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NAVSHIPS 91689

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INSTRUCTION BOOK

for

TELETYPEWRITER REPEATER SET AN/FGC-7A

PATCH AND TEST
FILE COPY

STELMA, INCORPORATED
Stamford, Connecticut

BUREAU OF SHIPS NAVY DEPARTMENT

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TELETYPEWRITER REPEATER SET AN/FGC-7A

STELMA, INCORPORATED
Stamford, Connecticut

BUREAU OF SHIPS NAVY DEPARTMENT

Contract: NObsr-52696

Approved by BuShips: 11 JUNE 1952

LIST OF EFFECTIVE PAGES

PAGE NUMBERS	CHANGE IN EFFECT	PAGE NUMBERS	CHANGE IN EFFECT
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3-0 to 3-10	Original		

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

IN REPLY REFER TO
Code 993-100
11 June 1952

From: Chief, Bureau of Ships
To: All Activities Concerned with the Installation, Operation and Maintenance of the Subject Equipment

Subj: Instruction Book for Teletypewriter Repeater Set AN/FGC-7A NAVSHIPS 91689

1. This is the instruction book for the subject equipment and is in effect upon receipt.

2. When superseded by a later edition, this publication shall be destroyed.

3. Extracts from this publication may be made to facilitate the preparation of other Department of Defense Publications.

4. All Navy requests for NAVSHIPS Electronics publications should be directed to the nearest District Publications and Printing Office. When changes or revised books are distributed, notice will be included in the Bureau of Ships Journal and in the Index of Bureau of Ships General and Electronics Publications, NAVSHIPS 250-020.

H. N. WALLIN
Chief of Bureau

RECORD OF CORRECTIONS MADE

CHANGE NO.	DATE	SIGNATURE OF OFFICER MAKING CORRECTION

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GUARANTY

The Contractor guarantees that at the time of delivery thereof the supplies provided for under this contract will be free from any defects in material or workmanship and will conform to the requirements of this contract. Notice of any such defect or non-conformance shall be given by the Government to the Contractor within one year of the delivery of the defective or non-conforming item, unless a different period of Guaranty is specified in the Schedule. If required by the Government within a reasonable time after such notice, the Contractor shall with all possible speed correct or replace the defective or non-conforming item or part thereof. When such correction or replacement requires transportation of the item or part thereof, shipping costs, not exceeding usual charges, from the delivery point to the Contractor's plant and return, shall be borne by the Contractor; the Government shall bear all other shipping costs. This Guaranty shall then continue as to corrected or replacing supplies or, if only part of such supplies are corrected or replaced, to such corrected or replacing parts, until one year after the date of redelivery, unless a different period of Guaranty is specified in the Schedule. If the Government does not require correction or replacement of a defective or non-conforming item, the Contractor, if required by the Contracting Officer within a reasonable time after the notice of defect or non-conformance, shall repay such portion of the contract price of the item as is equitable in the circumstances.

INSTALLATION RECORD

Contract No.: NObsr-52696 Date of Contract: 27 June 1951

Serial Number of equipment .....

Date of acceptance by the Navy .....

Date of delivery to contract destination .....

Date of completion of installation .....

Date placed in service .....

Blank spaces on this page shall be filled in at time of installation.

REPORT OF FAILURE

Report of failure of any part of this equipment, during its entire service life, shall be made to the Bureau of Ships in accordance with current regulations using form NAVSHIPS NBS 383 (revised) except for Marine Corps equipment, in which case the "Signal Equipment Failure Report" form shall be used and distributed in accordance with instructions pertaining thereto. The report shall cover all details of the failure and give the date of installation of the equipment. For procedure in reporting failures see Chapter 67 of the *Bureau of Ships Manual* or superseding instructions.

ORDERING PARTS

All requests or requisitions for replacement material should include the following data:

1. Federal stock number, or when ordering from a Marine Corps or Signal Corps supply depot, the Signal Corps stock number.
2. Name and short description of part.

If the appropriate stock number is not available the following shall be specified:

1. Equipment model or type designation, circuit symbol and item number.
2. Name of part and complete description.
3. Manufacturer's designation.
4. Contractor's drawing and part number.
5. JAN or Navy type number.

DESTRUCTION OF ABANDONED MATERIAL IN THE COMBAT ZONE

In case it should become necessary to prevent the capture of this equipment, and when ordered to do so, DESTROY IT SO THAT NO PART OF IT CAN BE SALVAGED, RECOGNIZED, OR USED BY THE ENEMY. BURN ALL PAPERS AND BOOKS.

Means:

1. Explosives, when provided.
2. Hammers, axes, sledges, machetes, or whatever heavy object is readily available.
3. Burning by means of incendiaries such as gasoline, oil, paper or wood.
4. Grenades and shots from available firearms.
5. Burying all debris, where possible and when time permits.
6. Throwing overboard or disposing of in streams or other bodies of water.

Procedure:

1. Obliterate all identifying marks. Destroy nameplates and circuit labels.
2. Demolish all panels, castings, switch and instrument boards.
3. Destroy all controls, switches, relays, connections and meters.
4. Rip out all wiring and cut interconnections of electrical equipment. Smash gas, oil, and water cooling systems in gas engine generators, etc.
5. Smash every electrical or mechanical part, whether rotating, moving or fixed.
6. Break up all operating instruments such as keys, phones, microphones, etc.
7. Destroy all classes of carrying cases, straps, containers, etc.
8. Bury or scatter all debris.

DESTROY EVERYTHING!

SAFETY NOTICE

The attention of officers and operating personnel is directed to Chapter 67 of the *Bureau of Ships Manual* or superseding instructions on the subject of radio safety precautions to be observed.

This equipment employs voltages which are dangerous and may be fatal if contacted by operating personnel. Extreme caution should be exercised when working with the equipment.

While every practicable safety precaution has been incorporated in this equipment, the following rules must be strictly observed:

KEEP AWAY FROM LIVE CIRCUITS:

Operating personnel must at all times observe all safety regulations. Do not change tubes or make adjustments inside equipment with high voltage supply on. Under certain conditions dangerous potentials may exist in circuits with power controls in the off position due to charges retained by capacitors. To avoid casualties, always remove power and discharge and ground circuits prior to touching them.

DON'T SERVICE OR ADJUST ALONE:

Under no circumstances should any person reach within or enter the enclosure for the purpose of servicing or adjusting the equipment without the immediate presence or assistance of another person capable of rendering aid.

DON'T TAMPER WITH INTERLOCKS:

Do not depend upon door switches or interlocks for protection, but always shut down motor generators or other power equipment. Under no circumstances should any access gate, door, or safety interlock switch be removed, short-circuited, or tampered with in any way, by other than authorized maintenance personnel, nor should reliance be placed upon the interlock switches for removing voltages from the equipment.

RESUSCITATION

AN APPROVED POSTER ILLUSTRATING THE RULES FOR RESUSCITATION BY THE PRONE PRESSURE METHOD SHALL BE PROMINENTLY DISPLAYED IN EACH RADIO, RADAR OR SONAR ENCLOSURE. POSTERS MAY BE OBTAINED UPON REQUEST TO THE BUREAU OF MEDICINE AND SURGERY.

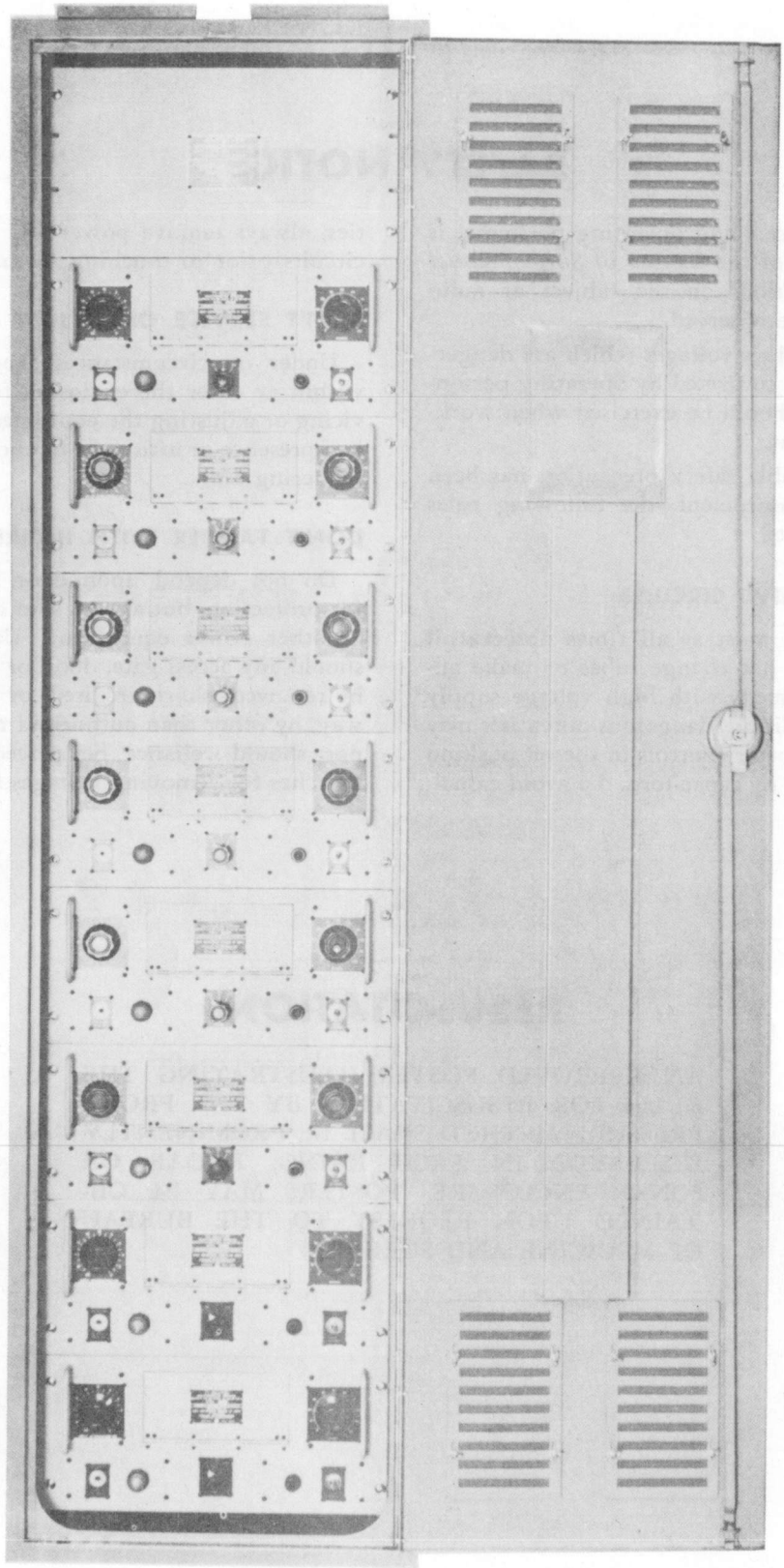


Figure 1-1. Teletypewriter Repeater Set AN/FGC-7A

SECTION 1
GENERAL DESCRIPTION

1. EQUIPMENT ILLUSTRATION

Figure 1-1 illustrates the Teletypewriter Repeater Set AN/FGC-7A which utilizes an AN Cabinet CY-614/G to house eight Teletypewriter Repeaters TT-63A/FGC.

2. PURPOSE AND BASIC PRINCIPLES

Teletypewriter Repeater TT-63A/FGC (hereafter referred to as Repeater) 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 Repeaters may be used to receive a Diplex teletype signal. One Repeater will produce the leading diplex signal at its output regenerated to standard simplex timing. The other Repeater will produce the lagging diplex signal at its output regenerated to standard simplex timing.

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

c. Regeneration of the teletype signal in the Repeater is accomplished by electronic means. Sampling pulses are generated in the Repeater 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 Repeater output. If the sampling pulse coincides with a space, the relay circuit will produce a space of proper duration at the Repeater output.

3. DESCRIPTION OF UNITS

The Teletypewriter Repeater TT-63A/FGC is illustrated in Figure 1-2. The panel is 3/16" thick by 19" long by 8-3/4" high, and is finished in ocean gray enamel. The chassis extends 10-1/2" behind the panel and is supported to the panel on each side by brackets. The controls most often used are located on the Repeater panel. Seldom used controls and fuses are located behind the access door in the center of the panel. Input, output, and power connections are located at the rear of the Repeater chassis. All vacuum tubes and relay are readily accessible from the rear of the Repeater and are mounted in a vertical position. The Repeater normally functions as an individual unit in

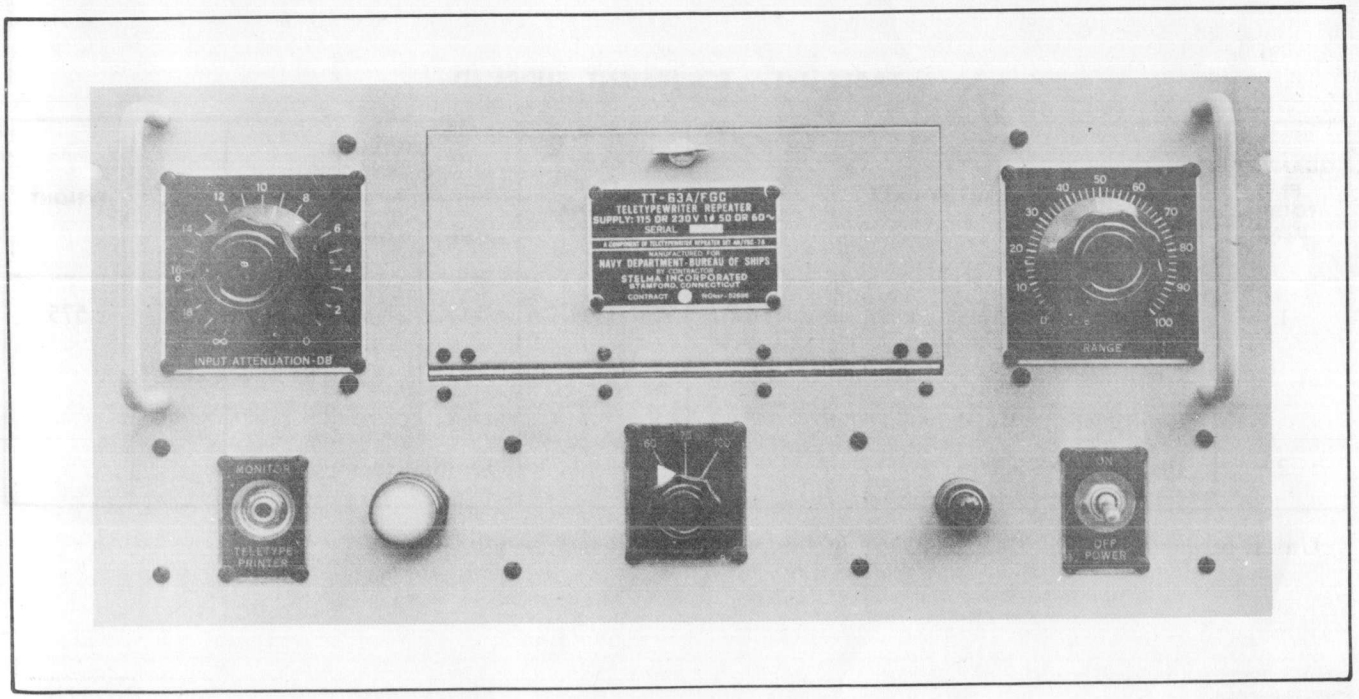


Figure 1-2. Teletypewriter Repeater TT-63A/FGC

the Teletypewriter Repeater Set AN/FGC-7A. On Diplex reception the input of two Repeaters 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 Repeater is in the form of relay contacts. -(DRY KEYING)

4. REFERENCE DATA

a. Nomenclature: Teletypewriter Repeater Set AN/FGC-7A housing eight teletypewriter Repeaters TT-63A/FGC.

b. Contract NObsr-52696, 27 June 1951.

c. Contractor: Stelma, Inc.

d. Cognizant Naval Inspector: Inspector of Naval Material, Bridgeport, Conn.

e. Number of packages per complete shipment.

f. Total cubical contents including equipment spares:

g. Total weight including equipment spares:

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

i. Input keying: tone — 500 to 3,600 cps, 30 ma polar, 60 ma neutral, simplex or diplex; dc keying must be negative with respect to ground on mark, tone keying may be either normal or inverse.

j. Output: Relay contacts in series with a 310 ohm resistor. Either mark Hold or Normal output operation available.

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

l. Output distortion: less than 5%.

m. Tone input level: −20 DBM to 0 DBM.

n. Power requirements: 105 to 125v, 50 to 60 cps, 85 watts per Repeater TT-63A/FGC.

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

p. Power Supply: Built in on each Repeater.

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

5. EQUIPMENT APPLICATIONS

The AN/FGC-7A equipment is similar from a mechanical standpoint to the AN/FGC-7 equipment except for location of blank panel. From an operational standpoint, the equipments are also similar except for the differences pointed out in Table 1-3. Circuit-wise there is a considerable difference between the output circuits of the TT-63/FGC and the TT-63A/FGC. This book covering the AN/FGC-7A Teletypewriter Repeater Set should not be used in conjunction with the AN/FGC-7 equipment. The book for the AN/-FGC-7 equipment should not be used for the AN/-FGC-7A equipment.

TABLE 1-1. EQUIPMENT SUPPLIED

QUANTITY PER EQUIPMENT	NAME OF UNIT	NAVY TYPE DESIGNATION	OVER-ALL DIMENSIONS			VOLUME	WEIGHT
			HEIGHT	WIDTH	DEPTH		
1	Teletypewriter Repeater Set consists of 8 Teletypewriter Repeaters TT-63A/FGC mounted in one AN cabinet CY-614/G	AN/FGC-7A	87-1/2	22-3/8	24	27	575
	Equipment Spare Parts Carton						
2	Instruction Books		Mounted in Equipment				

Unless otherwise stated, dimensions are inches, volume cubic feet, weight pounds.

TABLE 1-2. SHIPPING DATA

SHIPPING BOX NUMBER	CONTENTS		OVER-ALL DIMENSIONS			VOLUME	WEIGHT
	NAME	DESIGNATION	HEIGHT	WIDTH	DEPTH		
1	Teletypewriter Repeater Set Equipment Spare Parts Box	AN FGC-7A	106	36	38	83.92	1075

Unless otherwise stated, dimensions are inches, volume cubic feet, weight pounds.

TABLE 1-3. BASIC DIFFERENCES IN MODEL AN/FGC-7 SERIES EQUIPMENT

MODEL	OPERATING VOLTAGE	ELECTRON TUBE COMPLEMENT	SUB-PANEL CONTROLS	MECHANICAL DESIGN	REMARKS
TT-63/FGC	115v, 50/60 cycle 1 Φ	See Table 1-3 NAVSHIPS-91247	Toggle switch for input switch	Blank panel at bottom of CY-614/G rack.	In using oscilloscope, adjustments are made to secure six sampling pips, one on each 22 ms pulse of signal −(60 wpm). Output always MARK HOLD.
TT-63A/FGC	115/230v, 50/60 cycle, 1 Φ	See Table 1-4 this book	POLAR position on input rotary selector switch. Output toggle switch to select MARK HOLD or NORMAL operation. Controls rearranged on sub-panel.	Blank panel at top of CY-614/G rack. Some components rearranged on chassis, terminal boards, and sub-panel.	In using oscilloscope, adjustments are made to secure seven sampling pips, one on each 22 ms pulse and one in stop mark −(60 wpm). Output may be MARK HOLD or NORMAL.

TABLE 1-4. TELETYPEWRITER REPEATER TT-63A/FGC ELECTRON TUBE COMPLEMENT

SYMBOL	TYPE	CIRCUIT
V1	JAN-6SN7GT	Audio Amplifier
V2	JAN-6H6GT	Series Limiter
V3	JAN-6H6GT	Signal Full Wave Rectifier
V4	JAN-6SN7GT	Trigger
V5	JAN-6SN7GT	One Shot Multivibrator
V6	JAN-6SN7GT	One Shot Multivibrator
V7	JAN-6SN7GT	Gated Multivibrator
V8	JAN-6SL7GT	Gate and Phase Reverse
V9	JAN-6SL7GT	Coincidence Gate
V10	JAN-6SN7GT	Bistable Trigger
V11	JAN-6SN7GT	Cathode Follower and Gate
V12	JAN-5U4G	Full Wave Rectifier
V13	JAN-0D3/VR150	Voltage Regulator
V14	JAN-0D3/VR150	Voltage Regulator
V15	JAN-0C3/VR105	Voltage Regulator

SECTION 2
THEORY OF OPERATION

1. GENERAL DESCRIPTION OF CIRCUITS

a. Since the Teletypewriter Repeater Set AN/FGC-7A consists of eight individual Teletypewriter Repeaters TT-63A/FGC, this description will confine itself to a Teletypewriter Repeater TT-63A/FGC.

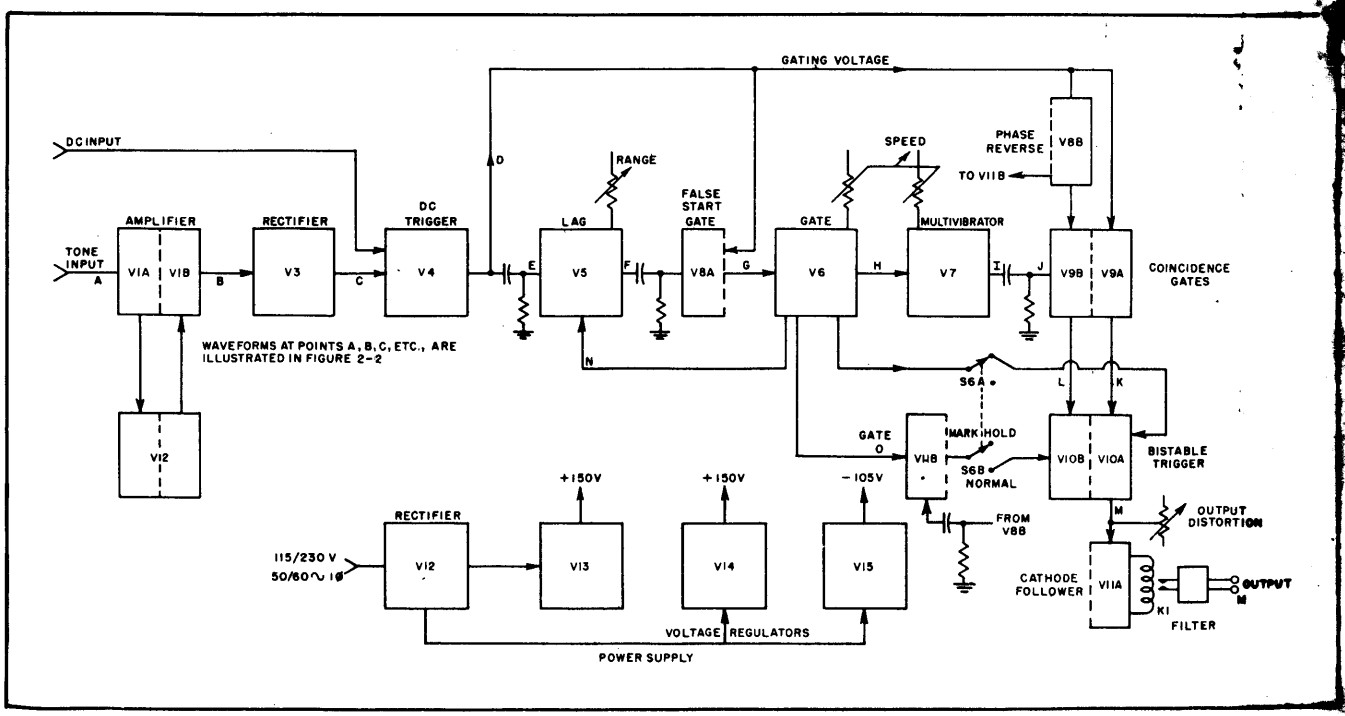
(1) Figure 2-1 illustrates a block diagram of the Repeater showing routing of signal from input to output. Figure 2-2 is a functional drawing showing wave shapes of the signal at pertinent points of the circuit on a time base. The time base is for 60 wpm operation, but similar circuit function occurs at 75 and 100 wpm so these time bases are not shown. A speed switch not shown on the Block Diagram changes timings in tubes V5, V6, and V7 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 2-1 and 2-2. Reference to these figures should be made when necessary without further direction.

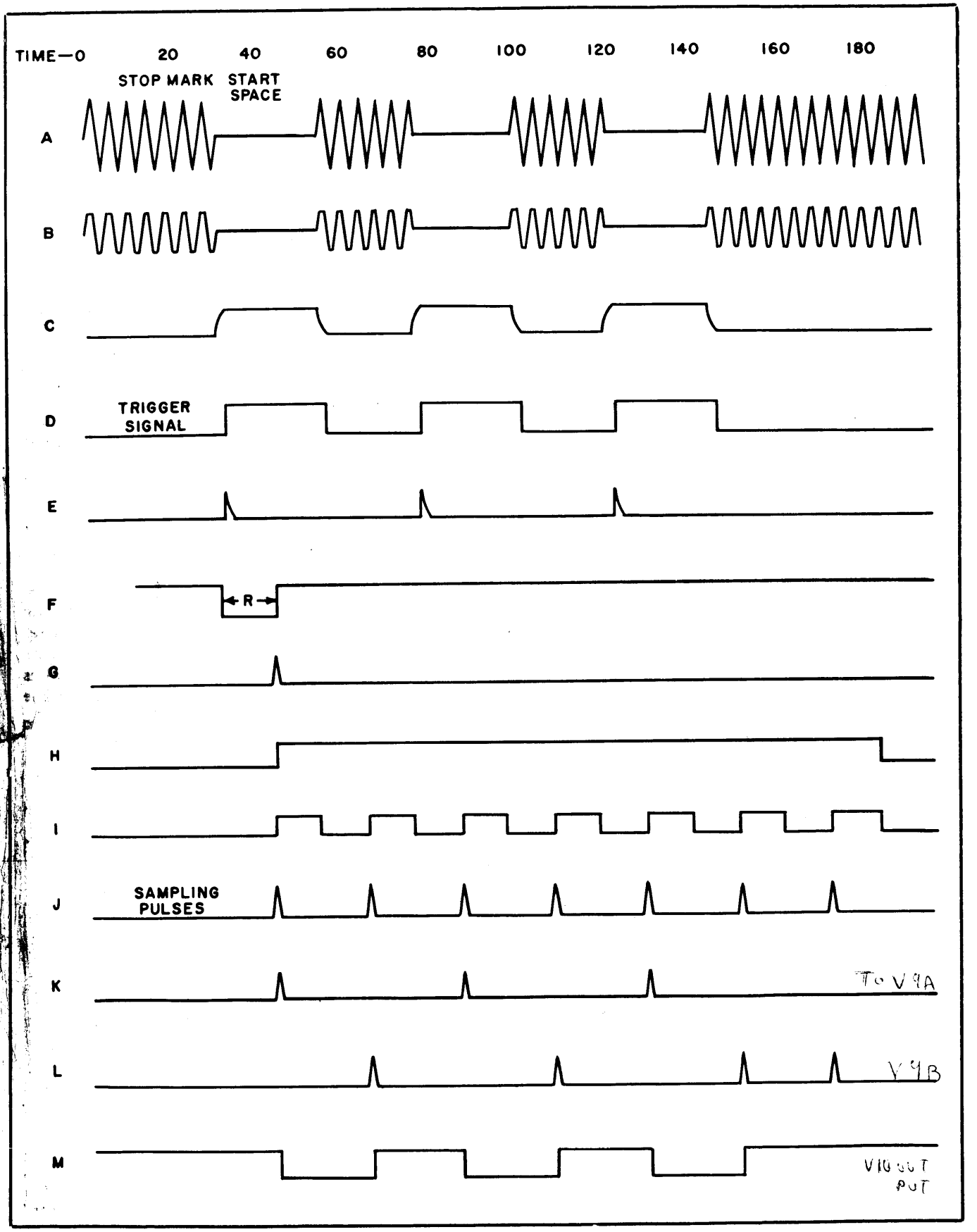
(3) It will be assumed that a keyed tone teletype signal is applied to the input of the Repeater. A signal for the character Y is illustrated in the Functional Drawing, Figure 2-2 where tone is on for the stop mark and off for the start space.

(4) The tone signal is amplified by triode V1A, limited by dual diode V2 to allow operation on vary-ing line levels, and again amplified by triode V1B. This signal (point B Fig. 2-1 and line B, Fig. 2-2) is then applied to a full wave rectifier tube V3, the out-put of which is illustrated in line C. The curve on rise and decay time of voltage is due to filtering in the rectifier. The output of V3 is applied to trigger tube V4 as is the dc input voltage when polar or neu-tral dc keying is applied to the Repeater, 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 V8A, V8B, and V9A. 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 (point F, Fig. 2-1 and line 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



Figur 2-1. Block Diagram



Figur 2-2. Functional Diagram

tube will trigger off at the time center of the start space. Output from V5 is differentiated at point G (see line G) and the resultant positive pulse is applied to the False Start Gate 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 143 ms (line H) during which time it performs two operations: (1) Lag tube V5 is biased off (connection N 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 6-1/2 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 22 ms teletype pulses and for the stop mark. 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 both sections of coincidence gate tube V9 which operates in similar fashion to False Start Gate tube V8A. A gating voltage is also fed to the coincidence tube V9A from the trigger tube output. A gating voltage 180° out of phase with the trigger voltage is fed to tube V9B. Tube V8B is used to secure the phase reversal. The first, third, and fifth sampling pulses applied to V9A will coincide with a positive gating voltage to that tube and will appear at the output of tube V9A to drive tube V10A. (See line K). The second, fourth, sixth, and seventh sampling pulses applied to tube V9B will coincide with a positive gating voltage to that tube and will be applied to tube V10B. (See line L).

(7) Tube V10 is a bistable trigger tube which triggers to one stable state when a pulse is applied to the "A" section. When a pulse is applied to the "B" section it triggers back to the original state. Output from tube V10 is shown in line M. This is an undistorted replica of the input signal. Cathode follower tube V11A is used to drive the relay K1 and is driven by the output from tube V10A. The input impedance of V11A is high and does not load tube V10. A Potentiometer in the grid circuit of V11A regulates the relay current and provides the output DISTORTION control. Relay output will also look like line M.

(8) Two types of output operation are possible from the Repeater. For MARK HOLD operation switch S6A applies a pulse from Gate tube V6 to trigger the Bistable Trigger tube V10A to mark at the end of each gate cycle. Thus the output will return to mark even when the input goes from mark to steady state space. For NORMAL output (output follows steady input state) a transition from mark to space will allow the last multivibrator sampling pulse to sample space and leave the output on space. On a space to mark transition sampling pulses are not generated. The transition pulse is therefore applied from tube V8B through an RC differentiating circuit to Gate tube V11B and then through switch S6B to Bistable Trigger tube V10B to trigger the output to mark. When the Repeater is in operation with a message, the Gate tube V6 keeps tube V11B disabled (point 0, Fig. 2-1) during all space to mark transitions. Signals then applied to tube V11B from tube V8B do not appear at the output of V11B.

(9) During operation the sampling pulse at the center of each 22 ms 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 Repeater 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 Repeater without producing faulty output. Speed adjustment of the Repeater must, of course, be perfect to secure operation at 45% bias distortions.

2. CIRCUIT ANALYSIS

Circuit analysis for the Teletypewriter Repeater TT-63A/FGC 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 −20 dbm to 0 dbm. The dc input circuits provide suitable impedances to the dc input lines.

(1) TONE INPUT — Keyed tone input to the Repeater is applied to the primary of the input transformer T1 which has a nominal impedance of 600 ohms. Resistors R2, R90, and R5 form a fixed attentuating network at the secondary of T1 so that amplifier tube V1A is not overloaded when 0 db input is applied to the Repeater and Input Attentuater R6 is set for zero attentuation. Switch S2 must be set to TONE during tone input operation so that the output from T1 is connected through S2 and Input Attentuator R6 to the grid of amplifier tube V1A. For Diplex operation switch S1 is thrown to DIPLEX thus open-

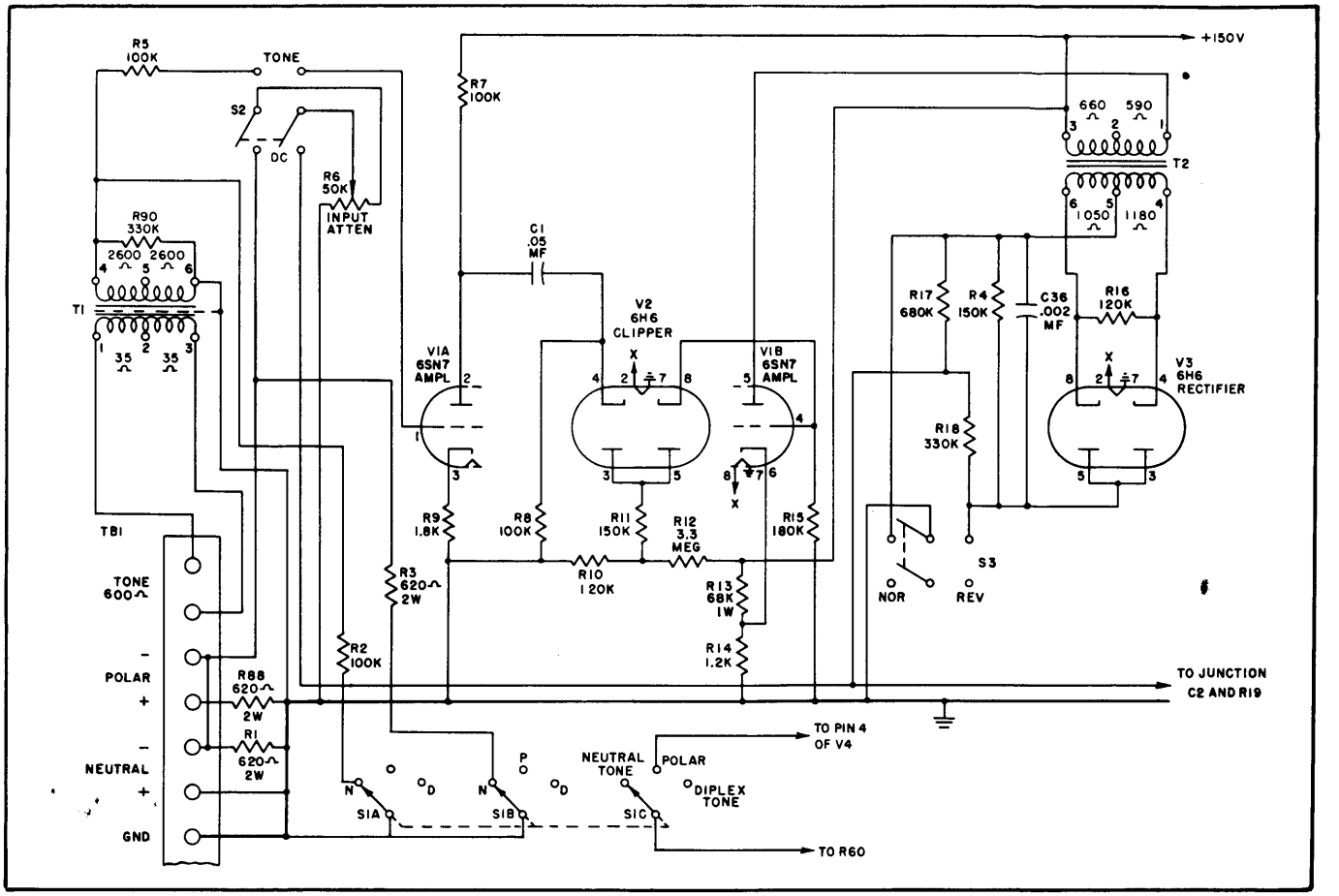


Figure 2-3. Input and Amplifier Circuits

ing resistor R2 from across the secondary of T1. This reflects an impedance of 1200 ohms to the primary so that when two Repeaters are connected in parallel for tone input, the impedance is again 600 ohms and the operating level of the Repeaters 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 Repeater. 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 is 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. Capacitors C36 and C2 provide filtering of the rectified signal. Resistor R4 provides an optimum load to the output of tube V3.

(2) DC INPUT — When polar or neutral dc keying is applied to the Repeater instead of tone input,

switch S2 must be set to dc. The Input Attenuator R6 is then connected between the input line and the input to trigger tube V4. For neutral simplex operation switch S1B 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 R88 present a 1240 ohm input balanced to ground. When two Repeater inputs are connected in parallel, 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 Repeater.

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.

(1) 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 I2 is on. Voltage (about 18 volts) is now developed across resistor R26. When signal is applied to the Repeater 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 I2 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 or 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,

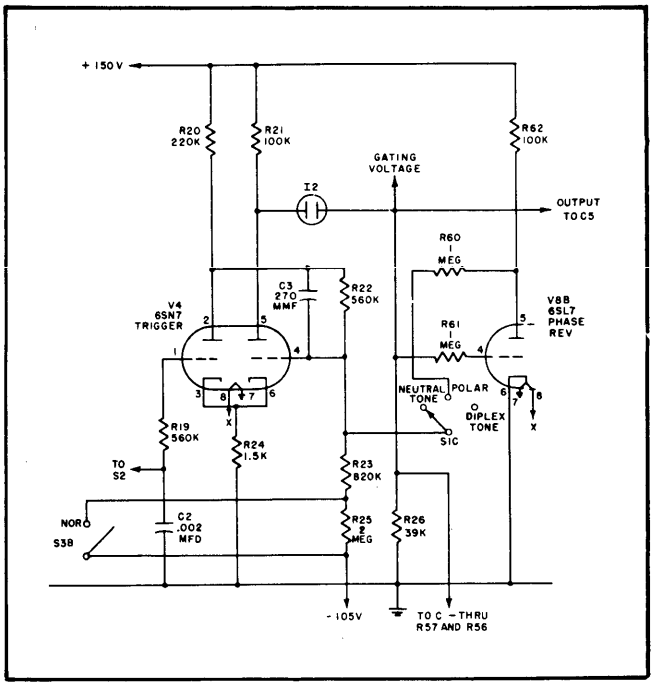


Figure 2-4. Trigger Circuit

the circuit flops back to its original state very rapidly due to the regenerative cathode coupling and neon lamp I2 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).

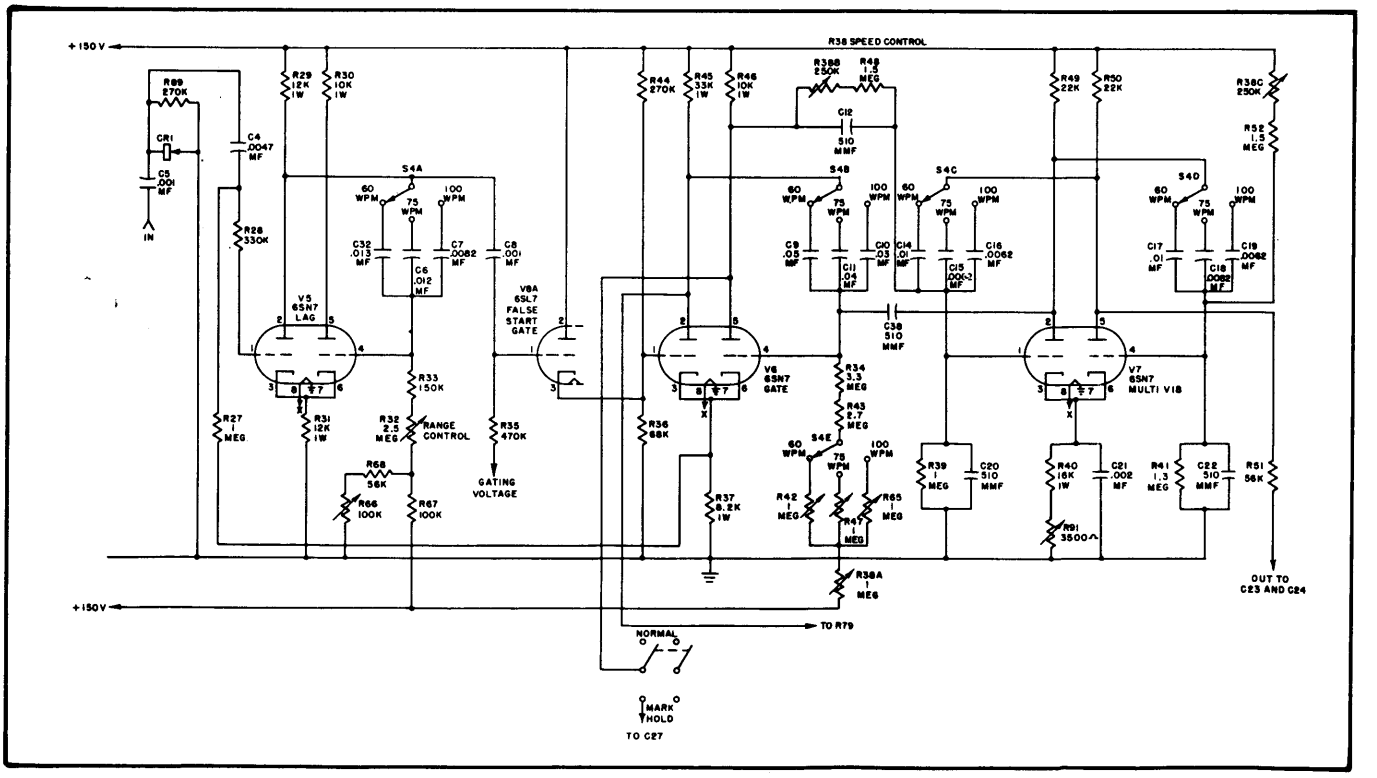
(2) When keying switch S3 is set to REVERSE, resistor R25 is inserted in the grid circuit of V4B so that V4B normally draws current. The voltage at the plate of V4B is below the operating potential of I2 and no voltage is developed across R26. Switch S2 also connects a positive output voltage from rectifier tube V3 to the grid of V4A. The inverse tone input signal will now have tone during the start pulse so that a positive dc 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 I2 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 Repeater, the input must be negative on the stop mark. DC input keying which is positive on the stop mark will not properly operate the Repeater.

(3) For polar input to the trigger circuit it is desirable that the circuit trigger one way with a nega-

tive input and remain in that state until a voltage of opposite polarity is applied to the input. This action is accomplished by using tube V8B, the grid of which is connected through current limiting resistor R61 to the output voltage developed across resistor R26, and the plate connected back through resistor R60 and switch S1C (when set to POLAR) to the grid of tube V4B. Resistor R62 serves as the plate load resistor for V8B. When a negative voltage is applied to the grid of tube V4A the plate of V4A and grid of V4B go positive. The plate of V4B goes negative and the neon lamp I2 is out. Tube V8B is cut off and its plate goes positive to make the grid of V4B more positive through the connection of R60. The grid of V4B is now held positive to such an extent that removal of voltage to the grid of V4A will not let the circuit trigger back to its original state. However, when sufficient positive voltage is applied to the grid of V4A, it will conduct, dropping the voltage at the grid of V4B which in turn is cut off allowing neon lamp I2 to go on. This causes tube V8B to draw current and further cut off tube V4B through the connection of resistor R60. Since the connection between V4B and V8B provides positive feedback, the trigger action is very sharp. Circuit constants are such that approximately the same value of positive voltage is required at the grid of V4A to trigger the circuit one way as negative voltage is required to trigger the circuit the other way.

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 determines 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 C5 and resistor R89 to provide a positive pulse to trigger the grid of lag tube V5A. The negative pulse resulting from differentiating is removed by crystal CR1. 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



Figur 2-5. Sampling Puls G n rating Circuits

in a positive direction is differentiated by capacitor C8 and resistor 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 2-2*c*) 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 or 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. Potentiometer R66 varies the voltage applied to R32 to allow adjustment for circuit tolerances. This is a factory adjustment.

(2) GATE CIRCUIT — Gate tube V6 utilizes a one shot multivibrator circuit similar to that of tube V5 except that its operating time (143 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 6-1/2 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 R34 plus R42 plus R38A. For 75 to 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 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 6-1/2 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 resistors R42, R47, and R65 provide a fine adjustment of the timing of V6 so that variable resistor R38A tracks properly (gates only 6-1/2 cycles) with R38B and R38C at any speed.

(a) Multivibrator tube V7 is turned on for 6-1/2 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 of 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 applies a pulse from the plate of V6B to the grid of V7A at the moment of starting. Capacitor C38 applies positive pulses at each half cycle point from the plate of V7A to the grid of V6B. At the time of the seventh 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 seventh positive pulse causes this triggering action to occur so that V6 always triggers off at the 6-1/2 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. Variable resistor R91 in the cathode circuit of tube V7 allows adjustment to compensate for circuit tolerances.

(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 and R27. 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 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. The gate cycle extends

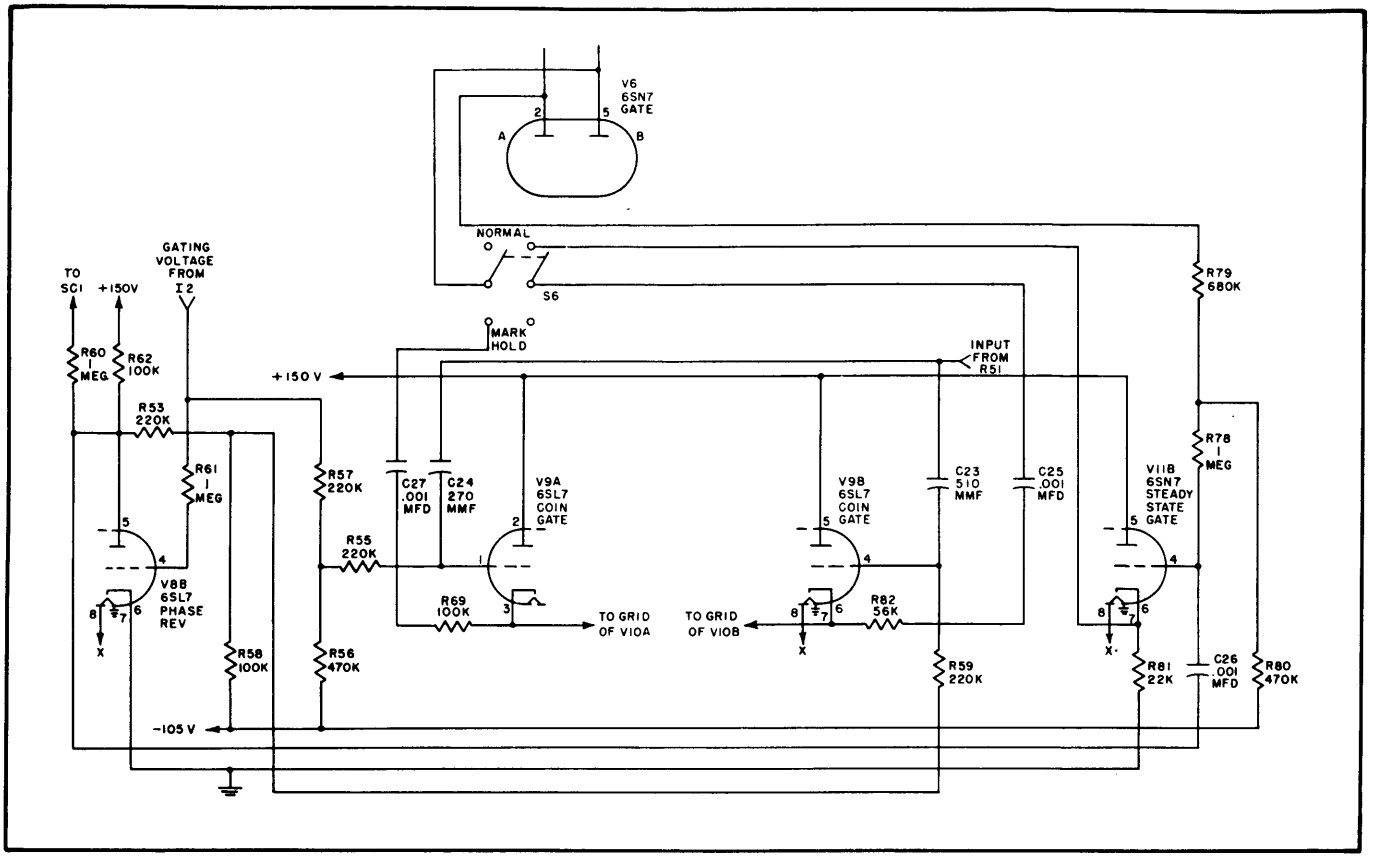


Figure 2-6. Gating Circuits

about 22 ms into the stop mark of the signal (60 wpm operation) at which time it turns off and the lag tube V5 is again ready to be triggered by the next start pulse. The extension of the gate cycle into the stop mark allows the Repeater to recover quickly if a start pulse is missing and the gate cycle is started by a following pulse.

(3) 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. 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 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 Repeater, this pulse will cause a gating voltage of 8 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 8 ms gating pulse. The pulse through capacitor C8 will thus occur 3 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 Repeater.

d. COINCIDENCE GATING CIRCUITS — The coincidence gating circuits are illustrated in Figure 2-6. They are used to drive the output circuit of the Repeater to provide the regenerated signal. Two input voltages are applied to the gate tube V9. Sampling pulses from the multivibrator V7 are applied to the grids of V9 through capacitors C23 and C24. These pulses appear at the grids as positive and negative spikes about 1 ms in duration. A gating voltage essentially of the same width as the teletype signal pulses is applied to V9A from the trigger circuit output (neon lamp I2) through resistors R57 and R55. A gating voltage 180° out of phase with the output from neon lamp I2 is applied to the grid of tube V9B through resistors R53 and R59. Tube V8B provides the required phase reversal. Resistors R57 and R56 in the grid circuit of V9A, and resistors R53 and R58 in the grid circuit of tube V9B keep the amplitudes of gating voltage to V9A and V9B roughly equal. The

cathodes of V9 are connected to the grids of V10 (not shown). Resistor dividers in the grids of V10 keep the cathodes of V9 at potentials which prevent any flow of current except when a positive sampling pulse from the multivibrator V7 coincides with a positive gating voltage at one of the V9 grids. The teletype start space applies a positive gating voltage to the grid of tube V9A. Tube V9A does not conduct however until the first sampling pulse applied through C24 occurs. This pulse appears at the cathode of V9A and is applied to the grid of tube V10A. The same sampling pulse applied to the grid of V9B through capacitor C23 does not appear at the cathode since the gating voltage to the grid of V9B is negative at this time. Negative pulses applied through capacitors C23 and C24 to tube V9 have no effect since the gating voltages alone do not allow tube V9 to draw current. If a mark follows the start space, a positive gating voltage will be applied to the grid of tube V9B and the second positive sampling pulse will be transmitted through tube V9B and be applied to the grid of tube V10B. Thus, positive sampling pulses coinciding with space appear at the cathode of V9A to drive the grid of tube V10A, and those coinciding with mark appear at the cathode of V9B to drive the grid of tube V10B.

(1) MARK HOLD operation is secured in the Repeater by supplying a pulse from the plate of gate tube V6B to the cathode of V9A (and grid of V10A) through capacitor C27 and resistor R69 when switch S6 is in the MARK HOLD position. A negative pulse is thus applied to the grid of V10A at the end of each gate cycle which triggers tube V10A to mark. Since the gate cycle is started each time the input to the Repeater goes from mark to space, the output of the Repeater will be returned to mark at the end of the gate cycle even though the last sampling pulse would sample space (as in a steady state transition from mark to space).

(2) NORMAL (S6 is up) operation in the Repeater is defined as having the output of the Repeater duplicate the input signal and follow any steady state input condition. A steady state transition from mark to space at the Repeater input will be followed at the output because the last sampling pulse samples a space condition and commands the output tube V10A to go to space. On a space to mark transition the gate cycle is not started. To return the output to mark under this condition, a positive pulse is applied from the plate of tube V8B through capacitor C26 to the grid of steady state gate tube V11B. This tube conducts during a steady input state and applies the pulse from its cathode through switch S6, capacitor C25, and resistor R82 to the grid of V10B, triggering tube V10B to a mark output condition. During normal operation of the Repeater when a message is being handled, pulses at the plate of tube V8B do not reach the cathode of tube V11B because gate tube V6 is in cycle with the plate of V6A negative. This negative state of V6A applies negative bias to tube V11B through the resistor network of R78, R79, and R80 and blocks the passage of signals at the grid of V11B from reaching the cathode.

e. OUTPUT CIRCUITS — The output circuits of the Repeater are illustrated in Figure 2-7. The circuits driving the relay produce essentially less than 1% bias distortion. The distortion at the output of the Repeater should be under 5% and depending on the particular relay, may be in the order of 2%. Tube V10 is used in a bistable trigger circuit which has two stable states and is driven into these states by sharp pulses applied to the grids. When tube V10 is in the state such that V10B is drawing current, its plate potential is at a reduced value. The grid of V10A is connected to the plate of V10B by the divider network of R76 and R77, and is cut-off. When a positive pulse is applied to the grid of tube V10A, V10A draws current causing the voltage at its plate to drop. This cuts off the grid of V10B through the divider network of R73 and R74 thus locking the circuit in its second stable state with V10B now cut off and V10A drawing current. A positive pulse at the grid of V10B will trigger the circuit back to the original state of V10B drawing current. Capacitors C28 and C29 speed up the switching action of the circuit. Under MARK HOLD operation a negative pulse is used to trigger V10A. A negative pulse readily triggers the circuit when it is applied to the section of V10 which is drawing current. A positive pulse triggers only when applied to the section of V10 which is cut off. Since tube V10 is driven by successive positive pulses from a multivibrator which are equally spaced, the amount of bias distortion of the signal at V10 is very low. It is undesirable to operate the output relay of the Repeater directly from the tube V10 as this would place an inductive load in one leg of V10. For this reason output from V10 is taken from the "A" section plate and fed to cathode follower V11A through output DISTORTION control R54. This potentiometer regulates the voltage applied to V11A and thereby the relay K1 current. Capacitor C37 speeds up the action of the relay to produce greater uniformity of action between various relays. The contacts of relay K1 are protected by resistor R83 and capacitor C33 in series across the contacts. Inductor L2 and capacitor C35 supply filtering to the output line which is not grounded. A jack J3 provides for connection of a remote teletypewriter monitor and keeps resistor R63 in series with the output circuit when the monitor is not connected.

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 Repeater. Tube V12 is a full wave rectifier whose output is filtered by reactor L1 and capacitors C30 and C31. All dc voltages used in the Repeater are regulated. Regulating resistor R84 and tube V13 provide one positive 150 volt supply. Regulating resistor R85 and tube V14 provide a second positive 150 volt supply. A regulated −105 volts is secured by con-

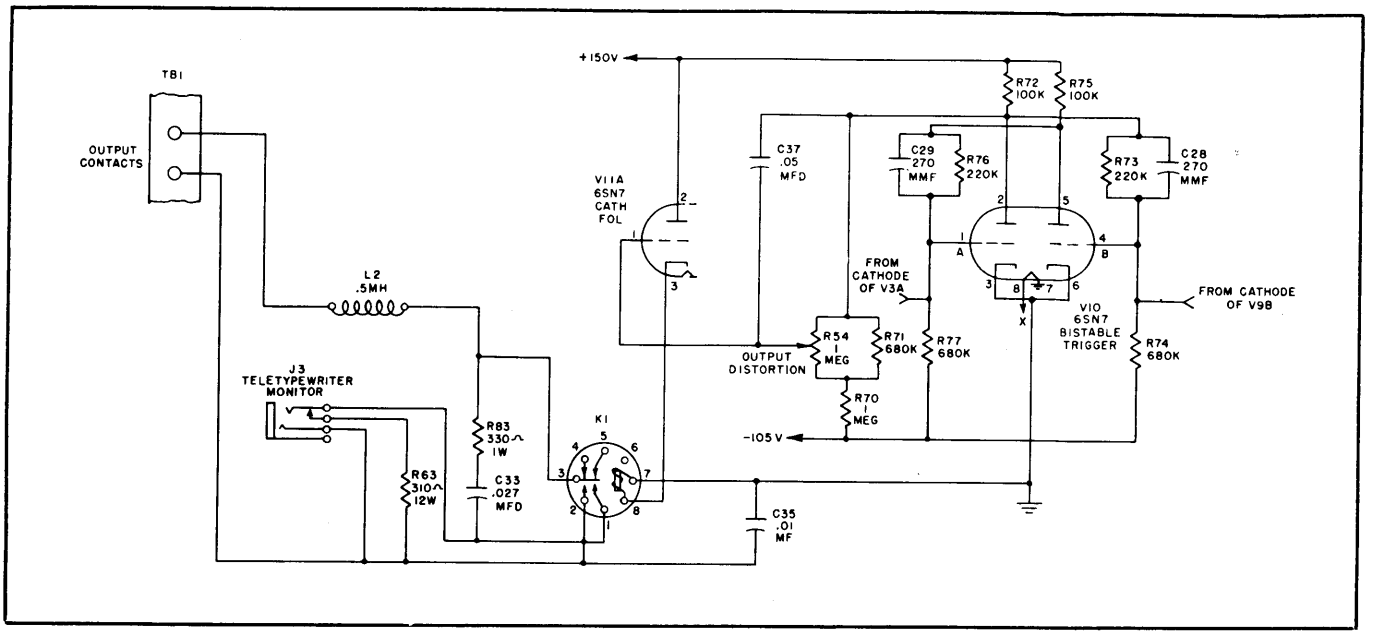
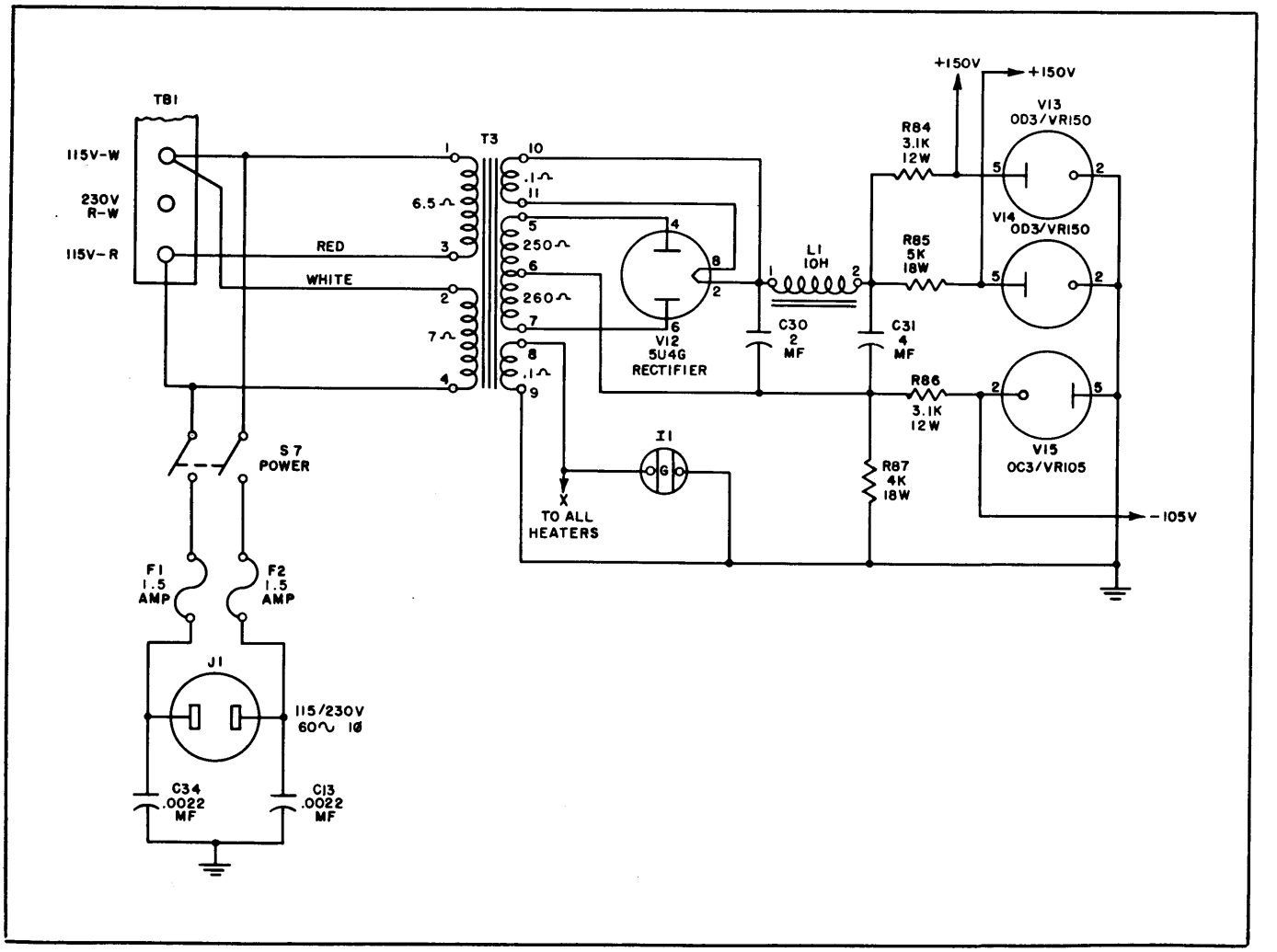


Figure 2-7. Output Circuits



Figur 2-8. Pow r Supply Circuit

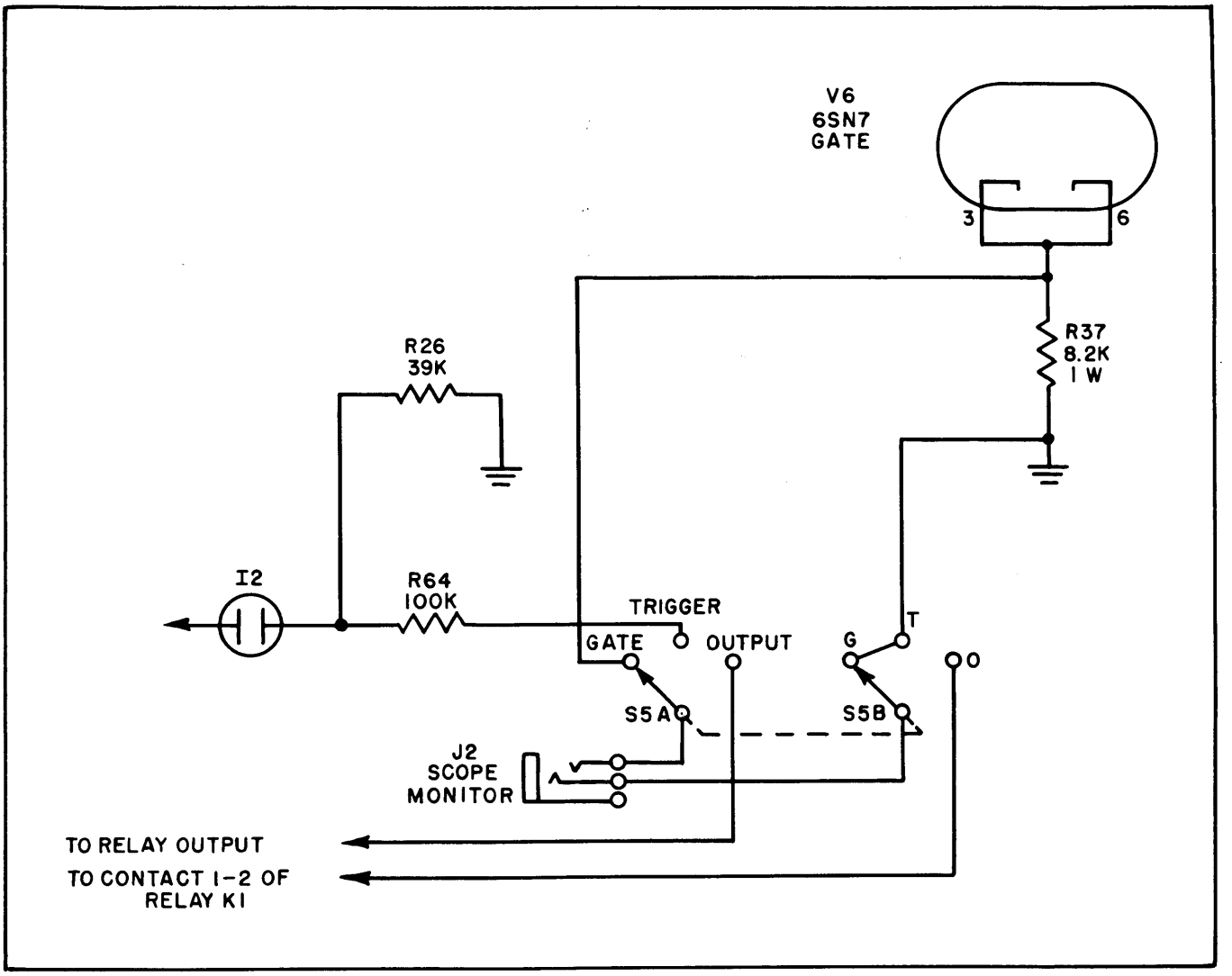


Figure 2-9. Oscilloscope Monitor Switch Circuit

necting resistor R87 between the center tap of the high voltage winding to secure a −150 volt drop, and regulating to −105 volts with series resistor R86 and tube V15. Power switch S7 breaks both sides of the ac line to turn the Repeater off. Both sides of the line are fused by F1 and F2. Capacitors C34 and C13 bypass either side of the ac line to ground to prevent radiation of noise voltages into the line. Provision is made for connecting transformer T3 for either 115 volt input or 230 volt input. For 115 volt input the two primaries are connected in parallel. For 230 volt input the windings are connected in series.

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

WARNING

When the oscilloscope monitor switch is in the OUTPUT position a dangerous potential may exist between the case of the oscilloscope and ground. Suitable precautionary measures should be taken.

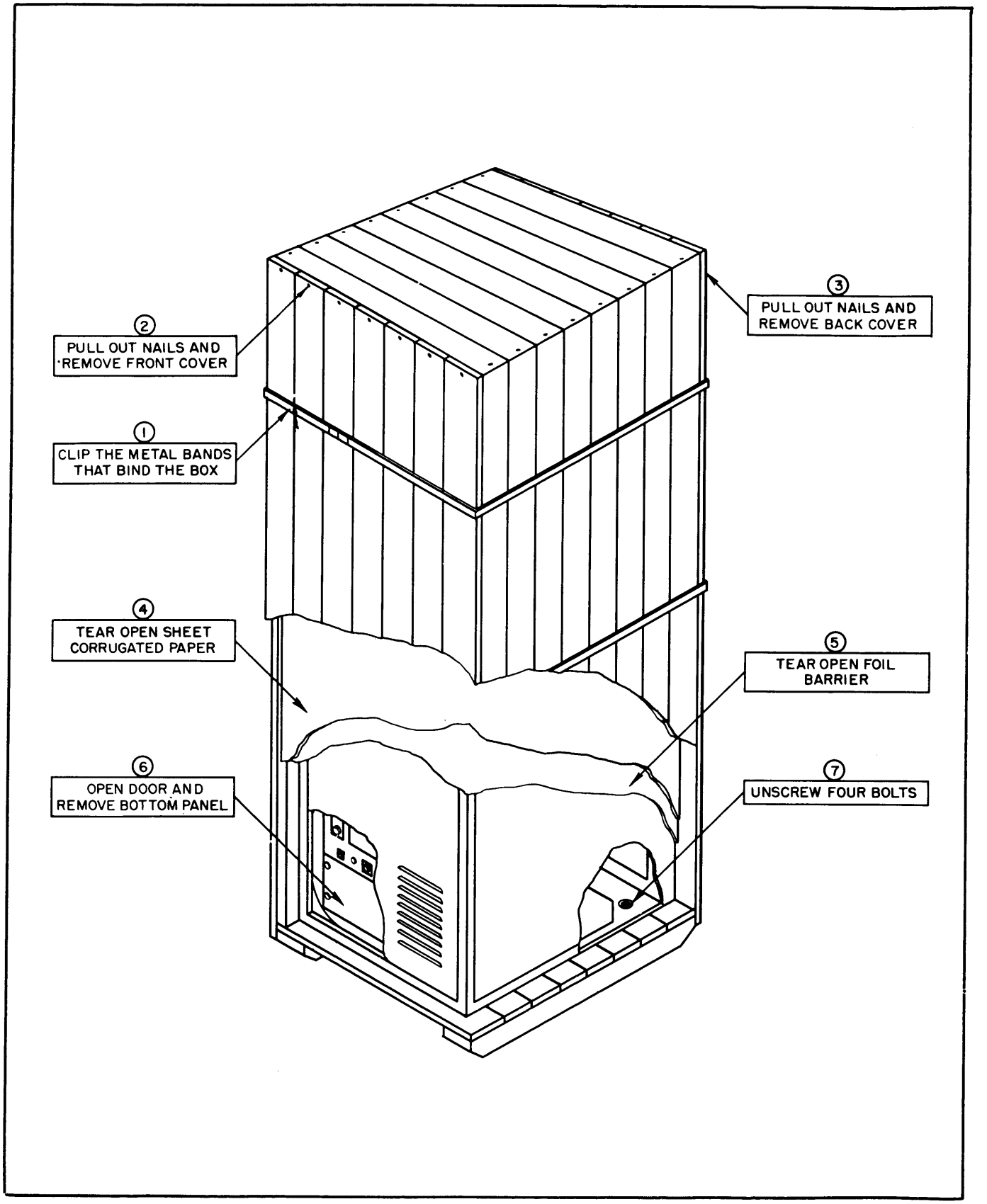


Figure 3-1. Teletypewriter Repeater Set AN/FGC-7A Unpacking Procedure

SECTION 3
INSTALLATION

1. UNPACKING

The steps for unpacking the Teletypewriter Repeater set AN/FGC-7A are illustrated in Figure 3-1. After removal of the Teletypewriter Repeater Set AN/FGC-7A from its packing crate, the equipment should be thoroughly inspected for damage. Both front and rear doors of the rack should be opened for this inspection.

2. INSTALLATION

The Teletypewriter Repeater Set AN/FGC-7A should be installed using the following procedure:

a. Open the back door of the rack and remove the wood bracket supporting the back of each Repeater. These supports are necessary only during shipment. A bolt at each end of the bracket must be removed to free the bracket.

b. Select a location for the equipment which provides sufficient clearance to allow opening the front and back doors of the rack. Access to the rear of the Repeaters is necessary for replacing tubes. A location convenient to a source of ac power and to the teletype input and output lines is desirable.

c. Provide cable entrance to the racks in the manner most suitable to the particular installation as follows:

(1) Determine whether power and signal lines can be brought into the equipment most conveniently at the top of the rack or at the bottom of the rack. The top plate of the metal box at the top rear of the rack may be removed and drilled for cable entrance. Either or both of the small side plates at the bottom of the rack may be removed and drilled for cable entrance.

(2) If several racks are to be installed side by side, the small side plates at the bottom of adjacent racks may be removed and cables pulled through these openings from one rack to another.

d. Install the equipment in the selected site using the Outline Drawing illustrated in Figure 3-3 as a guide to floor mounting and clearance dimensions.

e. Make up cables to connect power and signal voltages to the equipment and from the equipment to the teletypewriters. No cables are provided with the equipment except those wired in the rack as indicated in the Primary Power Distribution Diagram, Figure 3-4. Cables carrying ac primary power to the equipment should be adequate to supply one kw to each equipment rack. The AN/FGC-7A and TT-63A/FGC come connected for 115 volt ac line input. For operation on 230 volt input rack the TT-63A/FGC may be reconnected as shown in Figure 3-4 for 230 volt operation. The trouble lamp on the AN Cabinet CY-614/G must be changed to a 230 volt lamp if it is to be used.

f. A power supply suitable to operate the teletypewriters must be connected in series with the output of each Teletypewriter Repeater TT-63A/FGC as illustrated in the Interconnecting Drawing, Figure 3-5. Output wiring should be made in accord with this drawing. 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 Repeater terminal board. Since neither connection of the output from the Repeaters is connected to ground, a two-wire shielded cable is necessary to connect the output from each Repeater to the respective teletypewriter. A suitable variable series resistor may be necessary in the output circuit to each teletypewriter for securing the optimum operating current.

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

(1) For Neutral or Polar dc inputs 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 Repeater is ground. The positive Polar input connection to the Repeater is 620 ohms to ground as is th negative terminal. Inputs that are balanced to ground are thus provided for polar operation.

(2) Tone input to the Repeater is normally 600 ohms balanced to ground but one of the Tone input terminals may be grounded to provide unbalanced input if desired.

(3) For diplex operation the inputs of the two Repeaters 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.

3. INITIAL ADJUSTMENTS

After the Teletypewriter Repeater Set AN/FGC-7A has been installed and the Repeaters wired in accordance with Section 3-2, each Repeater should be oper-

ated and checked. Adjustments should be made only if checks indicate such a need.

a. INITIAL CHECK — Make an initial check on the Repeater 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) Open the access door on the Repeater Panel and 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 Repeater after installation to make sure the equipment is properly adjusted for operation.

(1) Allow the Repeater 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 Repeater. Set the front panel SPEED selector switch to the correct position.

(3) Determine the type of teletype signal for which the Repeater is connected at the input (DC Neutral, Polar, Diplex, or Tone), and set the three keying switches behind the front panel access door 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 NEUTRAL-TONE, POLAR, DIPLEX-TONE switch is set to NEUTRAL-TONE for either neutral dc or tone simplex signals. For polar dc inputs the switch is set to POLAR, and for diplex neutral dc or tone the switch is set to DIPLEX-TONE.

(4) Set the NORMAL-MARK HOLD toggle switch to secure the desired type of output operation. Operation during a signal will be the same for either position but on steady states the NORMAL position provides an output which is the same as the steady input state. On MARK-HOLD the output will stay on mark for either mark or space steady input.

(5) 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 3-2 for the oscilloscope connections.

(6) Apply a teletype signal to the Repeater. 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 (6 db) beyond the trigger point.

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

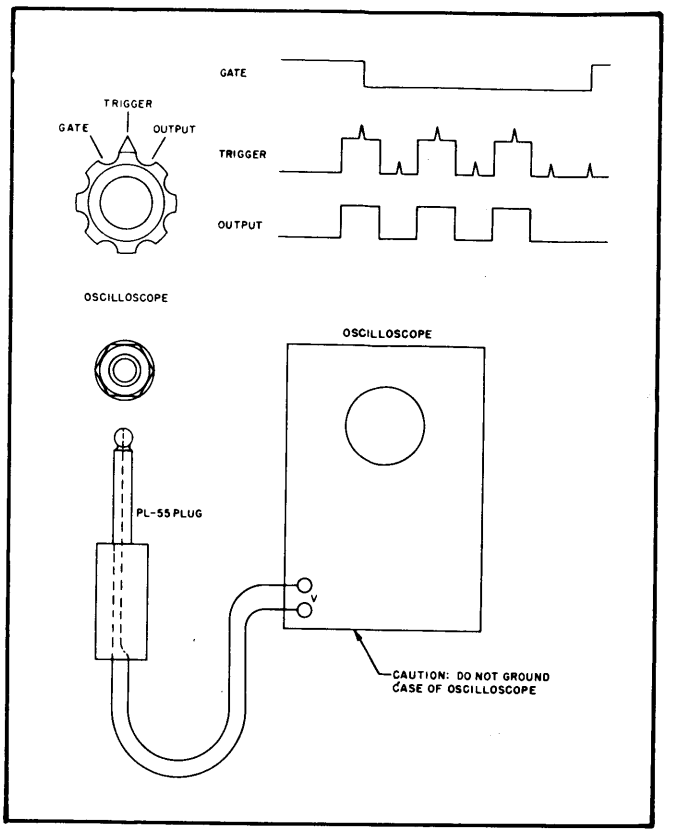


Figure 3-2. Oscilloscope Connections and Patterns

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

(9) Apply an undistorted repeated character telegraph test signal to the repeater. 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 and for the stop pulse. See Figure 3-2 for a typical pattern for the character Y.

(10) 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.

(11) 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 subpanel is in need of adjustment and step (12) should be performed.

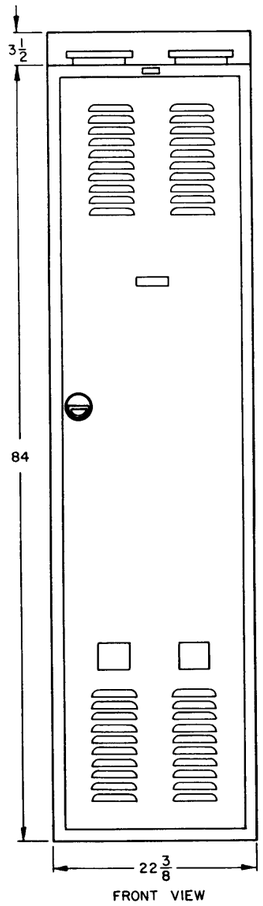
(12) After the setting of the RANGE control to center the first sampling pip on the start pulse, adjust slowly with a screwdriver the SPEED control until the

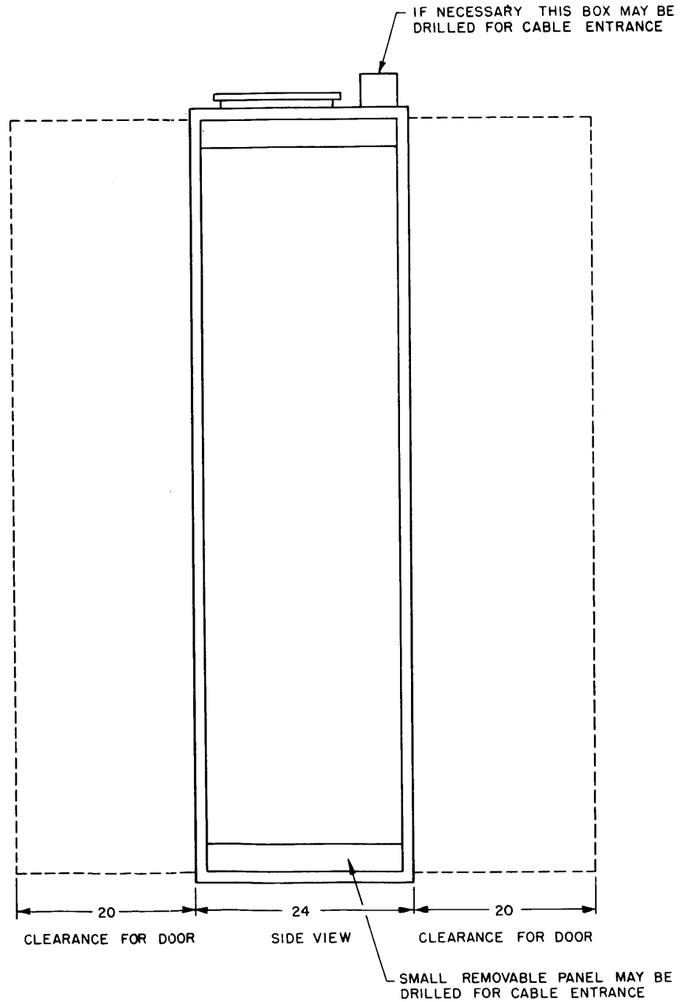
WEIGHT OF UNIT CRATED — 1075 LBS
WEIGHT OF UNIT UNCRATED — 575 LBS

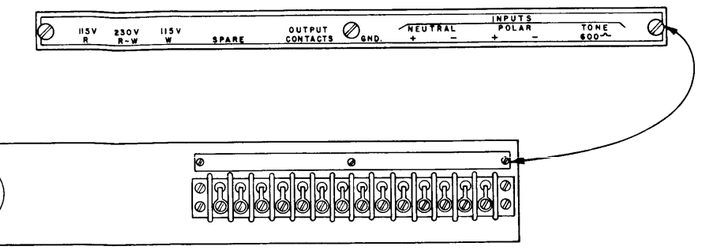
VACUUM TUBE REQUIREMENTS
56 TYPE JAN 6SN7GT
16 TYPE JAN 6H6GT
16 TYPE JAN 6SL7GT
8 TYPE JAN 5U4G
16 TYPE JAN 0D3/VR150
8 TYPE JAN 0C3/VR105

OVERALL DIMENSIONS OF UNIT CRATED
106 HIGH X 36 WIDE X 38 DEEP

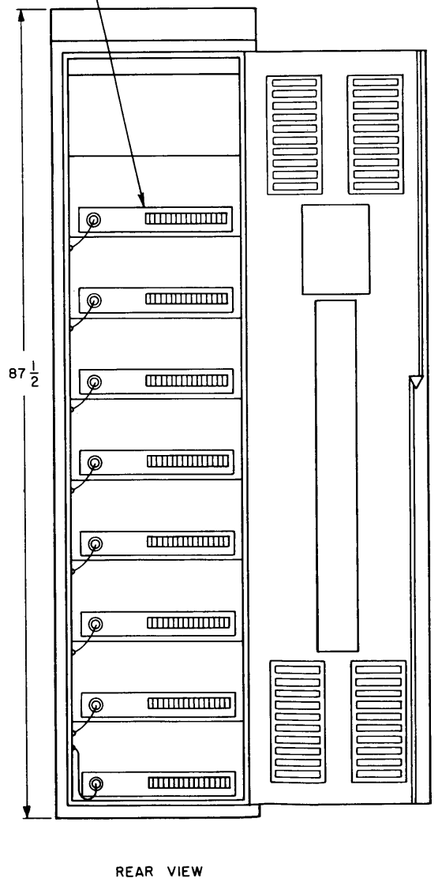
HEAT DISSIPATION - 680 WATTS
AMBIENT TEMPERATURE 20°C TO 30°C

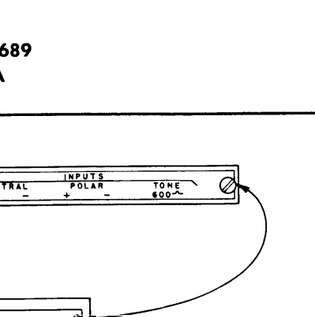




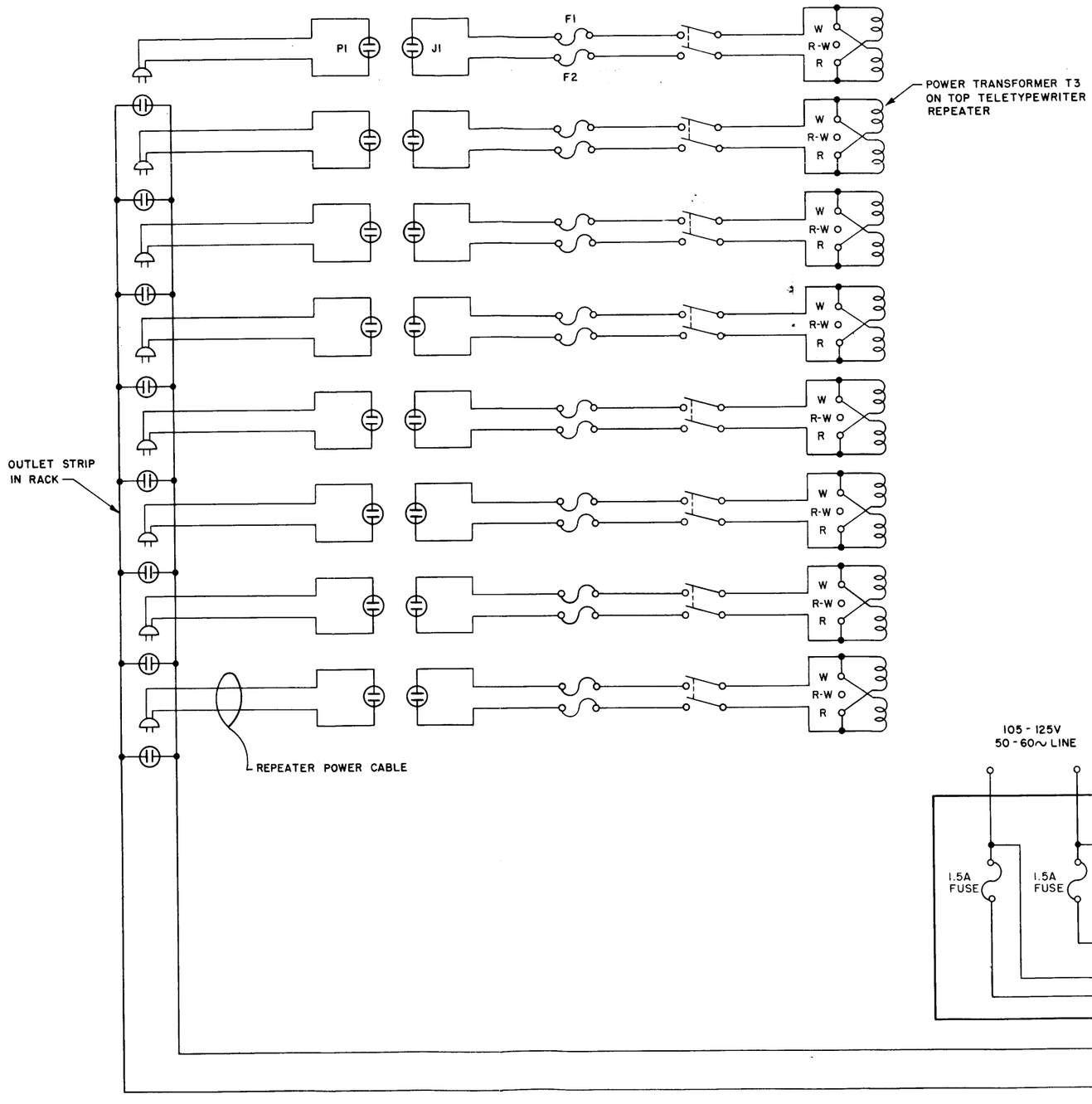


ENLARGED VIEW OF BACK OF TELETYPE REPEATER TYPE TT-63A/FGC CHASSIS. EIGHT REPEATERS ARE MOUNTED IN ONE RACK

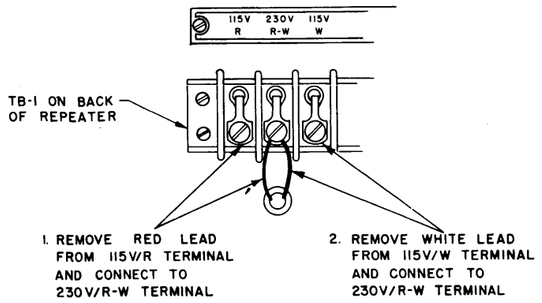


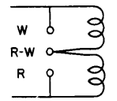


Figur 3-3. T letypewriter R peater Set AN/FGC-7A Outlin Drawing



TELETYPWRITER REPEATER TT-63A/FGC
MAY BE CONNECTED FOR 230V A.C. LINE AS FOLLOWS:





SCHEMATIC FOR 230V OPERATION

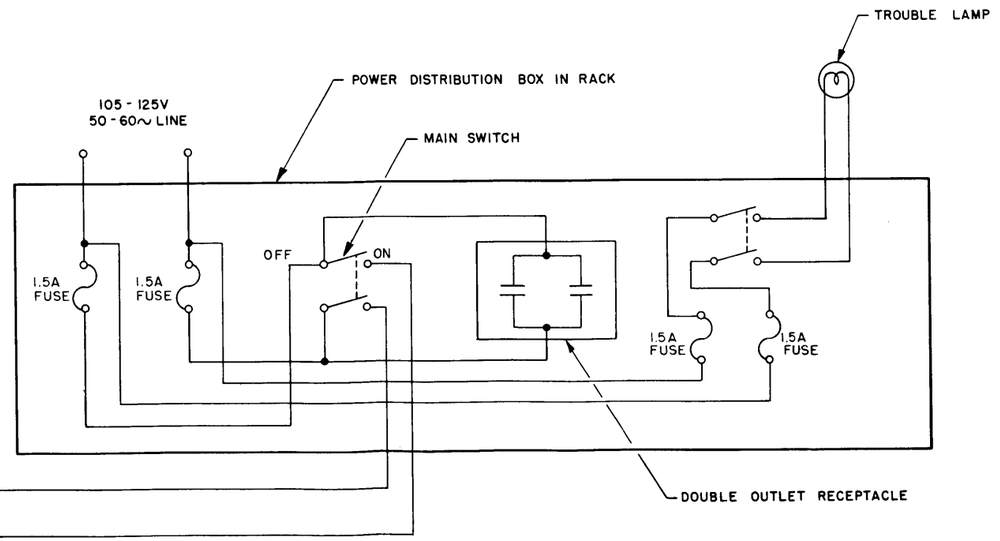


Figure 3-4. TT-63A/FGC Teletypewriter Repeater Set AN/FGC-7A Primary Power Distribution Diagram

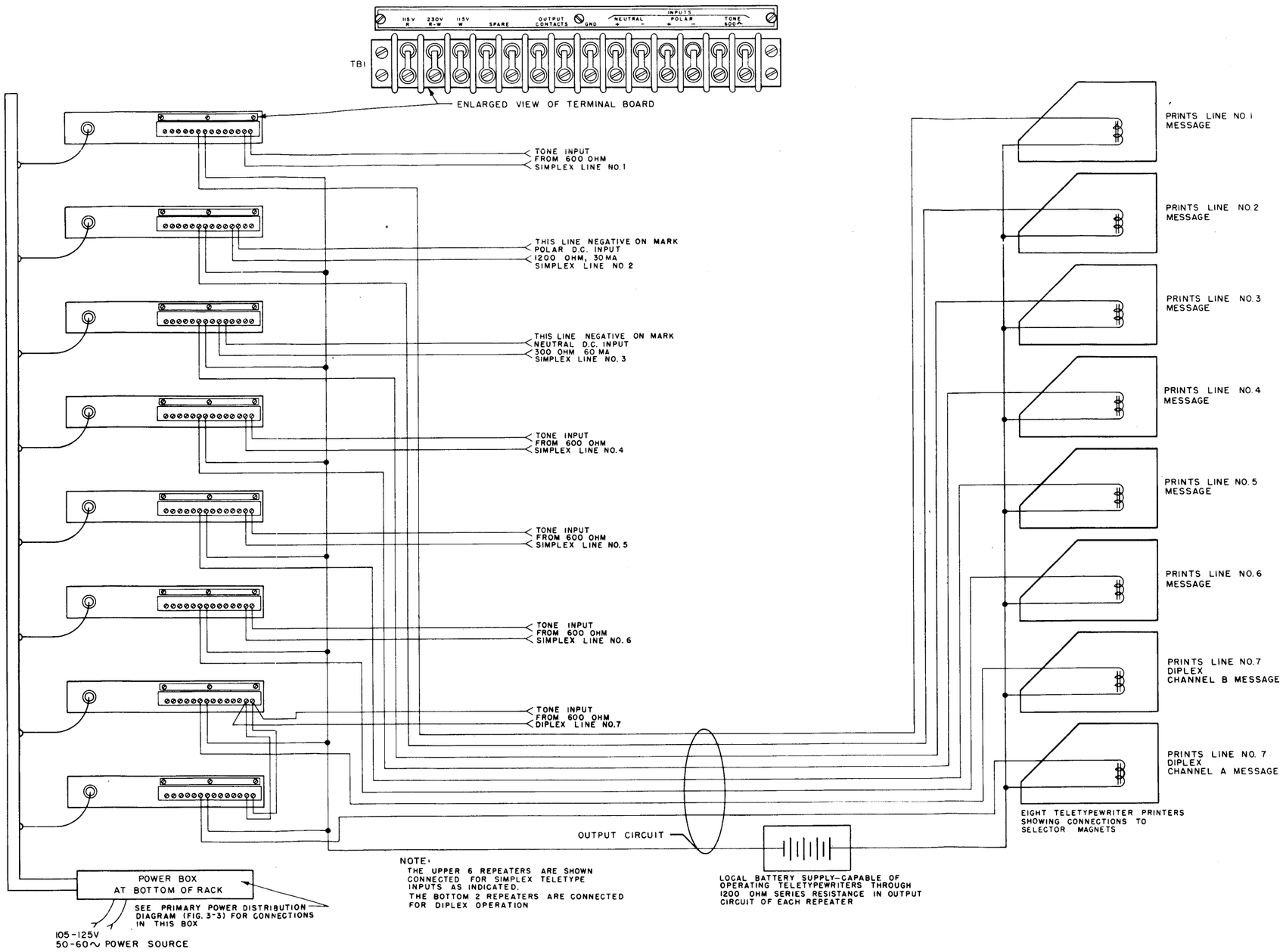


Figure 3-5. Teletypewriter Repeater Set AN/FGC-7A Interconnecting Drawing

next to 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 and one in the stop mark. This represents the correct adjustments for the RANGE and SPEED controls.

(13) Set the OSCILLOSCOPE selector switch to the OUTPUT position and observe the output signal from the Repeater. 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 screwdriver the DISTORTION control until mark and space pulses are equal in length.

WARNING

When the oscilloscope monitor switch is in the OUTPUT position a dangerous potential may exist between the case of the oscilloscope and ground. Suitable precautionary measures should be taken.

(14) Connect a teletype printer to the MONITOR jack on the Repeater panel and check operation of the printer.

Note

The polarity of the MONITOR jack depends on the polarity of connection to the output terminals of the Repeater. The tip of the plug going into the MONITOR jack is normally negative and the shell positive. If battery connections are not as shown in Figure 3-5 the reverse polarity may apply at the MONITOR jack.

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.

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

(16) Rotate the Range control counterclockwise 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. Acurate speed adjustment of the Repeater is necessary before the RANGE control can be varied over its full range on a signal free of bias distortion. 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.

(17) Perform the above checks on each Repeater in the Teletypewriter Repeater Set AN/FGC-7A. After these installation checks, the equipment is ready for normal operation.

4. REMOTE INSTALLATION OF TELETYPEWRITER REPEATER TT-63A/FGC

In some cases it may be desirable to use a singl Repeater at a location remote from the Teletypewriter Repeater Set AN/FGC-7A. For such an installation the following steps are necessary:

a. Remove any wiring which may be connected to the terminal board at the rear of the Repeater in the rack.

b. Disconnect the Repeater power cord from the ac receptacle in the rack by pulling out the plug at the rack outlet.

c. Remove the four machine screws securing the Repeater panel to the rack.

d. Pull the Repeater out of the rack using the two handles on the Repeater panel.

e. Place the Repeater in the desired location remote from the rack. A position convenient for wiring would be advantageous.

f. Connect the ac power cord of the Repeater to a source of 115/230 volt 50/60 cycle power. An extension cord may be necessary for this operation as the power cable on the Repeater is short for rack installation.

g. Connect the teletype input line to the proper input terminals of the Repeater.

h. Connect the teletype output terminals to the teletype printer or output line as the case may be. As indicated in Figure 3-4, a suitable power supply must be connected in series with the Repeater output circuit and the teletype printer. If it is desired to send a keyed tone over a line from the Repeater, a tone generator may be connected in series with the Repeater output terminal and one side of the line. The grounded output terminal should connect to the other side of the line. Capacitor C33 (See Figure 7-2 for the location of capacitor C33) must be disconnected from the circuit for this type of operation.

i. Perform an operational check on the Repeater as outlined in Section 3-3*b*. The Repeater is now ready for normal operation.

SECTION 4
OPERATION

1. INTRODUCTION

The Teletype Repeater TT-63A/FGC should seldom require attention from the operator after the equipment is installed, checked, and adjusted as outlined in Section 3. While the adjustments of the Repeater 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 Repeater, or unless the speed or amplitude of the input signal changes.

2. CAPABILITIES AND LIMITATIONS

The Repeater 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 Repeater output. There are conditions which will cause faulty operation of the Repeater. 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 Repeater will be started by a following intelligence pulse and will print errors for a few characters until the Repeater 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 Repeater 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 Repeater 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 Repeater as outlined in Section 5-1.

3. OPERATION OF EACH FUNCTION

The Repeater 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 diplex teletype signals to single channel form for the operation of a teletype printer.

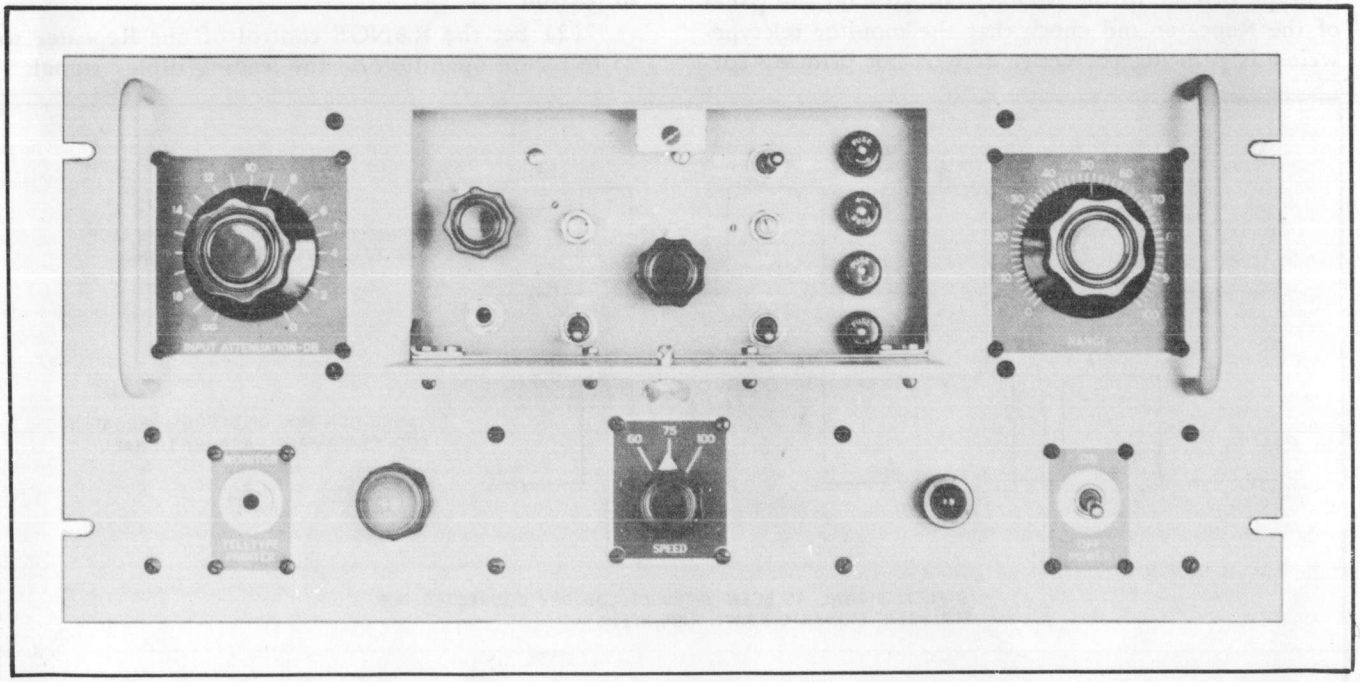


Figure 4-1. Teletypewriter Repeater TT-63A/FGC, Panel and Sub-Panel Controls

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

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

Note

The Repeater 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 Repeater 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 Repeater, more secure operation may be had by advancing the INPUT ATTENTUATOR 10 or 12 steps beyond the trigger point.

(3) Set the RANGE control of the Repeater to 50. The remote teletype printer to which the Repeater 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 Repeater 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 3-3*b* should be repeated.

(4) Rotate slowly the RANGE control of the Repeater 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 erors when set to 0, it is probable that the subpanel SPEED adjustment is incorrect. The SPEED adjustment should be checked as outlined in Section 3-3*b*.

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

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

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

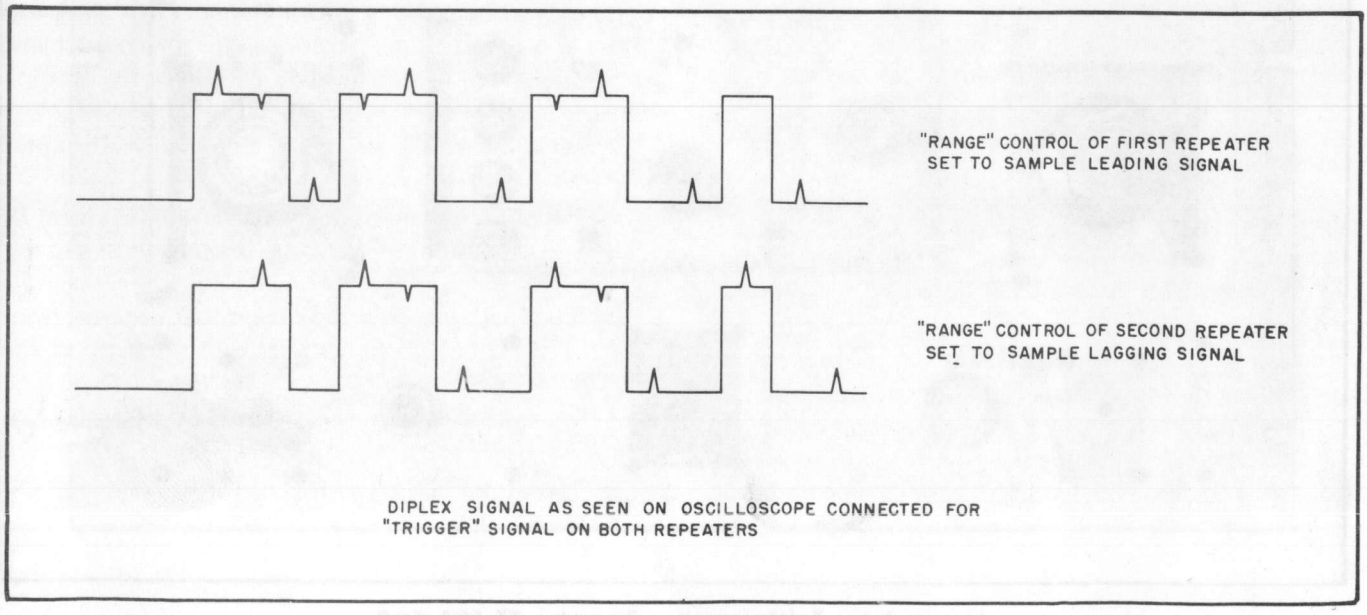


Figure 4-2. Oscilloscope Patterns, Display Operation

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

(4) Connect a monitor teletype printer to the MONITOR jack of the first Repeater. Observe that printing is correct. Rotate the RANGE control of the first Repeater 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 MONITOR jack of the second Repeater. Observe that printing is correct. Rotate the RANGE control of the second Repeater 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 Repeater 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 Repeater. 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 Repeater is adjusted to sample the leading diplex signal and the second Repeater is sampling the lagging diplex signal.

(c) Adjust the RANGE control of the Repeater 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 next to 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.

WARNING

When the oscilloscope monitor switch is in the OUTPUT position a dangerous potential may exist between the case of the oscilloscope and ground. Suitable precautionary measures should be taken.

(e) Repeat the above steps *(a)*, *(b)*, *(c)*, and *(d)* for the second Repeater 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 Repeater 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 Repeater to coincide with the speed of the incoming signal.

b. Operate the Repeater as outlined in Section 4-4*a*. It is probable that slight readjustments of the sub-panel SPEED control and DISTORTION control will be necessary as outlined in Section 3-3*b*.

5. SELECTING OUTPUT

The desired type of output operation may be secured by setting the NORMAL-MARK HOLD toggle switch. Operation during a signal will be the same for either position but on steady states the NORMAL position provides an output which is the same as the steady input state. On MARK-HOLD the output will stay on mark for either mark or space steady input.

6. SUMMARY OF OPERATION

The following summary describes briefly the operation of the Repeater.

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 Repeater to 25 and the RANGE control of the second Repeater 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. Set the NORMAL-MARK HOLD toggle switch for the desired type of output operation.

g. Turn the POWER switch of the Repeater to OFF to stop the unit.

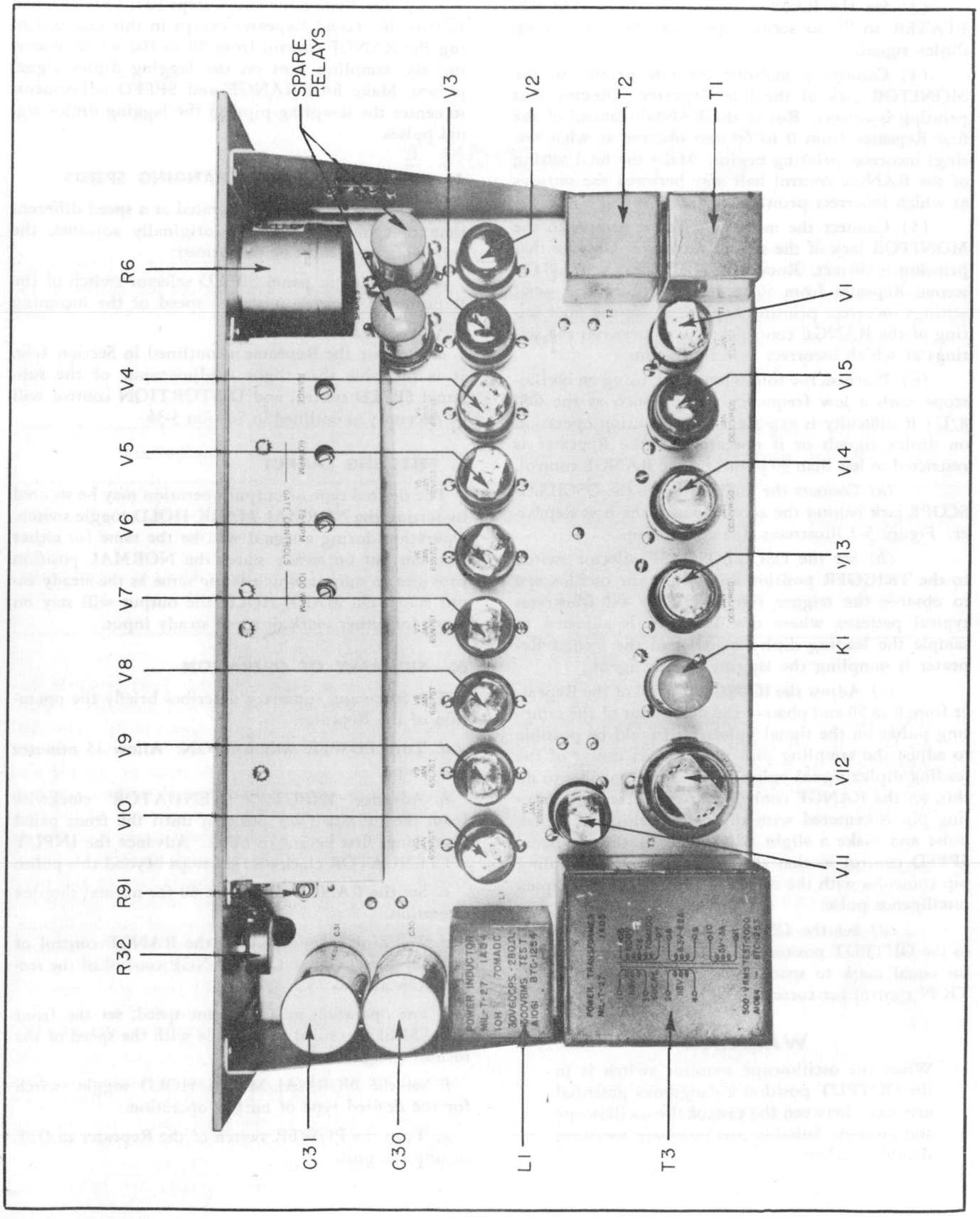


Figure 5-1. Teletypewriter Repeater TT-63A/FGC, Tube Locations

SECTION 5
OPERATOR'S MAINTENANCE

1. ROUTINE CHECK CHART

Table 5-1 illustrates routine checks which should be made on the Repeater daily using an oscilloscope with a low frequency sweep, similar to the OS-8/U. Such checks will assure that the Repeater is in optimum adjustment. They will also disclose the quality of the signals applied to the Repeater and delivered from the Repeater.

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.

WARNING

When the oscilloscope monitor switch is in the OUTPUT position a dangerous potential may exist between the case of the oscilloscope and ground. Suitable precautionary measures should be taken.

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.

CAUTION

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 the Teletypewriter Repeater Set AN/FGC-7A rack would normally be indicated by the failure of all pilot lamps in the individual Repeaters to be on when all power switches are turned on. The back door of the rack must be opened and the main power switch and two 15 ampere screw-in type fuses in the power box at the bottom of the rack must be checked in event of complete lack of power.

(b) Fuse failure in an individual Repeater would normally be indicated by failure of the pilot lamp to be on when the power switch is turned on. Electron tubes in the Repeater would not be lighted. The two 1½ ampere ACTIVE fuses behind the access door of the Repeater 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 Repeater. 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 Repeater may be caused by defective tubes V1, V2, V3, or V4 or a defective neon lamp T2. The neon lamp may be removed from the front of the Repeater by unscrewing the jewel and unplugging the bayonet type lamp.

If the neon lamp does blink when signals are ap-

plied to the input of the Repeater, and all tubes are lighted, the relay K1 may be replaced by the spare relay mounted on the Repeater chassis behind the Input Level control. All tubes and relays in the Repeater plug in to standard octal sockets.

(b) All electron tubes in the Repeater are accessible from the rear of the rack. One tube clamp is used in each Repeater to hold the rectifier tube V12. Pressure on this clamp may be relieved by finger or screw driver to remove the 5U4G tube from its socket.

Note

If tubes are removed from the Repeater 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 Repeater controls. Tubes may be tested in a standard tube tester such as Tube Tester TV-3/U Series for quality.

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.

Note

The attention of maintenance personnel is invited to the Requirements of Chapter 67 of the *Bureau of Ships Manual,* of the latest issue.

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 subpanel 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 subpanel 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 subpanel 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 b 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 tester such as Tube Tester TV-3/U Series.	Replace tubes in same sockets from which removed. Check adjustment of controls if new tubes are put in Repeater.

WARNING

When the oscilloscope monitor switch is in the OUTPUT position a dangerous potential may exist between the case of the oscilloscope and ground. Suitable precautionary measures should be taken.

FAILURE REPORTS

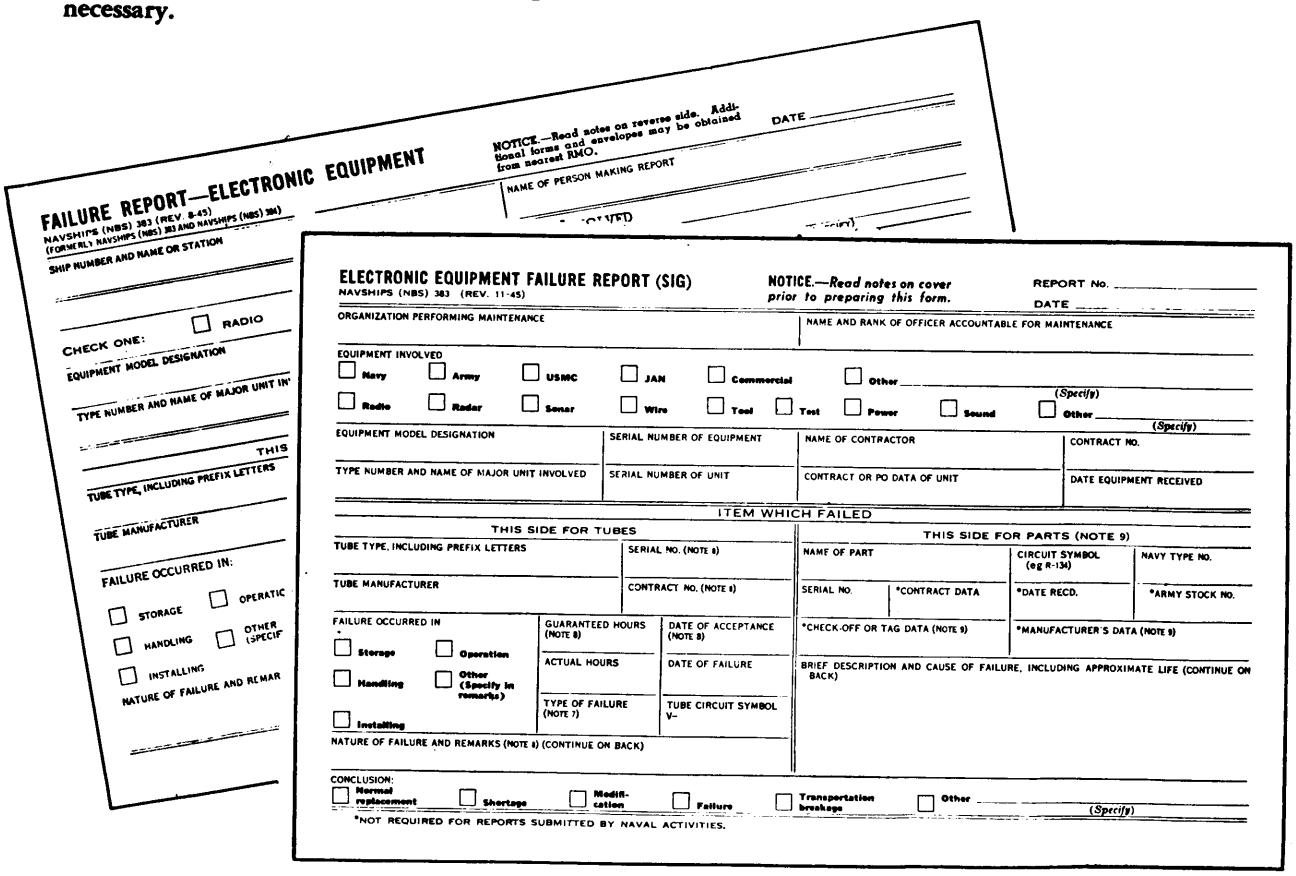
A FAILURE REPORT must be filled out for the failure of any part of the equipment whether caused by defective or worn parts, improper operation, or external influences. It should be made on Failure Report form NAVSHIPS-383, which has been designed to simplify this requirement. The card must be filled out and forwarded to BUSHIPS. Full instructions are to be found on pages interlaced with each pad of report cards.

Use great care in filling the card out to make certain it carries adequate information. For example, under "Circuit Symbol" use the proper circuit identification taken from the schematic drawings, such as T-803 in the case of a transformer, or R-207, for a resistor. Do not substitute brevity for clarity. Use the back of the card to completely describe the cause of failure. Attach an extra piece of paper if necessary.

The purpose of this report is to inform BUSHIPS of the cause and rate of failures. The information is used by the Bureau in the design of future equipment and in the maintenance of adequate supplies to keep the present equipment going. The cards you send in, together with those from hundreds of other ships, furnish a store of information permitting the Bureau to keep in touch with the performance of the equipment of your ship and all other ships of the Navy.

This report is not a requisition. You must request the replacement of parts through your Officer-in-Charge in the usual manner.

Make certain you have a supply of Failure Report cards and envelopes on board. They may be obtained from the nearest District Publications and Printing office.



FAILURE REPORT—ELECTRONIC EQUIPMENT
NAVSHIPS (NBS) 383 (REV. 8-45)
(FORMERLY NAVSHIPS (NBS) 383 AND NAVSHIPS (NBS) 384)
NOTICE.—Read notes on reverse side. Additional forms and envelopes may be obtained from nearest RMO.
DATE
NAME OF PERSON MAKING REPORT
SHIP NUMBER AND NAME OR STATION
CHECK ONE: RADIO
EQUIPMENT MODEL DESIGNATION
TYPE NUMBER AND NAME OF MAJOR UNIT IN
THIS
TUBE TYPE, INCLUDING PREFIX LETTERS
TUBE MANUFACTURER
FAILURE OCCURRED IN:
STORAGE OPERATIC
HANDLING OTHER (SPECIF
INSTALLING
NATURE OF FAILURE AND REMAR

ELECTRONIC EQUIPMENT FAILURE REPORT (SIG)
NAVSHIPS (NBS) 383 (REV. 11-45)
NOTICE.—Read notes on cover prior to preparing this form.
REPORT No.
DATE
ORGANIZATION PERFORMING MAINTENANCE
NAME AND RANK OF OFFICER ACCOUNTABLE FOR MAINTENANCE
EQUIPMENT INVOLVED
Navy Army USMC JAN Commercial Other (Specify)
Radio Radar Sonar Wire Tool Test Power Sound Other (Specify)
EQUIPMENT MODEL DESIGNATION
SERIAL NUMBER OF EQUIPMENT
NAME OF CONTRACTOR
CONTRACT NO.
TYPE NUMBER AND NAME OF MAJOR UNIT INVOLVED
SERIAL NUMBER OF UNIT
CONTRACT OR PO DATA OF UNIT
DATE EQUIPMENT RECEIVED
ITEM WHICH FAILED
THIS SIDE FOR TUBES
TUBE TYPE, INCLUDING PREFIX LETTERS
SERIAL NO. (NOTE 8)
TUBE MANUFACTURER
CONTRACT NO. (NOTE 8)
FAILURE OCCURRED IN
Storage Operation
Handling Other (Specify in remarks)
Installing
GUARANTEED HOURS (NOTE 8)
DATE OF ACCEPTANCE (NOTE 8)
ACTUAL HOURS
DATE OF FAILURE
TYPE OF FAILURE (NOTE 7)
TUBE CIRCUIT SYMBOL V-
NATURE OF FAILURE AND REMARKS (NOTE 6) (CONTINUE ON BACK)
THIS SIDE FOR PARTS (NOTE 9)
NAME OF PART
CIRCUIT SYMBOL (eg R-134)
NAVY TYPE NO.
SERIAL NO.
*CONTRACT DATA
*DATE RECD.
*ARMY STOCK NO.
*CHECK-OFF OR TAG DATA (NOTE 9)
*MANUFACTURER'S DATA (NOTE 8)
BRIEF DESCRIPTION AND CAUSE OF FAILURE, INCLUDING APPROXIMATE LIFE (CONTINUE ON BACK)
CONCLUSION:
Normal replacement Shortage Modification Failure Transportation breakage Other (Specify)
*NOT REQUIRED FOR REPORTS SUBMITTED BY NAVAL ACTIVITIES.

Figure 7-1. Failure Report, Sample Form

SECTION 7
CORRECTIVE MAINTENANCE

1. SYSTEM TROUBLE SHOOTING

The Teletypewriter Repeater Set AN/FGC-7A consists of eight individual Teletypewriter Repeaters TT-63A/FGC. Each Repeater has its own input and output connections and works as a completely separate unit in the rack. For this reason the only system trouble shooting that may be involved will be with regard to an individual Repeater and its input and output circuits. Test equipment similar to oscilloscope OS-8/U, Multimeter TS-352/U, and Electronic Multimeter ME-25/U Series may be used.

a. INPUT CIRCUITS — If the neon lamp on the front panel of the Repeater does not blink when the Repeater 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 Repeater. The input voltage to the Repeater should be checked with an oscilloscope or suitable meter.

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

(1) Check that the output power supply is operating properly and that output circuit wiring is in accord with Figure 3-5, Interconnecting Drawing.

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

(3) Check the signal voltage at the output terminals of the Repeater with an oscilloscope or dc meter. If no signal voltage is found here, the Repeater 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 Teletypewriter Repeater TT-63A/FGC is illustrated in Table 7-1.

The 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 7-4, which illustrates wave form 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 7-4 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 Table 7-2, Voltage and Resistance Chart. The values of voltage and resistance tabulated in Tabe 7-2 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.

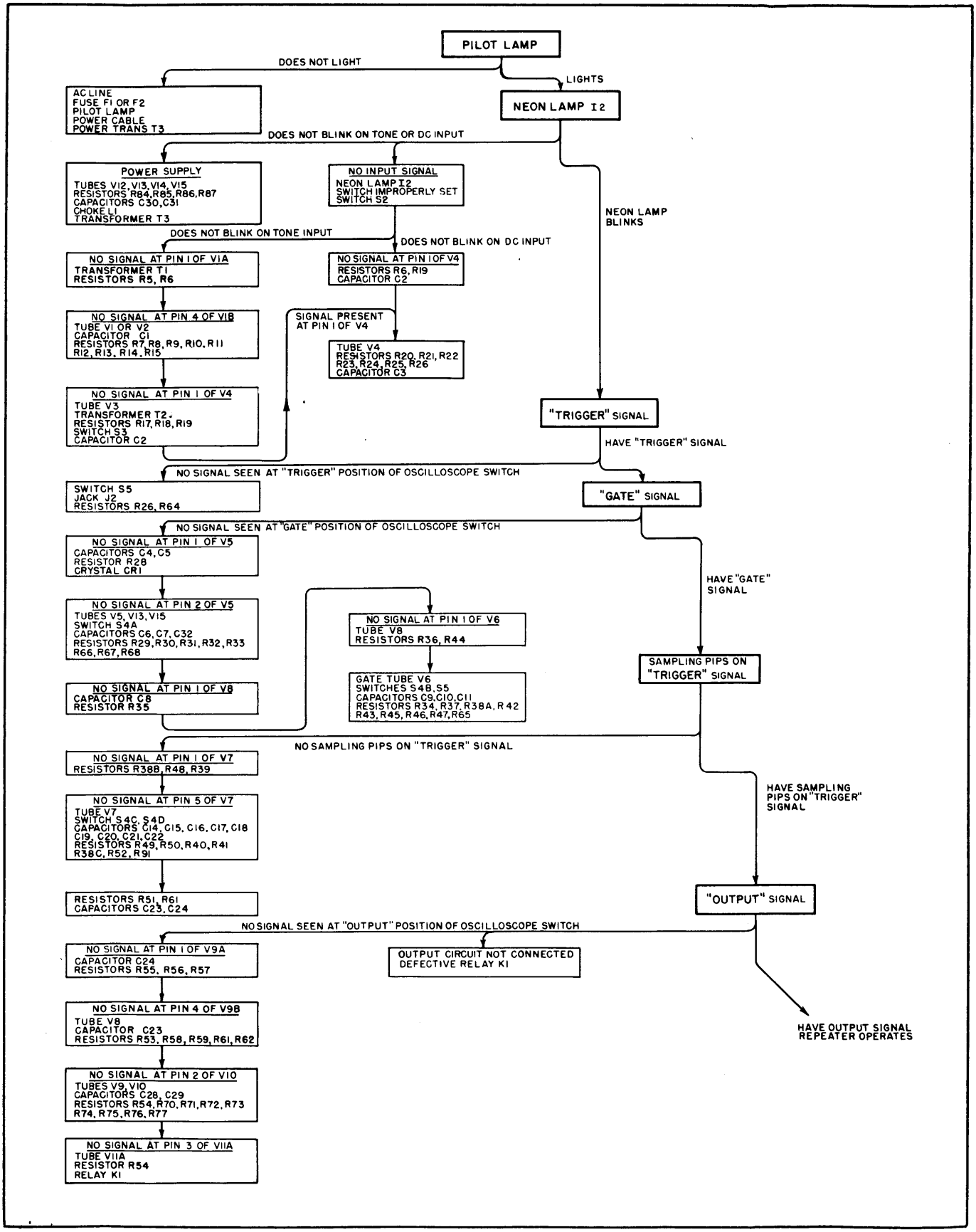
b. REPAIR.

(1) ELECTRICAL ADJUSTMENTS — The adjustments of all front panel and sub-panel controls of the Repeater are described in Section 3-3*b*. Failure to secure proper operation of the Repeater when all circuit components, voltages, and signals appear normal is probably due to misadjustment of sub-panel controls or to improper setting of variable resistors R42, R47, R65, or lag control R66 located at the back-top of the sub-panel. These adjustments are available if the Repeater is pulled forward about two inches out of the rack (See Figure 5-1.)

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

(b) Improper settings of variable resistors R42, R47, or R65 will be in evidence if less than seven positive samplings pips are observed on the oscilloscope during the adjustment of the sub-panel SPEED control. Variable resistor R42 provides adjustment for this condition at 60 wpm speed, R47 at 75 wpm speed, and R65 at 100 wpm speed. If there are only six positive sampling pips seen (none in the stop mark), the shaft of the variable resistor corresponding to the speed of operation should be rotated clockwise by means of a screwdriver beyond the point where the seventh pip first appears until a negative pip appears about one-half pulse duration (11 ms for 60 wpm operation) beyond the last positive pip. The control should not be rotated clockwise beyond the point where this negative pip appears. If there are more than seven sampling pulses, operation of the gate-multivibrator cycle will be erratic causing lack of synchronization

TABLE 7-1. TROUBLE SHOOTING CHART



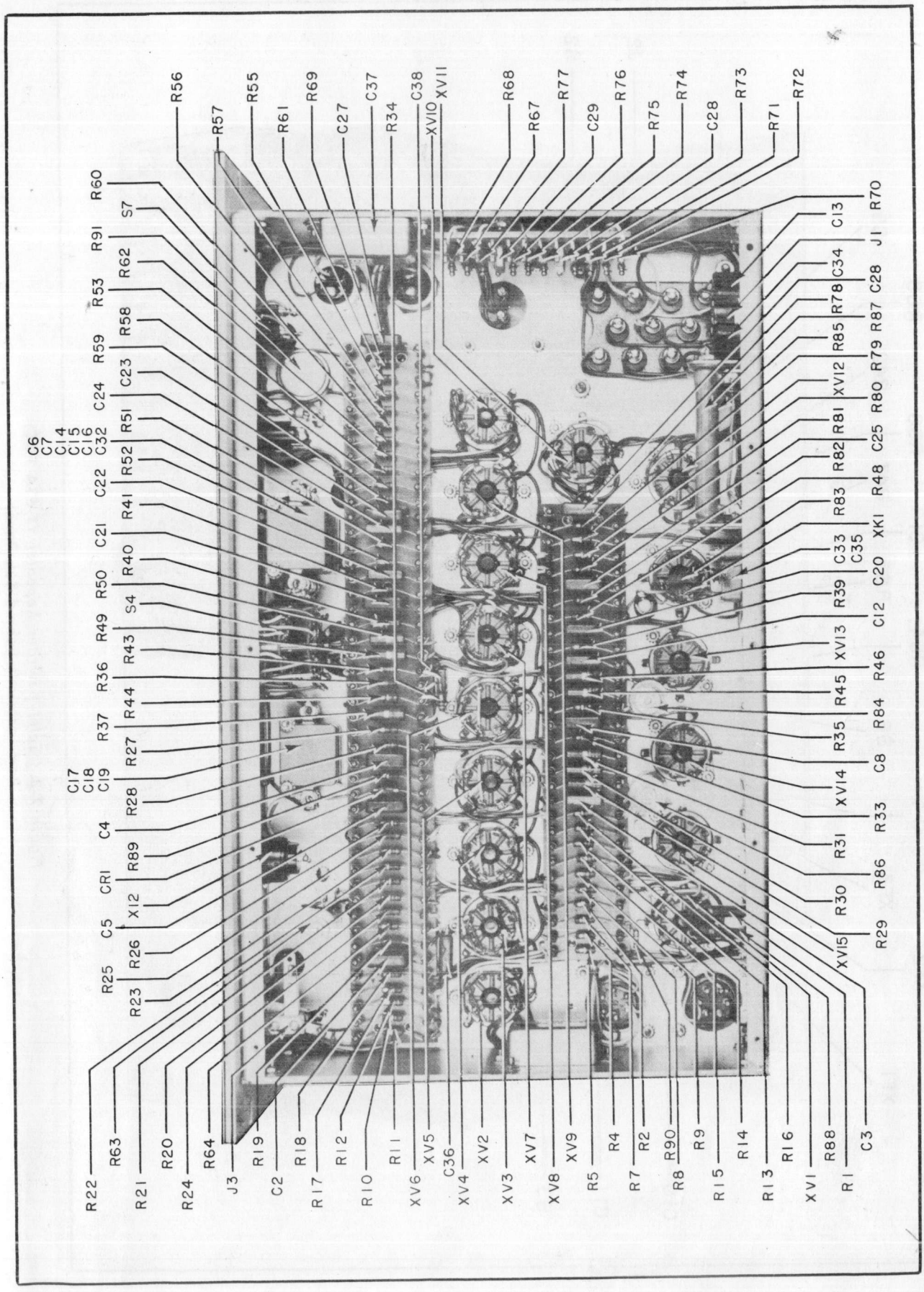


Figure 7-2. Teletypewriter Repeater TT-63A/FGC, Part Locations Below Chassis

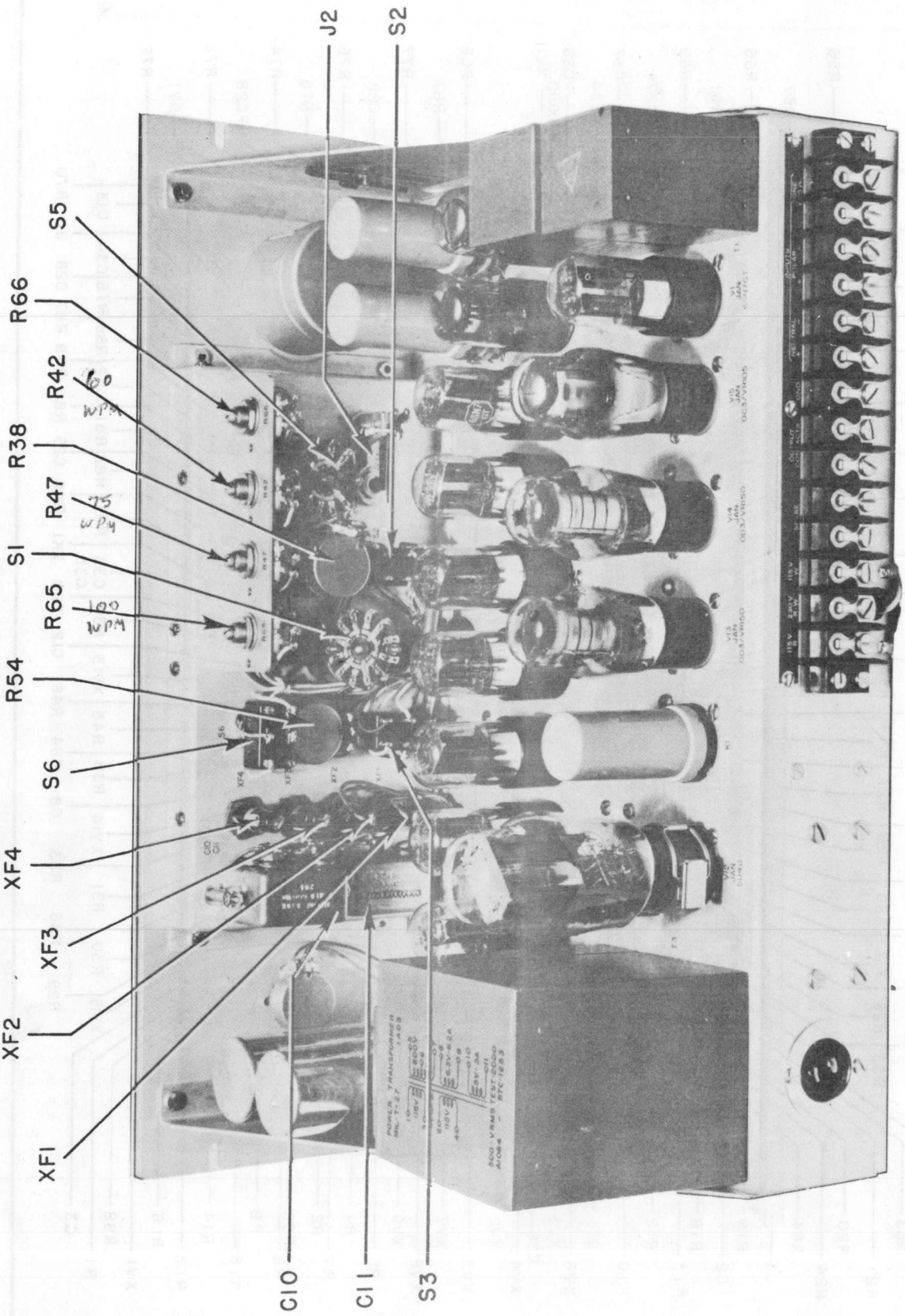
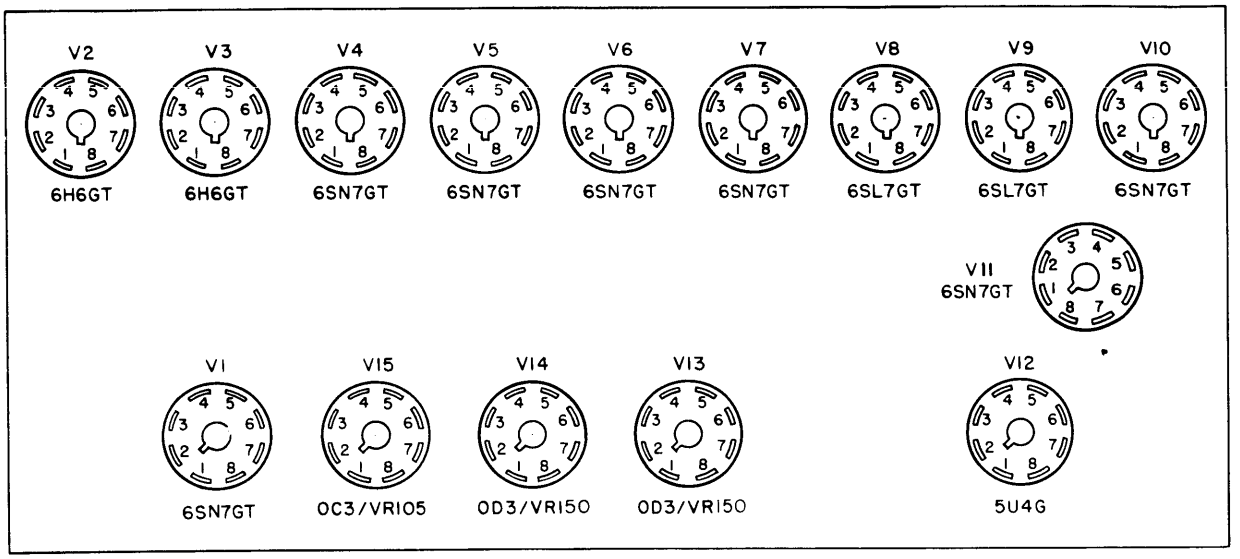


Figure 7-3. Teletypewriter Repeater TT-63A FGC, Part Locations Behind Sub-Panel

TABLE 7-2. VOLTAGE AND RESISTANCE CHART

TUBE LAYOUT



(BOTTOM VIEW)

TABLE 7-2 VOLTAGE AND RESISTANCE CHART

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	27K	46	132K	1.8	1.8K	1.2	178K	145	35K	6.4V	1.2K	0	0	♦ 6.2	0	6SN7GT
V2	0	0	♦ 6.2	0	.8	275K	1.0	96K	.8	275K	0	∞	0	0	1.1	185K	6H6GT
V3	0	0	♦ 6.2	0	-.8	130K	0	1.1K	-.8	130K	0	∞	0	0	0	1K	6H6GT
V4	-.5	850K	27	220K	.7	1.6K	-28	310K	76	135K	.7	1.6K	0	0	♦ 6.2	0	6SN7GT
V5	37	1.3M	148	45K	51	12.7K	50	2.2M	105	44K	51	12.7K	0	0	♦ 6.2	0	6SN7GT
V6	31	56K	140	62K	41	8.5K	41	7M	100	43K	41	8.5K	0	0	♦ 6.2	0	6SN7GT
V7	36	610K	148	56K	53	♦♦♦ 18K	53	730K	90	56K	53	♦♦♦ 18K	0	0	♦ 6.2	0	6SN7GT
V8	18	510K	148	33K	32	56K	-.1	1M	39	94K	0	0	0	0	♦ 6.2	0	6SL7GT
V9	-20	390K	148	40K	.5	242K	-49	330K	148	40K	-23	235K	0	0	♦ 6.2	0	6SL7GT
V10	.5	250K	4.6	112K	0	0	-22	235K	102	143K	0	0	0	0	♦ 6.2	0	6SN7GT
V11	-18	270K	148	40K	0	4K	6	1.3M	148	40K	13.8	23K	0	0	♦ 6.2	0	6SN7GT
V12	0	∞	270	36K	0	∞	♦♦ 400	4.1K	0	∞	♦♦ 400	4.1K	0	∞	270	36K	5U4G
V13	0	∞	0	0	0	∞	0	∞	148	33K	0	∞	0	∞	0	∞	0D3/VR150
V14	0	∞	0	0	0	∞	0	∞	148	40K	0	∞	0	∞	0	∞	0D3/VR150
V15	0	∞	-109	68K	0	∞	0	∞	0	0	0	∞	0	∞	0	∞	0C3/VR105

NOTES—

1. MEASUREMENTS MADE WITH ELECTRONIC MULTIMETER WITH NO SIGNAL AT INPUT
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. 6) OF POWER TRANSFORMER
7. ♦♦♦ MAY VARY, DEPENDING ON SETTING OF R91
8. K = X 1,000
9. M = X 1,000,000

between the sampling pips and the signal. This condition may be corrected by rotating the appropriate gate control completely counterclockwise and then rotating clockwise to secure the negative pip beyond the seventh positive pip as previously described in this paragraph.

(c) Variable resistor R66 may be set to adjust the extent of range of the front panel RANGE control. With the RANGE control set at its maximum clockwise setting and an undistorted test signal applied to the Repeater, adjust R66 until the sampling pip on the start pulse is close to the end of the start pulse (within 2 ms at 60 wpm). The sampling pip should now be close to the center of the start pulse when the RANGE control is set to 50.

(d) Variable resistor R91 in the Repeater is used

TABLE 7-3. TUBE OPERATING VOLTAGES & CURRENTS

TUBE TYPE	SYMBOL DESIG.	FUNCTION	PLATE (E)	PLATE (MA)	CATHODE (E)	GRID (E)	HEATER (E) AC
6SN7 GT	V1A	1st Audio Amplifier	46	1	1.8	0	6.2
	V1B	2nd Audio Amplifier	145	2.9	6.4	1.2	
6H6 GT	V2A	Series Limiter (input sect.)	.8	.01	1.0	—	6.2
	V2B	Series Limiter (output sect.)	.8	.006	1.1	—	
6H6 GT	V3A	Full Wave Rectifier	—.8	0	0	—	6.2
	V3B		—.8	.004	0	—	
6SN7 GT	V4A	Trigger (input sect.)	27	.4	.7	—.5	6.2
	V4B	Trigger (output sect.)	76	0	.7	—28	
6SN7 GT	V5A	Lag (input sect.)	148	0	51	37	6.2
	V5B	Lag (output sect.)	105	4	51	50	
6SN7 GT	V6A	Gate (input sect.)	140	0	41	31	6.2
	V6B	Gate (output sect.)	100	4.7	41	41	
6SN7 GT	V7A	Multivibrator (input sect.)	148	0	53	36	6.2
	V7B	Multivibrator (output sect.)	90	2.4	53	53	
6SL7 GT	V8A	False Start Gate	148	0	32	18	6.2
	V8B	Phase Inverter	39	.8	0	—.1	
6SL7 GT	V9A	Coincidence Gate	148	0	.5	—20	6.2
	V9B	Coincidence Gate	148	0	—23	—49	
6SN7 GT	V10A	Multivibrator	4.6	1.2	0	.5	6.2
	V10B	Multivibrator	102	0	0	—22	
6SN7 GT	V11A	Cathode Follower	148	0	0	—18	6.2
	V11B	Steady State Gate	148	.6	13.8	6	
5U4G	V12	Full Wave Rectifier	240 (AC)	64	—	—	5.0
OD3/ VR150	V13	Voltage Regulator	148	17	—	—	—
OD3/ VR150	V14	Voltage Regulator	148	21	—	—	—
OC3/ VR105	V15	Voltage Regulator	—108	19	—	—	—

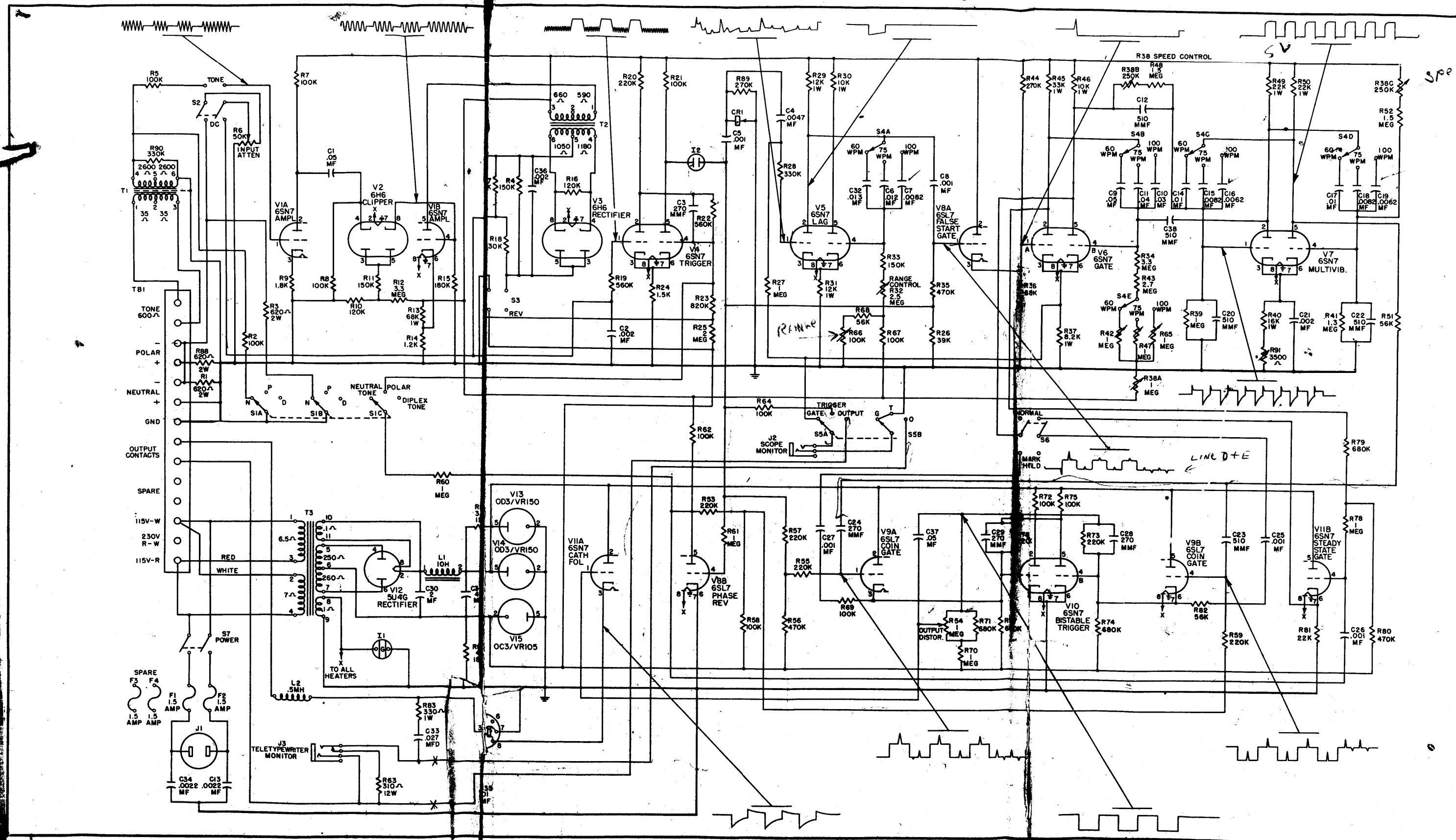


Figure 7-4. Teletypewriter Repeater TT-63A/FGC, Sch matic Diagram

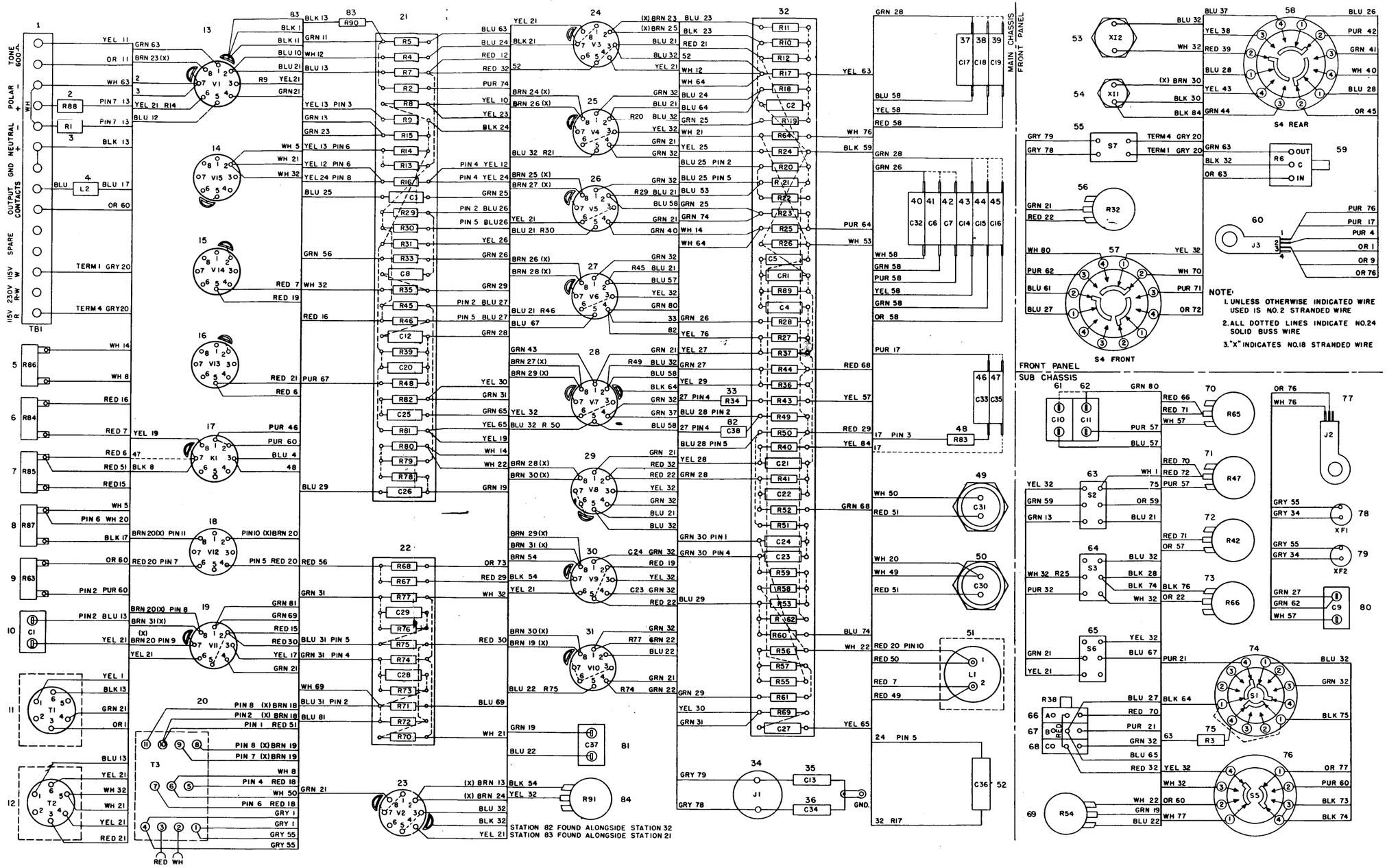


Figure 7-5. Teletypewriter Repeater TT-63A/FGC, Wiring Diagram

to set the sub-panel SPEED control at the center of its range. This control is located to the right of the sub-panel on the main chassis and is available when the Repeater is pulled forward about two inches out of the rack. (See Figure 5-1.) To adjust this control, the sub-panel SPEED control should be set to the center of its range and control R91 adjusted with a screwdriver until the next to last sampling pip is set to the center of the last teletype intelligence pulse. Readjustment of variable gate resistors R42, R47, and R65 will probably be required if any adjustment is made on R91.

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

(a) REMOVAL AND REPAIR — Since nearly all small parts in the Repeater are mounted under the chassis on terminal boards, the replacement of these parts is readily performed. In replacing more complicated parts such as the SPEED selector switch S4, the Wiring Diagram, Figure 7-7 should be closely followed in rewiring the replacement part.

(3) COMPONENT CHARACTERISTICS.

(a) ELECTRON TUBES — Normal operating currents and voltages of all tubes in the Repeater are shown in Table 7-3. Table 7-4 lists the Tube Characteristics for tubes used in the Repeater.

(b) RELAY CHARACTERISTICS — Charact r-istics of the Western Electric relay K1 used in the Repeater are listed in Table 7-5.

(4) DRAWINGS.

(a) SCHEMATIC DIAGRAM — The Schematic Diagram of the Repeater is illustrated in Figure 7-4. Voltage measurements, resistance values and waveforms are shown on this diagram for convenient servicing.

(b) WIRING DIAGRAM — Th Wiring Diagram of the Repeater is illustrated in Figure 7-5. Routing of all wires to various parts in the equipment is illustrated.

TABLE 7-4. TUBE CHARACTERISTICS

TUBE TYPE	FILAMENT VOLTAGE (V)	FILAMENT CURRENT (A)	PLATE VOLTAGE (V)	GRID BIAS (V)	PLATE CURRENT (A)	AC PLATE RESISTANCE (Ohms)	VOLTAGE AMPLIFICATION FACTOR (MU)	TRANSCONDUCTANCE (Micromhos)		EMISSION	
								NORMAL	MINIMUM	IS (MA)	TEST VOLT
Each Sect. 6SN7GT	6.3	0.6	250	—8	9	7700	20	2600	2000	40	30
6H6GT 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.						
OC3/VR105			105		5 Min. 30 Max.						

TABLE 7-5. RELAY CHARACTERISTICS

RELAY TYPE	COIL RESISTANCE (Ohms)	OPERATE CURRENT WINDINGS SERIES AIDING	RELEASE CURRENT WINDINGS SERIES AIDING	CONTACT RATING (Watts)	MOUNTING
275B	4000 ±10%	.008	.0035	20	Octal Socket — Vertical Position

SECTION 8
PARTS LIST

TABLE 8-1. WEIGHTS AND DIMENSIONS OF SPARE PARTS BOXES

EQUIPMENT SPARES						STOCK SPARES					
SPARE PARTS BOX	OVERALL DIMENSIONS			VOL-UME	WEIGHT	SPARE PARTS BOX	OVERALL DIMENSIONS			VOL-UME	WEI HT
	HEIGHT	WIDTH	DEPTH				HEIGHT	WIDTH	DEPTH		

TABLE 8-2. SHIPPING WEIGHTS AND DIMENSIONS OF SPARE PARTS BOXES

EQUIPMENT SPARES							STOCK SPARES						
SHIP-PING BOX NUM-BER	SPARE PARTS BOX	OVERALL DIMENSIONS			VOL-UME	WEIGHT	SHIP-PING BOX NUM-BER	SPARE PARTS BOX	OVERALL DIMENSIONS			VOL-UME	WEI HT
		HEIGHT	WIDTH	DEPTH					HEIGHT	WIDTH	DEPTH		

TABLE 8-3. LIST OF MAJOR UNITS

SYMB L GROUP	NAME OF MAJOR UNIT	NAVY TYPE DESIGNATION
	RACK MOUNTING CABINET — A unit of Teletypewriter Repeater Set AN/FGC-7A.	CY-614/G
1 - 100	TELETYPEWRITER REPEATER — A unit of Teletypewriter Repeater Set AN/FGC-7A.	TT-63A/FGC

TABLE 8-4. TABLE OF REPLACEABLE PARTS

REF. DESIG.	STOCK NUMBERS: SIGNAL CORPS STANDARD NAVY AIR FORCE	NAME AND DESCRIPTION	LOCATING FUNCTIONS	JAN AND (NAVY TYPE) NO.	MANUFACTURER AND MFGRS. DESIGNATION	CONTRACTOR DWG. AND PART NO.	ALL SYMBOL DESIG. INVOLVED
C1		Capacitor, fixed: paper dielectric; single section; 50,000 mmfd ± 5%; 600 vdcw; hermetically sealed metal case; 1-3/4" lg x 1" wd x 3/4" h; mineral oil filled and impregnated; two rivet lug terminals located on side; no internal ground connection; two mtg feet w/ 3/16" dia hole in ea on 2-1/8" cntrs.	V1A-V2 coupling		Aerovox type 630M	B2073	C1, C9, C37
C2	N16-C-31797-5533	Capacitor, fixed: JAN type, Spec. JAN-C-5; 53/64" lg; 53/64" wd; 11/32" thk; mounts by terminals.	V3 output filter	CM35C202J	Sangamo #CR-1220		C2, C21, C36
C3	N16-C-29613-2671	Capacitor, fixed: JAN type, Spec. JAN-C-5; 51/64" lg; 15/32" wd; 7/32" thk; mounts by terminals.	V4A-V4B coupling	CM20A271K	Sangamo #KR-1327		C3, C24, C28, C29
C4	N16-C-32646-6813	Capacitor, fixed: JAN type, Spec. JAN-C-5; 53/64" lg; 53/64" wd; 11/32" thk; mounts by terminals.	I2-V5 coupling	CM35C472K	Sangamo #CR-1247		C4
C5	N16-C-31096-4213	Capacitor, fixed: JAN type, Spec. JAN-C-5; 53/64" lg; 53/64" wd; 11/32" thk; mounts by terminals.	I2-V5 coupling	CM35C102K	Sangamo #CR-1210		C5, C8, C25, C26, C27
C6	N16-C-33802-4176	Capacitor, fixed: JAN type, Spec. JAN-C-5; 1-1/4" lg; 1-1/8" wd; 29/64" thk; two .144" dia mtg holes spaced 1.312" c-c.	V5 timing (75 wpm)	CM50B123J	Sangamo #H-1112		C6
C7	N16-C-33274-8076	Capacitor, fixed: JAN type, Spec. JAN-C-5; 1-1/4" lg; 1-1/8" wd; 23/64" thk; two .144" dia mtg holes spaced 1.312" c-c.	V5 timing (100 wpm)	CM45B822J	Sangamo #H-1282		C7, C15, C18
C8		Same as C5.	V5A-V8A coupling				
C9		Same as C1.	V6 timing (60 wpm)				
C10		Capacitor, fixed: paper dielectric; single section; 30,000 mmfd ± 5%; 600 vdcw; hermetically sealed metal case; 1-3/4" lg x 1" wd x 3/4" h; mineral oil filled and impregnated; two rivet lug terminals located on side; no internal ground connection; two mtg feet w/ 3/16" dia hole in ea on 2-1/8" cntrs.	V6 timing (100 wpm)		Aerovox type 630M	B2075	C10

REF. DESI.	STOCK NUMBERS: SIGNAL CORPS STANDARD NAVY	NAME AND DESCRIPTION	LOCATIN FUNCTIONS	JAN AND (NAVY TYPE) NO.	MANUFACTURER AND MF RS. DESI NATION	CONTRACTOR DWG. AND PART N.	ALL SYMBOL DESIG. INVOLVED
C11		Capacitor, fixed: paper dielectric; single section; 40,000 mmfd ± 5%; 600 vdcw; hermetically sealed metal case; 1-3/4" lg x 1" wd x 3/4" h; mineral oil filled and impregnated; two rivet lug terminals located on side; no internal ground connection; two mtg feet w/ 3/16" dia hole in ea on 2-1/8" cntrs.	V6 timing (75 wpm)		Aerovox type 630M	B2074	C11
C12	N16-C-30188-5133	Capacitor, fixed: JAN type, Spec. JAN-C-5; 53/64" lg; 53/64" wd; 11/32" thk; mounts by terminals.	V6B-V7A coupling	CM35C511J	Sangamo #CR-1351		C12, C20, C22, C23, C38
C13	N16-C-31908-1608	Capacitor, fixed: JAN type, Spec. JAN-C-5; 53/64" lg; 53/64" wd; 11/32" thk; mounts by terminals.	RF filter on ac line	CM35B222K	Sangamo #CR-1222		C13, C34
C14	N16-C-33617-7276	Capacitor, fixed: JAN type, Spec. JAN-C-5; 1-1/4" lg; 1-1/8" wd; 23/64" thk; two .144" dia mtg holes spaced 1.312" c-c.	V7 timing (60 wpm)	CM45B103J	Sangamo #H-1110		C14, C17, C35
C15		Same as C7.	V7 timing (75 wpm)				
C16	N16-C-32905-5476	Capacitor, fixed: JAN type, Spec. JAN-C-5; 1-1/4" lg; 1-1/8" wd; 23/64" thk; two .144" dia mtg holes spaced 1.312" c-c.	V7 timing (100 wpm)	CM45B622J	Sangamo #H-1262		C16, C19
C17		Same as C14.	V7 timing (60 wpm)				
C18		Same as C7.	V7 timing (75 wpm)				
C19		Same as C16.	V7 timing (100 wpm)				
C20		Same as C12.	V7A grid loading				
C21		Same as C2.	V7 cathode bypass				
C22		Same as C12.	V7B grid loading				
C23		Same as C12.	V7B-V9B coupling				
C24		Same as C3.	V7B-V9A coupling				
C25		Same as C5.	V9B cathode				
C26		Same as C5.	V8B-V11B coupling				
C27		Same as C5.	V9A cathode				
C28		Same as C3.	V10A-V10B coupling				

C29		Same as C3.	V10B-V10A coupling				
C30	N16-C-49221-9953	Capacitor, fixed: JAN type, Spec. JAN-C-25; 4-1/2" lg; 1-1/2" dia; mounts by bushing 1/2" lg; 3/4"-16.	B+ input filter	CP41B1DG205V	Aerovox type 1010		C30
C31	N16-C-49981-9991	Capacitor, fixed: JAN type, Spec. JAN-C-25; 4-1/2" lg; 1-1/2" dia; mounts by bushing 1/2" lg; 3/4"-16.	B+ output filter	CP41B1DF405V	Aerovox type 610		C31
C32	N16-C-33881-5376	Capacitor, fixed: JAN type, Spec. JAN-C-5; 1-1/4" lg; 1-1/8" wd; 29/64" thk; two .144" dia mtg holes spaced 1.312" c-c.	V5 timing (60 wpm)	CM50B133J	Sangamo #H-1113		C32
C33	N16-C-34672-8376	Capacitor, fixed: JAN type, Spec. JAN-C-5; 1-1/4" lg; 1-1/8" wd; 29/64" thk; two .144" dia mtg holes spaced 1.312" c-c.	K1 contact noise suppressor	CM50B273J	Sangamo #H-56844		C33
C34		Same as C13.	RF filter on ac line				
C35		Same as C14.	K1 contact noise suppressor				
C36		Same as C2.	V3 plate				
C37		Same as C1.	V10A-V11A coupling				
C38		Same as C12.	V7A-V6B coupling				
CR1	N16-T-51743	Crystal unit, rectifying: type 1N43; germanium; phenolic shell body, nickel plated brass ends; max ave forward current, 40 ma, max peak sine wave forward current, 125 ma, max allowable reverse voltage 60 v; cylindrical shape; 1/2" lg overall x .24" dia; two wire leads 1-3/8" lg; polarity marked on phenolic shell.	Shunts negative pulses across R89.		W. E. #400A	B2076	CR1
E1		Knob, octagonal: phenolic; black; accomodates round shaft 1/4" dia; 3/4" deep shaft hole; two #10-32 set screws; brass insert; white indicator line; 2-1/16" dia, 27/32" thk.	Knob for R6		H-D #4108-B	B2093	E1, E2
E2		Same as E1.	Knob for R32				
E3		Knob, octagonal: phenolic; black; accomodates round shaft 1/4" dia; 9/16" deep shaft hole; two set screws; brass insert; white arrow marking; 1-1/8" dia, 11/16" thk.	Knob for S5		H-D #4100-Z	B2094	E3, E4, E5
E4		Same as E3.	Knob for S1				

REF. DESIG.	STOCK NUMBERS: SIGNAL CORPS STANDARD NAVY AIR FORCE	NAME AND DESCRIPTION	LOCATIN FUNCTIONS	JAN AND (NAVY TYPE) NO.	MANUFACTURER AND MF RS. DESIGNATION	CONTRACTOR DWG. AND PART NO.	ALL SYMB L DESIG. INVOLVED
E5		Same as E3.	Knob for S4				
E6	N16-C-300798-866	Clamp, electrical: nickel plated steel; lever type fastening; 1-3/8" dia, 3/4" high; 1 mtg slot, 3/16" wd x 5/16" lg.	Clamp for V12		Birtcher type 926C	B2035	E6
F1		Fuse, cartridge: 1-1/2 amp; open in one hour at 135% load and in 25 sec at 200% load; rated continuous at 110% load; 250v; one time; glass tube body; round term; 1-1/4" lg; x 1/4" dia. overall.	Component protection		Buss AGC 1½ amp 250 v	B2077	F1, F2, F3, F4
F2		Same as F1.	Component protection				
F3		Same as F1.	Spare fuse				
F4		Same as F1.	Spare fuse				
I1	N17-L-6297	Lamp, incandescent: 6-8v; 1 w; bulb T-3-1/4 clear; 1-3/16" lg overall; miniature bayonet base; tungsten filament; burn any position.	Power indicator		G E #47	B2040	I1
I2	N17-L-6811	Lamp, glow: 105/125v; 1/4 w; bulb T-4-1/2 clear; 1-1/2" lg overall; double contact bayonet candelabra base; burn any position; neon gas filled JGC-991.	V4 output switch		G E #NE-16	B2078	I2
J1	N17-C-73428-3259	Connector, receptacle: two partially rounded male, nonpolarized contacts; straight type; 1.625" OD x .937" lg o/a; 10 amp, 250v; cylindrical metal and plastic body; locking; two .156" mtg holes, 1.375" between mtg cntrs.	AC input receptacle		H-H #7466	B2079	J1
J2	N17-J-39525-4047	Jack, telephone: JAN type, Spec. JAN-J-641.	Oscilloscope monitor jack	JJ-103	Mallory #702-B		J2
J3		Jack, telephone: for 2 cond 1/4" dia plug; J10 contact arrangement; 1-5/8" lg, 1-5/8" wd, 3/4" h; 3/8" dia mtg hole required; includes one hex nut 3/8-32 thread, 1/2" OD x 3/32" thk, and one brass washer, 5/8" OD x 3/8" ID, nickel finish.	Teletypewriter monitor jack		Mallory #703-B	B2080	J3

K1	N17-R-65372-6895	Relay, armature: SPDT w/2 back and 2 front cont; cont rating 5 amp at 50v and 0.5 amp at 500v; mercury cont; single wnd; oper cur 0.0081 amp; release cur 0.0036 amp; 4000 ohm ind; ins coil; oper v 35v DC; plug-in term on octal mtg base; 3-3/16" lg x 1-5/16" dia o/a; octal mtg; fast acting; dust proof cover; cont HS in gas-filled glass.	Output keying relay to operate teletype-writer.		W E #275B	B2081	K1
L1		Reactor, filter choke: MIL-T-27; 1 sect; 10 hy, 70 madc; 280 ohms DC resistance; 1500v rms test; hermetically sealed steel case; 2-7/32" lg, 1-15/16" wd, 3-1/8" h; four mtg studs 6-32 x 3/8" on 1.437" x 1.687" mtg/c; 2 post type terminals on bottom.	B+ filter choke		BTC #1254	B2082	L1
L2	N16-C-74168-4240	Coil, RF: choke; 3 pie universal wound; 1 wnd; unshielded; 5 mh, 150 ma, 6 ohms; 1-15/16" lg, 1/2" dia o/a; ceramic form; single mtg hole threaded for 6-32 screw; 2 cotter pin term on side; moist-ure resistant bakelite resin varnish cover-ing.	Noise radiation suppressor		National #R-300S	B2083	L2
R1	N16-R-49823-171	Resistor, fixed: JAN type, Spec. JAN-R-11; 1.41" lg; .405" dia; mounts by termi-nals.	Neutral input DC loading	RC40BF621J	IRC #BT-2		R1, R3, R88
R2	N16-R-50632-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by termi-nals.	T1 secondary loading	RC20BF104J	IRC #BTS		R2, R5, R7, R8, R21, R62, R67, R69, R72, R75, R64
R3		Same as R1.	Polar input DC loading				
R4	N16-R-50677-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by termi-nals.	V3 plate	RC20BF154J	IRC #BTS		R4, R11, R33, R58
R5		Same as R2.	Fixed input attenuator				
R6	N16-R-87847-6510	Resistor, variable steptype: utilizes 19 fixed composition resistors; 50,000 ohms ± 5%; 9 w at 70° C continuous operating temp; 3 solder lug term; enclosed metal case, 2-1/4" dia x 1-3/4" deep; round metal shaft 1/4" dia x 1" lg; contact arm insulated; two inserts threaded for #8-32 mtg screws, 1-1/2" between mtg cntrs; step type potentiometer having 20 st ps with 1 DB change in attenuation per step; last step counter-clockwise gives infinite attenuation; 15° rotation of shaft between steps.	Variable input attenuator		Daven #CP-251-S	B2084	R6

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R7		Same as R2.	V1A plate loading				
R8		Same as R2:	V2 cathode biasing				
R9	N16-R-49984-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V1A cathode biasing	RC20BF182J	IRC #BTS		R9
R10	N16-R-50650-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V2 plate supply voltage divider	RC20BF124J	IRC #BTS		R10, R16
R11		Same as R4.	V2 plate loading				
R12	N16-R-51109-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V2 plate supply voltage divider	RC20BF335J	IRC #BTS		R12, R34
R13	N16-R-50551-751	Resistor, fixed: JAN type, Spec. JAN-R-11; .750" lg; .280" dia; mounts by terminals.	V1B fixed biasing	RC30BF683J	IRC #BTA		R13
R14	N16-R-49939-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V1B cathode biasing	RC20BF122J	IRC #BTS		R14
R15	N16-R-50695-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V1B Grid	RC20BF184J	IRC #BTS		R15
R16		Same as R10.	T2 secondary loading				
R17	N16-R-50893-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V3 diode loading	RC20BF686J	IRC #BTS		R17, R71, R74, R77, R79
R18	N16-R-50758-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V3 diode loading	RC20BF334J	IRC #BTS		R18, R28, R90
R19	N16-R-50857-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V4A series grid	RC20BF564J	IRC #BTS		R19, R22
R20	N16-R-50713-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V4A plate loading	RC20BF224J	IRC #BTS		R20, R53, R55, R57, R59, R73, R76

R21		Same as R2.	V4B plate loading				
R22		Same as R19.	V4A plate to grid coupling				
R23	N16-R-50929-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V4B grid	RC20BF824J	IRC #BTS		R23
R24	N16-R-49966-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V4 cathode biasing	RC20BF152J	IRC #BTS		R24
R25	N16-R-51046-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V4B grid	RC20BF205J	IRC #BTS		R25
R26	N16-R-50443-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	Neon I2 loading	RC20BF393J	IRC #BTS		R26
R27	N16-R-50974-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V5A grid-V6 cathode	RC20BF105J	IRC #BTS		R27, R39, R60, R61, R70, R78
R28		Same as R18.	V5A grid limiting				
R29	N16-R-50318-751	Resistor, fixed: JAN type, Spec. JAN-R-11; .750" lg; .280" dia; mounts by terminals.	V5A plate loading	RC30BF123J	IRC #BTA		R29, R31
R30	N16-R-50281-751	Resistor, fixed: JAN type, Spec. JAN-R-11; .750" lg; .280" dia; mounts by terminals.	V5B plate loading	RC30BF103J	IRC #BTA		R30, R46
R31		Same as R29.	V5 cathode biasing				
R32		Resistor, variable: composition; 1 sect; 2.5 meg; ± 20%; 2 w; std "A" taper; 3 solder lug term; 1-3/32" dia; 21/32" deep encl metal case; round metal shaft 1/4" dia; 1" lg; high torque; mounted by bushing 3/8"-32, 3/8" lg; non-turn device on .531" radius at 9 o'clock.	Range control (V5 timing)		CTS #S-2288A		R32
R33		Same as R4.	V5B grid: limits range of R32				
R34		Same as R12.	V6B grid				
R35	N16-R-50821-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V8A grid	RC20BF474J	IRC #BTS		R35, R56, R80

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R36	N16-R-50551-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V6A grid	RC20BF683J	IRC #BTS		R36
R37	N16-R-50236-751	Resistor, fixed: JAN type, Spec. JAN-R-11; .750" lg; .280" dia; mounts by terminals.	V6 cathode biasing	RC30BF822J	IRC #BTA		R37
R38		Resistor, variable: composition; 3 sect; sect A 1 meg; sect B and C .25 meg; ± 20% tolerance each sect; 1/2 w power rating each sect; std "A" taper each sect; 3 solder lug terminals each sect; 1-1/8" dia, 1-1/2" deep encl metal case; slotted metal shaft 1/4" dia, 7/8" lg; bushing mounted, 3/8"-32, 3/8" lg; non-turn device on 35/64" radius at 9 o'clock; w/ lock washer, mounting nut, and locknut.	V6, V7 variable timing control (speed control)		CTS #Y-4498		R38
R39		Same as R27.	V7A grid				
R40		Resistor, fixed: JAN type, Spec. JAN-R-11; .750" lg; .280" dia; mounts by terminals.	V7 cathode biasing	RC30BF163J	AB #EB1635		R40
R41	N16-R-51001-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V7B grid	RC20BF135J	IRC #BTS		R41
R42		Resistor, variable: composition; 1 sect; 1 meg; ± 20%; 2 w; std "A" taper; 3 solder lug term; 1-3/32" dia, 21/32" deep enclosed metal case; slotted metal shaft 1/4" dia, 1/2" lg; high torque; mounted by bushing 3/8"-32, 3/8" lg; non-turn device on .531" radius at 9 o'clock.	R38 tracking		CTS #S-2287		R42, R47, R54, R65
R43	N16-R-51091-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V6B grid	RC20BF275J	IRC #BTS		R43
R44	N16-R-50740-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V6A grid to B+	RC20BF274J	IRC #BTS		R44, R89

R45	N16-R-50416-751	Resistor, fixed: JAN type, Spec. JAN-R-11; .750" lg; .280" dia; mounts by terminals.	V6A plate loading	RC30BF333J	IRC #BTA		R45
R46		Same as R30.	V6B plate loading				
R47		Same as R42.	R38 tracking				
R48	N16-R-50019-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V6B-V7A DC coupling	RC20BF155J	IRC #BTS		R48, R52
R49	N16-R-50371-751	Resistor, fixed: JAN type, Spec. JAN-R-11; .750" lg; .280" dia; mounts by terminals.	V7A plate loading	RC30BF223J	IRC #BTA		R49, R50, R81
R50		Same as R49.	V7B plate loading				
R51	N16-R-50515-431	Resistor, fixed: JAN type, Spec. JAN-R-11; .468" lg; .249" dia; mounts by terminals.	V7B-V9B coupling	RC20BF563J	IRC #BTS		R51, R68, R82
R52		Same as R48.	V7B grid to B+				
R53		Same as R20.	V8B-V9B coupling				
R54		Same as R42.	V11A bias adjust				
R55		Same as R20.	V9A grid				
R56		Same as R35.	V9A grid				
R57		Same as R20.	V4B-V9A coupling				
R58		Same as R4.	V9B grid				
R59		Same as R20.	V9B grid				
R60		Same as R27.	V8B-V4B coupling				
R61		Same as R27.	V4B-V8B coupling				
R62		Same as R2.	V8B plate loading				
R63		Resistor, fixed: JAN type, Spec. JAN-R-26A; 2" lg; 19/32" dia; mounts by terminals.	Teletypewriter series resistor	RW32G311	W-L *		R63
R64		Same as R2.	S5 noise pick-up decoupling				

*Mfr's designation same as JAN no.

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R65		Same as R42.	R38 tracking				
R66		Resistor, variable: composition; 1 sect; 100,000 ohms; ± 20%; 2 w; std "A" taper; 3 solder lug term; 1-3/32" dia, 21/32" deep encl metal case; slotted metal shaft 1/4" dia, 1/2" lg; high torque; mounted by bushing 3/8"-32, 3/8" lg; non-turn device on .531 radius at 9 o'clock.	V5B grid		CTS #S-2286		R66
R67		Same as R2.	V5B grid				
R68		Same as R51.	V5B grid				
R69		Same as R2.	V6B-V10A coupling				
R70		Same as R27	V11A grid				
R71		Same as R17.	V10A-V11A coupling				
R72		Same as R2.	V10A plate loading				
R73		Same as R20.	V10A-V10B coupling				
R74		Same as R17.	V10B grid				
R75		Same as R2.	V10B plate loading				
R76		Same as R20.	V10B-V10A coupling				
R77		Same as R17.	V10A grid				
R78		Same as R27.	V11B grid				
R79		Same as R17.	V6-V11B coupling				
R80		Same as R35.	V11B grid				
R81		Same as R49.	V11B cathode				
R82		Same as R51.	V9B cathode				
R83	N16-R-49705-751	Resistor, fixed: JAN type, Spec. JAN-R-11; .750" lg; .280" dia; mounts by terminals.	K1 contact noise suppressor	RC30BF331J	IRC #BTA		R83

R84		Resistor, fixed: JAN typ , Spec. JAN-R-26A; 2" lg; 19/32" dia; mounts by terminals.	V13 regulating resistor	RW32G312	W-L *		R84, R86
R85		Resistor, fixed: JAN type, Spec. JAN-R-26A; 2" lg; 19/32" dia; mounts by terminals.	V14 regulating resistor	RW33G502	W-L *		R85
R86		Same as R84.	V15 regulating resistor				
R87		Resistor, fixed: JAN type, Spec. JAN-R-26A; 2" lg; 19/32" dia; mounts by terminals.	Negative supply dropping resistor	RW33G402	W-L *		R87
R88		Same as R1.	Polar input DC loading				
R89		Same as R44.	V5A grid				
R90		Same as R18.	T1 secondary loading				
R91		Resistor, variable: composition; 1 sect; 3500 ohms; ± 10%; 2 w; std "A" taper; 3 solder lug term; 1-3/32" dia, 21/32" deep encl metal case; slotted metal shaft 1/4" dia, 1/2" lg; high torque; mounted by bushing 3/8"-32, 3/8" lg; non-turn device on .531" radius at 9 o'clock.	Auxiliary speed control		CTS #SF-6932		R91
S1		Switch, rotary: 1 sect; 3 positions; 3 poles; 3 throws; silver plated brass contacts; bakelite section; 7/8" lg; 1-3/8" wd; 1-1/2" h; mounted by 3/8" lg, 3/8"-32 thread bushing; solder lug terminals; round shaft, 17/32" lg, 1/4" dia.	Diplex tone, polar, neutral tone		Oak #51325-N1	B2085	S1
S2	N17-S-74139-4844	Switch, toggle: JAN type, Spec. JAN-S-23; 1-9/32" lg; 23/32" deep; 23/32" wd; mounts by bushing 15/32"-32, 15/32" lg.	Tone-DC input switch	ST22N	A-H & H #82305		S2, S3, S6
S3		Same as S2.	Normal-reverse keying switch				
S4	N17-S-65207-2081	Switch, rotary: 6 pole, 3 position; 2 sect; silver plated brass cont; bakelite sections; 1-7/8" lg, 1-33/64" wd; 2-1/2" h; solder lug term; mounted by 3/8" lg, 3/8"-32 thread bushing; round shaft, 1/2" lg, 1/4" dia.	Speed selector switch		Oak #38763-H2	B2086	S4

*Mfr's designation same as JAN no.

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S5		Switch, rotary: 1 section; 3 positions; 2 poles, 3 throws; silver plated brass cont; bakelite section; 13/16" lg; 1-3/8" wd; 1-1/2" h; mounted by 3/8" lg, 3/8"-32 thread bushing; solder lug terminals; round shaft, 17/32" lg, 1/4" dia.	Oscilloscope monitor switch		Oak #49373-N1	B2087	S5
S6		Same as S2.	Normal-mark hold switch				
S7	N17-S-73082-9028	Switch, toggle; JAN type, Spec. JAN-S-23; 1-9/32" lg; 23/32" deep; 23/32" wd; mounts by bushing 15/32"-32, 15/32" lg.	Power switch	ST22K	A-H & H #82304		S7
T1		Transformer, AF: input type; Spec. MIL-T-27; 600 ohms pri impedance; 50,000 ohms sec impedance; pri center tapped; upright steel case; audio A core; 1-15/16" lg, 1-13/16" wd, 2-3/4" h, excl term; 1 to 9.13 turns ratio pri to sec, ± .5 db from 400 to 5000 cps freq response; not tuned; electrostatic shield connected to case; 6 header type terminals located on bottom; 4 mtg studs 6-32 x 3/8" on 3/8" x 1-1/4" mtg/c; impregnated and filled per MIL-T-27.	Tone input transformer	TF1A10EA	BTC #1525	B2089	T1
T2		Transformer, AF: plate coupling type; Spec. MIL-T-27; 2000 ohms pri impedance; 4000 ohms sec impedance; pri 10 ma DC; upright steel case; audio A core; 1-15/16" lg; 1-13/16" wd, 2-3/4" h; 1 to 1.414 turns ratio pri to sec; ± .5 db from 400 to 5000 cps freq response; not tuned; 5 header type term located on bottom; 4 mtg studs, 6-32 x 3/8 on 1-3/8" x 1-1/4" mtg/c; secondary center tapped; impregnated and filled per MIL-T-27.	Interstage audio transformer	TF1A15EA	BTC #1526	B2088	T2
T3		Transformer, power, step-down and step-up: Spec. MIL-T-27; upright steel case; 115/230v, 50/60 cycles, single phase input; sec 800 v/70 ma, 5 v/3A, 6.3 v/5A; 800 v sec center tapped; 1500 v insula-	Plate and filament supply for all tubes	TF1A03KB	BTC #1253	C3035	T3

		tion; impregnated and filled per MIL-T-27; 3-15/16" lg, 3-5/16" wd, 4-5/16" h; 11 stud terminals located on bottom; 4 mtg studs, 10-32 x 1/2" on 3" x 2-7/16" mtg/c; pri connected in series for 230 v input, in parallel for 115 v input.					
TB1	N17-B-78042-1555	Terminal board: 14 screw and solder lug term; molded phenolic board; barrier type; 8-7/8" lg; 1-5/16" wd; 5/8" thk; four 3/16" dia mtg holes on 8-7/16" x 1/2" mtg/c; nickel plated terminals.	Input and output termination		Jones #14-142-Y	B2029	TB1
V1	N16-T-56682	Tube, electron: JAN type, Spec. JAN-1-A double triode.	Audio amplifier	JAN 6SN7GT			V1, V4, V5, V6, V7, V10, V11
V2	N16-T-56348	Tube, electron: JAN type, Spec. JAN-1A double diode.	Series diode limiter	JAN 6H6GT			V2, V3
V3		Same as V2.	Full wave signal rectifier				
V4		Same as V1.	Trigger				
V5		Same as V1.	One shot multivibrator lag				
V6		Same as V1.	One shot multivibrator gate				
V7		Same as V1.	Multivibrator				
V8	N16-T-56677	Tube, electron: JAN type, Spec. JAN-1A double triode.	False start gate and phase inverter	JAN 6SL7GT			V8, V9
V9		Same as V8.	Coincidence gate				
V10		Same as V1.	Multivibrator				
V11		Same as V1.	Cathode follower				
V12	N16-T-55464	Tube, electron: JAN type, Spec. JAN-1A rectifier.	B+ rectifier	JAN 5U4G			V12
V13	N16-T-53060	Tube, electron: JAN type, Spec. JAN-1A voltage regulator.	Voltage regulator	JAN OD3/VR150			V13, V14
V14		Same as V13.	Voltage regulator				
V15	N16-T-53050	Tube, electron: JAN type, Spec. JAN-1A voltage regulator.	Voltage regulator	JAN OC3/VR105			V15

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XF1	N17-F-74266-9121	Holder, fuse: extractor post type; for single AGC1 fuse; 1-1/4" lg x 1/4" dia; bakelite body; 15A, 250 v max; 2-3/8" lg x 3/8" dia overall; 3/8" dia threaded body for panel hole mtg; 2 solder lug term.	Holder for fuse F1		BUSS #HKP-H	B2090	XF1, XF2, XF3, XF4
XF2		Same as XF1.	Holder for fuse F2				
XF3		Same as XF1.	Holder for fuse F3				
XF4		Same as XF1.	Holder for fuse F4				
XI1A		Lampholder; accommodates miniature bayonet base lamp; 8 v, 1 w; brass shell; 1-11/16" lg, .800" dia; 2 solder lug term; 11/16" dia mtg hole required; threaded for lens holder.	Holder for I1		Dialco #12410	B2031	XI1A
XI1B		Lens, indicator light; green; 1/2" dia; hemispherical; glass; sandblasted back; 13/16" dia, 13/16" deep; dull black brass mounting; threaded mounting; 11/16"-27 female thread, 5/8" lg.	Lens for I1		Dialco #12-112	B2064	XI1B
XI2A		Lampholder: accommodates double contact candelabra bayonet base T-4-1/2 bulb; brass shell; 1-5/8" lg, 1-1/8" dia; 2 solder lug term; 1" dia mtg hole required; threaded for lens holder.	Lens for I2		Dialco #511006	B2091	XI2A
XI2B		Lens, indicator light: clear; 1" dia, torpedo type; glass; sandblasted black; 1-1/16" dia; 1" deep; threaded mounting; 1"-32 female thread, 1/2" lg.	Lens for I2		Dialco #51-517	B2092	XI2B
XK1	N16-S-63529-1976	Socket, electron tube: JAN type, Spec. JAN-S-28A.	Socket for K1	TS101P01	Cinch #16203		XK1, XVI to & incl XV15
XV1 to & incl. XV15		Same as XK1.	Sockets for V1 to & incl V15				

TABLE 8-5. MAINTENANCE PARTS KIT

KEY DESIG-NATION	QUANTITY FOR USAF EQUIPMENTS	QUANTITY FOR BUSHIPS EQUIPMENTS	KEY DESIG-NATION	QUANTITY FOR USAF EQUIPMENTS	QUANTITY FOR BUSHIPS EQUIPMENTS
C13	1	0	I2	5	0
C30	1	0	K1	0	16
C31	1	0	V1	50	0
C32	1	0	V2	10	0
CR1	8	0	V8	10	0
F1	40	0	V12	10	0
I1	5	0	V13	10	0
			V15	5	0

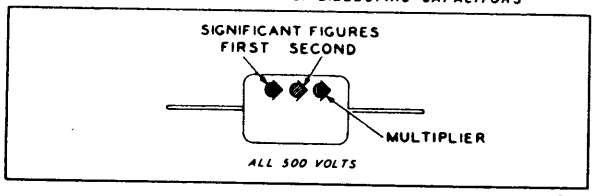
TABLE 8-6. CROSS REFERENCE PARTS LIST

JAN DESIGNATION	REFERENCE DESIGNATION	JAN DESIGNATION	REFERENCE DESIGNATION	JAN DESIGNATION	REFERENCE DESIGNATION
CM20A271K	C3	RC20BF104J	R2	RC20BF684J	R17
CM35B222K	C13	RC20BF105J	R27	RC20BF824J	R23
CM35C102K	C5	RC20BF122J	R14	RC30BF103J	R30
CM35C202J	C2	RC20BF124J	R10	RC30BF123J	R29
CM35C472K	C4	RC20BF135J	R41	RC30BF163J	R40
CM35C511J	C12	RC20BF152J	R24	RC30BF223J	R49
CM45B103J	C14	RC20BF154J	R4	RC30BF331J	R83
CM45B622J	C16	RC20BF155J	R48	RC30BF333J	R45
CM45B822J	C7	RC20BF182J	R9	RC30BF683J	R13
CM50B123J	C6	RC20BF184J	R15	RC30BF822J	R37
CM50B133J	C32	RC20BF205J	R25	RC40BF621J	R1
CM50B273J	C33	RC20BF224J	R20	RW32G311	R63
CP41B1DF405V	C31	RC20BF274J	R44	RW32G312	R84
CP41B1DG205V	C30	RC20BF275J	R43	RW33G402	R87
JAN-OC3/VR105	V15	RC20BF334J	R18	RW33G502	R85
JAN-OD3/VR150	V13	RC20BF335J	R12	ST22K	S7
JAN-5U4G	V12	RC20BF393J	R26	ST22N	S2
JAN-6H6GT	V2	RC20BF474J	R35	TF1A03KB	T3
JAN-6SL7GT	V8	RC20BF563J	R51	TF1A10EA	T1
JAN-6SN7GT	V1	RC20BF564J	R19	TF1A15EA	T2
JJ-103	J2	RC20BF683J	R36	TS101P01	XK1

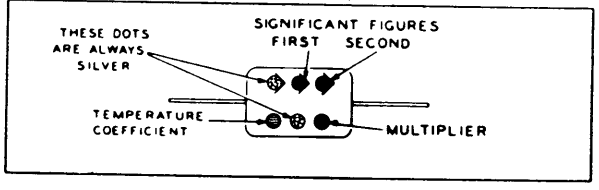
TABLE 8-7. COLOR CODES & MISCELLANEOUS DATA

CAPACITOR COLOR CODES

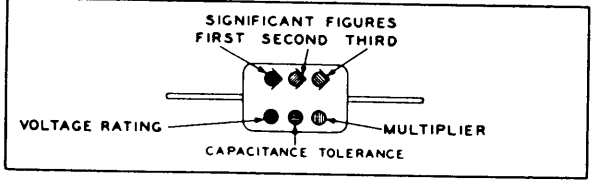
RMA 3-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



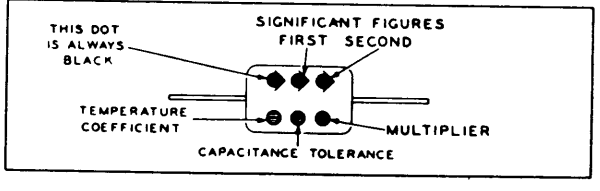
JAN 6-DOT COLOR CODE FOR PAPER-DIELECTRIC CAPACITORS



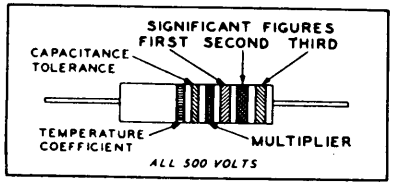
RMA 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



JAN 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS

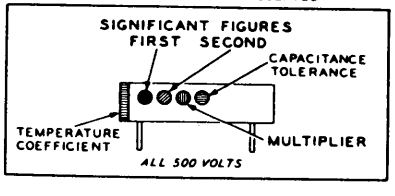


RMA COLOR CODE FOR TUBULAR CERAMIC-DIELECTRIC CAPACITORS

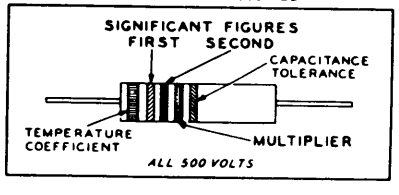


JAN COLOR CODE FOR FIXED CERAMIC-DIELECTRIC CAPACITORS

RADIAL TYPE NON-INSULATED



AXIAL TYPE INSULATED



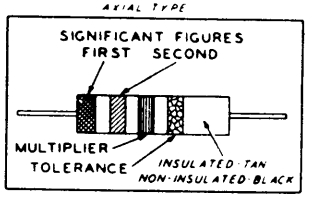
RMA: RADIO MANUFACTURERS ASSOCIATION
JAN: JOINT ARMY-NAVY

RESISTORS				CAPACITORS				
				MULTIPLIER				
TOLERANCE	MULTIPLIER	SIGNIFICANT FIGURE	COLOR	RMA MICA AND CERAMIC-DIELECTRIC	JAN MICA AND PAPER-DIELECTRIC	JAN CERAMIC DIELECTRIC	VOLTAGE RATING	TEMPERATURE COEFFICIENT
	1	0	BLACK	1	1	1		A
	10	1	BROWN	10	10	10	100	B
	100	2	RED	100	100	100	200	C
	1,000	3	ORANGE	1,000	1000	1000	300	D
	10,000	4	YELLOW	10,000			400	E
	100,000	5	GREEN	100,000			500	F
	1,000,000	6	BLUE	1,000,000			600	G
	10,000,000	7	VIOLET	10,000,000			700	
	100,000,000	8	GRAY	100,000,000		0.01	800	
	1,000,000,000	9	WHITE	1,000,000,000		0.1	900	
5	0.1		GOLD	0.1	0.1		1000	
10	0.01		SILVER	0.01	0.01		2000	
20			NO COLOR				500	

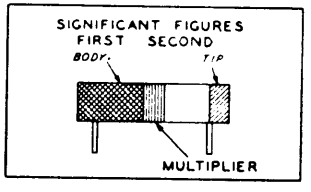
RESISTOR COLOR CODES

RMA COLOR CODE FOR FIXED COMPOSITION RESISTORS

AXIAL TYPE

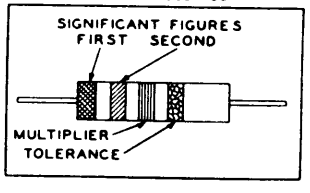


RADIAL TYPE



JAN COLOR CODE FOR FIXED COMPOSITION RESISTORS.

AXIAL TYPE INSULATED



RADIAL TYPE NON-INSULATED

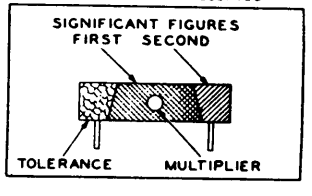


TABLE 8-8. LIST OF MANUFACTURERS

ABBREVIATIONS	PREFIX	NAME	ADDRESS
AB	CBZ	Allen-Bradley Co.	118 W. Greenfield Ave. Milwaukee, Wis.
Aerovox	CAW	Aerovox Corp.	742 Belleville Ave. New Bedford, Mass.
A-H&H	CHH	Arrow-Hart & Hegeman Electric Co.	102 Hawthorne St. Hartford, Conn.
Birtcher	CAIS	The Birtcher Corp.	5087 Huntington Drive Los Angeles 32, Calif.
BTC		Berkshire Transformer Co.	15 South St. New Milford, Conn.
Buss	CFA	Bussman Mfg. Co.	2530 W. University St. St. Louis, Mo.
Cinch	CMG	Cinch Mfg. Co.	2339 W. Van Buren St. Chicago, Ill.
CTS	CTC	Chicago Telephone Supply Co.	Elkhart, Ind.
Daven	CDN	Daven Co.	160 Summit St. Newark, N. J.
Dialco	CAYZ	Dial Light Corp.	900 Broadway New York, N. Y.
GE	CG	General Electric Co.	One River Rd. Schenectady, N. Y.
H-D		Harry Davies Molding Co.	1428 N. Wells St. Chicago 10, Illinois
H-H	CHU	Harvey Hubbell, Inc.	447 Concord Ave. Bridgeport, Conn.
IRC	CIR	International Resistance Corp.	401 N. Broad St. Philadelphia, Pa.
Jones	CJC	Howard B. Jones	2300 W. Wabansia Ave. Chicago, Ill.
Mallory	CMA	P. R. Mallory Co., Inc.	1941 Thomas St. Indianapolis, Ind.
National	CNA	National Company, Inc.	61 Sherman St. Malden, Mass.
Oak	COC	Oak Mfg. Co.	1200 N. Clybourne Ave. Chicago, Illinois
Sangamo	CAN	Sangamo Electric Co.	1935 Funk St. Springfield, Ill.
WE	CW	Western Electric Co.	120 Broadway New York 5, N. Y.
W-L	CAO	Ward Leonard Co.	45 South St. Mount Vernon, N. Y.