	AC line fuse	FU-100-1.5
F2	FUSE, cartridge: 1 1/2 amp.	AC line fuse	FU-100-1.5
F3	FUSE, cartridge: 1 1/2 amp.	Spare fuse	FU-100-1.5
F4	FUSE, cartridge: 1 1/2 amp.	Spare fuse	FU-100-1.5
I1	LIGHT, indicator: with lens, 1/2" diam., smooth green sandblasted lens inside, for min. T-3 1/4 lamp.	Power indicator	TS-120
I2	LIGHT, indicator: with lens, 1" diam. clear torpedo lens, sandblasted inside, for double contact candelabra bay. base; T-4 1/4 lamp.	Signal indicator	TS-119
J1	CONNECTOR, male contact: two non-polarized locking type rounded blades.	AC input receptacle	JJ-100

SYM	DESCRIPTION	FUNCTION	TMC PART NUMBER
J2	JACK, telephone: for two conductor, .25" diam. plug; J1 contact arrangement.	Oscillator monitor jack	JJ-126
J3	JACK, telephone: for three conductor, .25" diam. plug; J4 contact arrangement.	Teletype monitor jack.	JJ-125
K1	RELAY, armature: SPDT; 2 amp, 125 volts mercury contact.	Output keyer	RL-107
L1	REACTOR, filter: 10 hys, 70 ma; 280 ohms DC res.	Filter choke	TF-5006
L2	CHOKE, RF: .5 mh; 300 ma.	Noise suppressor	CL-110-1
L3	CHOKE, RF: .5 mh; 300 ma.	Noise suppressor	CL-110-1
R1	RESISTOR, fixed: composition; 620 ohms, $\pm 5\%$; 2 watts.	Input load	RC42GF621J
R2	RESISTOR, fixed: composition; 100,000 ohms, $\pm 5\%$; 1/2 watt.	T1 secdy load	RC20GF104J
R3	RESISTOR, fixed: composition; 620 ohms, $\pm 5\%$; 2 watts.	Input load	RC42GF621J
R4	RESISTOR, fixed: composition; 300,000 ohms, $\pm 5\%$; 1/2 watt.	T1 secdy load	RC20GF304J
R5	RESISTOR, fixed: composition; 100,000 ohms, $\pm 5\%$; 1/2 watt.	Fixed input attenuator	RC20GF104J
R6	RESISTOR, variable: step-type; 19 fixed composition resistance; 50,000 ohms, $\pm 5\%$; 9 watts.	Input attenuator	RR-107
R7	RESISTOR, fixed: composition; 100,000 ohms, $\pm 5\%$; 1/2 watt.	V1 load	RC20GF104J
R8	RESISTOR, fixed: composition; 100,000 ohms, $\pm 5\%$; 1/2 watt.	V2 cathode bias	RC20GF104J
R9	RESISTOR, fixed: composition; 1200 ohms, $\pm 5\%$; 1/2 watt.	V1 cathode bias	RC20GF122J
R10	RESISTOR, fixed: composition; 120,000 ohms, $\pm 5\%$; 1/2 watt.	V2 plate voltage divider	RC20GF124J
R11	RESISTOR, fixed: composition; 220,000 ohms, $\pm 5\%$; 1/2 watt.	V2 plate load	RC20GF224J
R12	RESISTOR, fixed: composition; 2.2 megohms, $\pm 5\%$; 1/2 watt.	V2 plate load divider.	RC20GF225J
R13	RESISTOR, fixed: composition; 68,000 ohms, $\pm 5\%$; 1 watt.	V1B cathode bias	RC30GF683J

SYM	DESCRIPTION	FUNCTION	TMC PART NUMBER
R14	RESISTOR, fixed: composition; 1200 ohms, $\pm 5\%$; 1/2 watt.	V1B cathode bias	RC20GF122J
R15	RESISTOR, fixed: composition; 180,000 ohms, $\pm 5\%$; 1/2 watt.	V1B Grid	RC20GF184J
R16	RESISTOR, fixed: composition; 120,000 ohms, $\pm 5\%$; 1/2 watt.	T2 secdy load	RC20GF124J
R17	RESISTOR, fixed: composition; 820,000 ohms, $\pm 5\%$; 1/2 watt.	V3 diode load	RC20GF824J
R18	RESISTOR, fixed: composition; 560,000 ohms, $\pm 5\%$; 1/2 watt.	V3 diode load	RC20GF564J
R19	RESISTOR, fixed: composition; 560,000 ohms, $\pm 5\%$; 1/2 watt.	V4 Grid	RC20GF564J
R20	RESISTOR, fixed: composition; 220,000 ohms, $\pm 5\%$; 1/2 watt.	V4 load	RC20GF224J
R21	RESISTOR, fixed: composition; 220,000 ohms, $\pm 5\%$; 1/2 watt.	V4 load	RC20GF224J
R22	RESISTOR, fixed: composition; 560,000 ohms, $\pm 5\%$; 1/2 watt.	V4 coupling	RC20GF564J
R23	RESISTOR, fixed: metallized film, 470,000 ohms, $\pm 1\%$; 1/2 watt.	V4 Grid	RR-104-474
R24	RESISTOR, fixed: composition; 8200 ohms, $\pm 5\%$; 1/2 watt.	V4 cathode bias	RC20GF822J
R25	RESISTOR, fixed: metallized film, 1.5 megohms, $\pm 1\%$; 1/2 watt.	V4 Grid	RR-104-155
R26	RESISTOR, fixed: composition; 62,000 ohms, $\pm 5\%$; 1/2 watt.	E6 loading	RC20GF623J
R27	RESISTOR, fixed: composition; 1 megohm, $\pm 5\%$; 1/2 watt.	V5 Grid	RC20GF105J
R28	RESISTOR, fixed: composition; 330,000 ohms, $\pm 5\%$; 1/2 watt.	V5 Grid limiter	RC20GF334J
R29	RESISTOR, fixed: composition; 12,000 ohms, $\pm 5\%$; 1 watt.	V5 plate load	RC30GF123J
R30	RESISTOR, fixed: composition; 10,000 ohms, $\pm 5\%$; 1 watt.	V5 plate load	RC30GF103J
R31	RESISTOR, fixed: composition; 12,000 ohms, $\pm 5\%$; 1 watt.	V5 cathode bias	RC30GF123J
R32	RESISTOR, variable: composition; 2.5 megohms, $\pm 20\%$; 2 watts.	V5 timing (range)	RV-100-4
R33	RESISTOR, fixed: composition; 220,000 ohms, $\pm 5\%$; 1/2 watt.	V5 Grid	RC20GF224J

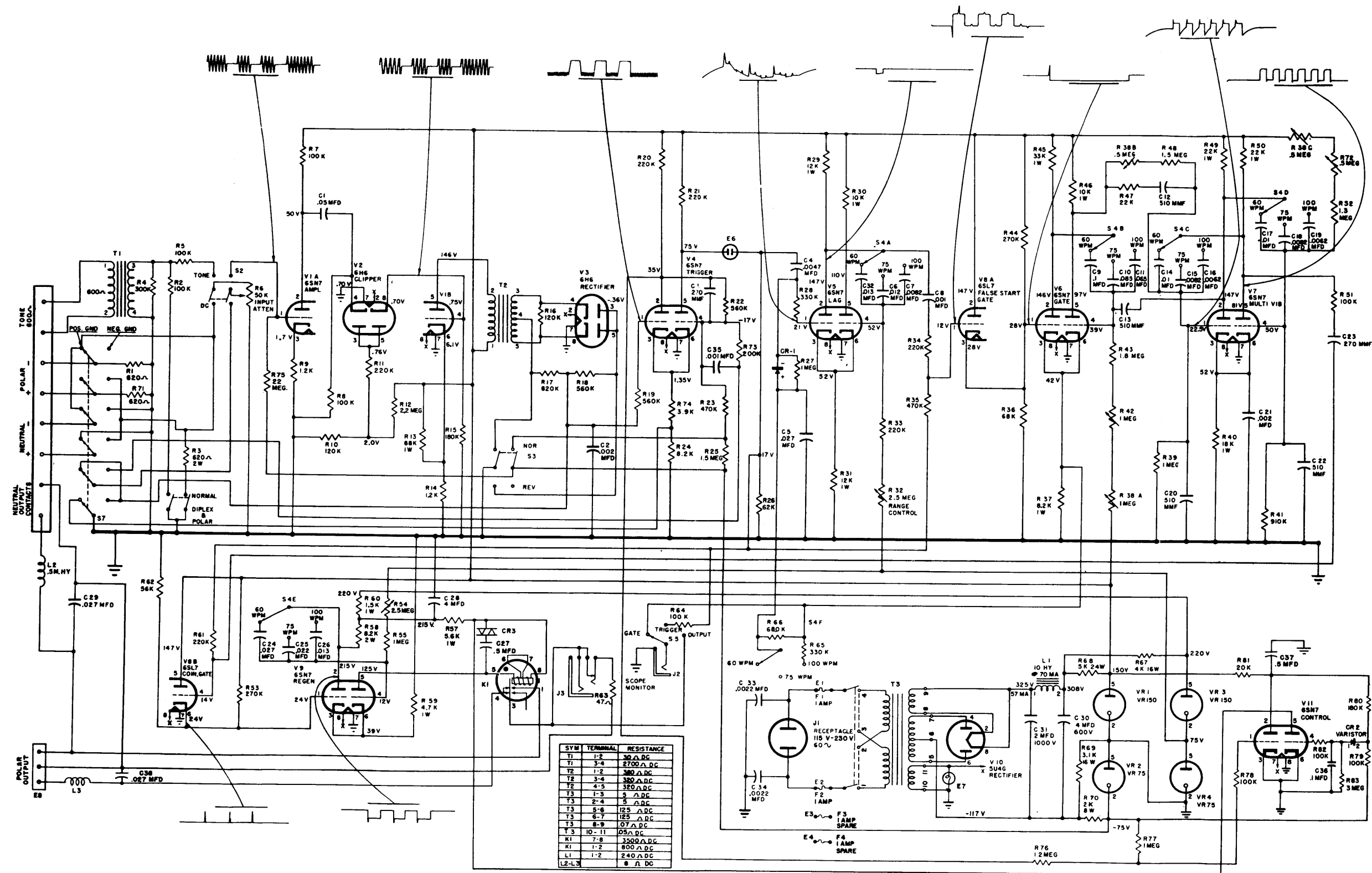
SYM	DESCRIPTION	FUNCTION	TMC PART NUMBER
R34	RESISTOR, fixed: composition; 220,000 ohms, $\pm 5\%$; 1/2 watt.	V5-8 coupling	RC20GF224J
R35	RESISTOR, fixed: composition; 470,000 ohms, $\pm 5\%$; 1/2 watt.	V8 Grid	RC20GF474J
R36	RESISTOR, fixed: composition; 68,000 ohms, $\pm 5\%$; 1/2 watt.	V6 Grid	RC20GF683J
R37	RESISTOR, fixed: composition; 8200 ohms, $\pm 5\%$; 1 watt.	V6 cathode	RC30GF822J
R38	RESISTOR, variable: composition; triple unit; Sect A-1 megohm, $\pm 20\%$; Sect. B-500,000 ohms, $\pm 20\%$; Sect. C-500,000 ohms, $\pm 20\%$; ea. sect. 2 watts, linear taper.	V6, 7 timing control (Speed)	RV-103
R39	RESISTOR, fixed: composition; 1 megohm, $\pm 5\%$; 1/2 watt.	V7 Grid	RC20GF105J
R40	RESISTOR, fixed: composition; 18,000 ohms, $\pm 5\%$; 1 watt.	V7 cathode bias	RC30GF183J
R41	RESISTOR, fixed: composition; 910,000 ohms, $\pm 5\%$; 1/2 watt.	V7 Grid	RC20GF914J
R42	RESISTOR, variable: composition; 1 megohm, $\pm 20\%$; 2 watts, linear taper.	V6 Grid tracks R38A	RV4ATSC105B
R43	RESISTOR, fixed: composition; 1.8 megohms, $\pm 5\%$; 1/2 watt.	V6 Grid	RC20GF185J
R44	RESISTOR, fixed: composition; 270,000 ohms, $\pm 5\%$; 1/2 watt.	V6 Grid	RC20GF274J
R45	RESISTOR, fixed: composition; 33,000 ohms, $\pm 5\%$; 1 watt.	V6 plate load	RC30GF333J
R46	RESISTOR, fixed: composition; 10,000 ohms, $\pm 5\%$; 1 watt.	V6 plate load	RC30GF103J
R47	RESISTOR, fixed: composition; 22,000 ohms, $\pm 5\%$; 1/2 watt.	V6-7 limiter	RC20GF223J
R48	RESISTOR, fixed: composition; 1.5 megohms, $\pm 5\%$; 1/2 watt.	V6-7 coupling	RC20GF155J
R49	RESISTOR, fixed: composition; 22,000 ohms, $\pm 5\%$; 1 watt.	V7 plate coupling	RC30GF223J
R50	RESISTOR, fixed: composition; 22,000 ohms, $\pm 5\%$; 1 watt.	V7 load	RC30GF223J
R51	RESISTOR, fixed: composition; 100,000 ohms, $\pm 5\%$; 1/2 watt.	Coupling V7-8	RC20GF104J

SYM	DESCRIPTION	FUNCTION	TMC PART NUMBER
R52	RESISTOR, fixed: composition; 1.3 megohm, $\pm 5\%$; 1/2 watt.	V7 Grid	RC20GF135J
R53	RESISTOR, fixed: composition; 270,000 ohms, $\pm 5\%$; 1/2 watt.	V8 cathode	RC20GF274J
R54	RESISTOR, variable: composition; 2.5 megohms, $\pm 20\%$; 2 watts; linear taper.	V9 timing res	RV4ATRD255B
R55	RESISTOR, fixed: composition; 1 megohm, $\pm 5\%$; 1/2 watt.	V9 Grid res	RC20GF105J
R56	RESISTOR, fixed: composition; 6800 ohms, $\pm 5\%$; 1/2 watt.	V9 Grid res	RC20GF682J
R57	RESISTOR, fixed: composition; 5600 ohms, $\pm 5\%$; 1 watt.	V9 plate load	RC30GF562J
R58	RESISTOR, fixed: composition; 8200 ohms, $\pm 5\%$; 2 watts.	V9 plate load	RC42GF822J
R59	RESISTOR, fixed: composition; 4700 ohms, $\pm 5\%$; 1 watt.	V9 cathode bias	RC30GF472J
R60	RESISTOR, fixed: composition; 1500 ohms, $\pm 5\%$; 1 watt.	V9 decouple	RC30GF152J
R61	RESISTOR, fixed: composition; 220,000 ohms, $\pm 5\%$; 1/2 watt.	E6-V8 coupling	RC20GF224J
R62	RESISTOR, fixed: composition; 56,000 ohms, $\pm 5\%$; 1/2 watt.	V8 cathode bias	RC20GF563J
R63	RESISTOR, fixed: composition; 47 ohms, $\pm 5\%$; 1 watt.	TT series res	RC30GF470J
R64	RESISTOR, fixed: composition; 100,000 ohms, $\pm 5\%$; 1/2 watt.	V5 noise decoupling	RC20GF104J
R65	RESISTOR, fixed: composition; 330,000 ohms, $\pm 5\%$; 1/2 watt.	V5 delay recov- ery 100 wpm	RC20GF334J
R66	RESISTOR, fixed: composition; 680,000 ohms, $\pm 5\%$; 1/2 watt.	V5 delay recov- ery 60-70 wpm	RC20GF684J
R67	RESISTOR, fixed: wire wound; 4000 ohms, $\pm 10\%$; 16 watts.	VR3,4 regulator	RW32G402
R68	RESISTOR, fixed: wire wound; 5000 ohms, $\pm 10\%$; 16 watts.	VR1 regulator	RW33G502
R69	RESISTOR, fixed: wire wound; 3100 ohms, $\pm 10\%$; 16 watts.	B- drop res	RW32G312
R70	RESISTOR, fixed: wire wound; 2000 ohms, $\pm 10\%$; 16 watts.	Regulator VR2	RW32G202

SYM	DESCRIPTION	FUNCTION	TMC PART NUMBER
R71	RESISTOR, fixed: composition; 620 ohms, ±5%; 2 watts.	Input load	RC42GF621J
R72	RESISTOR, variable: composition; 500,000 ohms, ±20%; 2 watts; linear taper.	Timing res V7	RV4ATSC504B
R73	RESISTOR, fixed: composition; 200,000 ohms, ±5%; 1/2 watt.	Voltage div V2	RC20GF204J
R74	RESISTOR, fixed: composition; 3900 ohms, ±5%; 1/2 watt.	Grid bias V2	RC20GF392J
R75	RESISTOR, fixed: composition; 2,200,000 ohms, ±5%; 1/2 watt.	Bias amp	RC20GF225J
R76	RESISTOR, fixed: composition; 1,200,000 ohms, ±5%; 1/2 watt.	Bias res V11	RC20GF125J
R77	RESISTOR, fixed: composition; 1,000,000 ohms, ±5%; 1 watt.	Coupling V4-V11	RC30GF105J
R78	RESISTOR, fixed: composition; 100,000 ohms, ±5%; 1 watt.	Grid res V11	RC30GF104J
R79	RESISTOR, fixed: composition; 100,000 ohms, ±5%; 1 watt.	Voltage divider V11	RC30GF104J
R80	RESISTOR, fixed: composition; 180,000 ohms, ±5%; 1 watt.	Voltage divider V11	RC30GF184J
R81	RESISTOR, fixed: composition; 20,000 ohms, ±5%; 2 watt.	Plate load V11	RC42GF203J
R82	RESISTOR, fixed: composition; 100,000 ohms, ±5%; 1 watt.	Grid res V11	RC30GF104J
R83	RESISTOR, fixed: composition; 3 megohms, ±5%; 1 watt.	Grid load V11	RC30GF305J
S1	SWITCH, toggle: DPST.	Normal duplex and polar input	ST22K
S2	SWITCH, toggle: DPDT.	Tone-DC input	ST22N
S3	SWITCH, toggle: DPDT.	Normal-Reverse keying	ST22N
S4	SWITCH, rotary: non-shorting; two sect., 3 pole, 3 position each sect; 2 1/2" diam. wafers.	SPEED selector	SW-128
S5	SWITCH, rotary: non-shorting; single sect.; 1 pole, 3 positions; 1 7/8" diam wafers.	Scope monitor	SW-127
S6	SWITCH, toggle: DPST.	Power on - off	ST22K

SYM	DESCRIPTION	FUNCTION	TMC PART NUMBER
S7	SWITCH, rotary: non-shorting; two sect., 3 pole, 2 position ea. sect.; 2 1/2" diam. wafers.	DC input selector.	SW-126
T1	TRANSFORMER, RF: primary 600 ohms; secdy. 15,000 ohms.	Tone input	TF-118
T2	TRANSFORMER, RF: primary 8,000 ohms; secdy. 15,000 ohms.	Interstage audio	TF-117
T3	TRANSFORMER, filament and power: primary 110/220 volts AC, 50/60 cycle; secdy #1-400-0-400 volts, 70 ma; secdy #2-5 volts, 3 amp; secdy #3-6.3 volts, 5 amp; 1500 volts ins.	Power	TF-119
V1	TUBE, electron: 6SN7GT, octal.	Audio amp.	6SN7GT
V2	TUBE, electron: 6H6, octal.	Series diode limiter	6H6
V3	TUBE, electron: 6H6, octal.	Full wave rect.	6H6
V4	TUBE, electron: 6SN7GT, octal.	Trigger	6SN7GT
V5	TUBE, electron: 6SN7GT, octal.	Multivibrator	6SN7GT
V6	TUBE, electron: 6SN7GT, octal.	Multivibrator	6SN7GT
V7	TUBE, electron: 6SN7GT, octal.	Multivibrator	6SN7GT
V8	TUBE, electron: 6SL7GT, octal.	Gate	6SL7GT
V9	TUBE, electron: 6SN7GT, octal.	Multivibrator	6SN7GT
V10	TUBE, electron: 5U4G, octal.	Rectifier, B+	5U4G
V11	TUBE, electron: 6SN7GT, octal.	Control	6SN7GT
VR1	TUBE, electron: 0D3/VR150, octal.	Voltage regulator	OD3
VR2	TUBE, electron: 0A3/VR75, octal.	Voltage regulator	OA3
VR3	TUBE, electron: 0D3/VR150, octal.	Voltage regulator	OD3

SYM.	DESCRIPTION	FUNCTION	TMC PART NUMBER
VR4	TUBE, electron: 0A3/VR75, octal.	Voltage regulator	0A3
XV1 thru XVR4	SOCKET, tube: octal.	Tube sockets	TS101P01
W1	CABLE ASSEMBLY: power, consists of one polarized locking type female receptacle, 6 feet cable, one male non-polarized plug.	Power cord	CA-103



SYM	TERMINAL	RESISTANCE
T1	1-2	30 Ω DC
T1	3-4	210 Ω DC
T2	1-2	30 Ω DC
T2	3-4	30 Ω DC
T2	4-5	30 Ω DC
T3	1-3	5 Ω DC
T3	2-4	5 Ω DC
T3	5-6	125 Ω DC
T3	6-7	125 Ω DC
T3	8-9	07 Ω DC
T3	10-11	05 Ω DC
K1	7-8	3500 Ω DC
K1	1-2	800 Ω DC
L1	1-2	240 Ω DC
L2-L3		0 Ω DC

T3 INPUT SHOWN WITH JUMPERS CONNECTED FOR 110 VAC INPUT. FOR 230 VAC INPUT REMOVE JUMPERS BETWEEN TERMINALS 1,2 AND 3,4 AND CONNECT BETWEEN TERMINALS 2,3.