INSTRUCTION BOOK

for

FREQUENCY SHIFT CONVERTER

MODEL CFA

THE TECHNICAL MATERIEL CORP.

Mamaroneck, N. Y.   Ottawa, Ontario

SECTION 1
GENERAL DESCRIPTION

1. PURPOSE AND BASIC PRINCIPLES

a. The MODEL CFA Frequency Shift Converter is a device used in radio frequency shift receiving systems to convert the mark and space tones from the output of a single receiver or receivers in diversity into DC pulses capable of operating a teleprinter, tape recorder or any device requiring make and break signals.

b. The Model CFA accomplishes its purpose by completely electronic means and has incorporated in it the capacity to easily correct for bias distortion of appreciably more than plus or minus 30%.

c. The Model CFA contains a newly engineered drift compensating circuit, which will accomodate total receiver drifts up to 1500 cps with no interruptions in service. Specifically, a total drift of 1200 cps will be tolerated when the input signal is being shifted 850 cps.

d. Every effort has been made to take advantage of the FM nature of the frequency shift principle. Maximum integration or de-emphasis, as it is called in FM terminology, has been employed to assist in the rejection of noise.

e. As a further illustration of point (d.), above, each channel has incorporated within it a series of limiter-amplifiers to effectively eliminate amplitude modulation and noise peaks superimposed on the signal carrier.

f. A CR type visual monitor is provided to permit extremely simple, straightforward, and rapid "setting up" and to facilitate receiver tuning in. By observation of the visual monitor the operator will know when he is precisely at the discriminator center, but also in which direction he has drifted and may judge approximately how far off center he has drifted.

g. The output is made available for external use through a special all electronic keying stage which operates exactly as neutral relay contacts. The output terminals may then operate floating or either side grounded with external battery.

2. DESCRIPTION OF UNIT

a. The Model CFA converter is illustrated in Figure 1-1. The front panel is 3/16" thick by 19" long and is only 3½" high and is finished in TMC Gray enamel. The total dimensions into the rack, including rear panel control protrusions, is 16".

b. Weight: 30 pounds.

c. The controls are so placed as to permit the

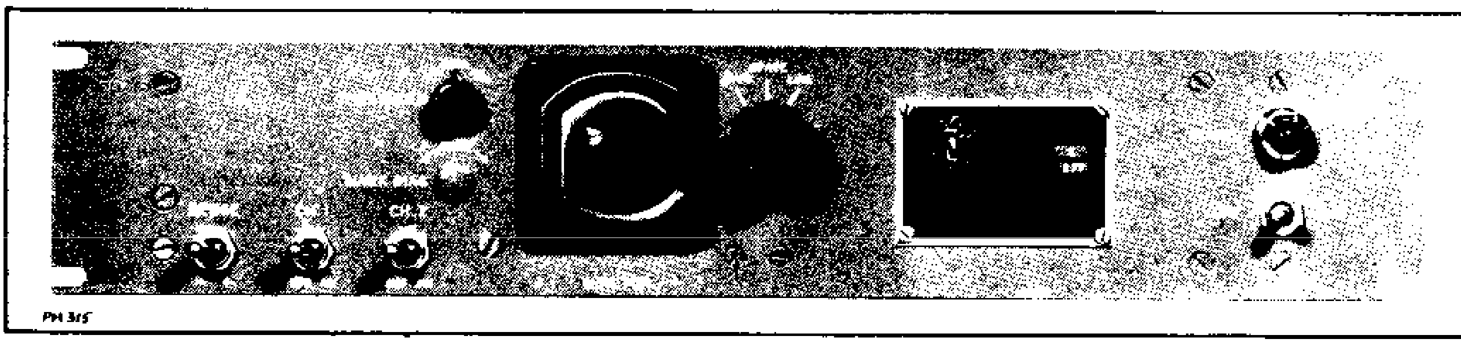


Figure 1-1. Frequency Shift Converter, Model CFA-1.

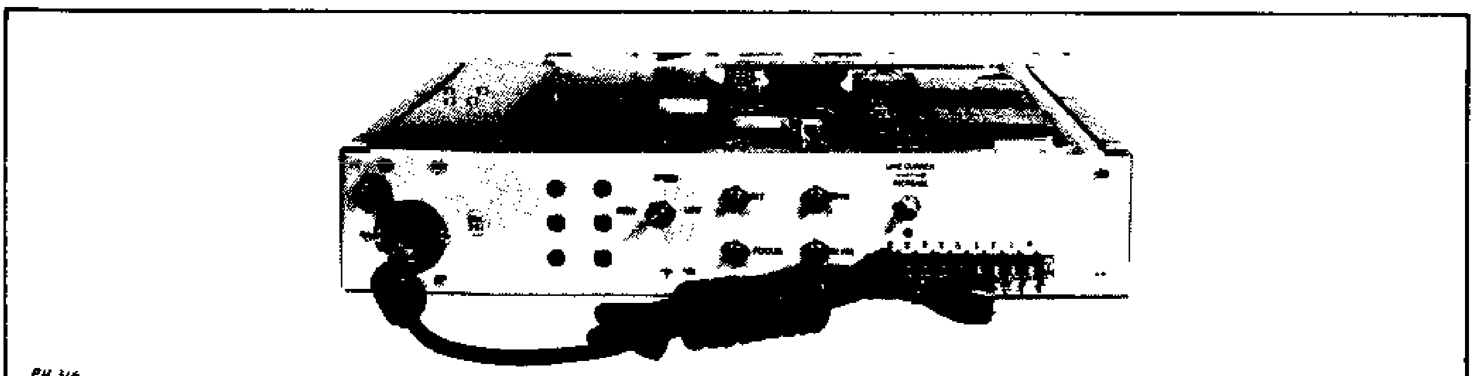


Figure 1-2. Frequency Shift Converter, Model CFA-1. Rear View

Figure 1-1. Frequency Shift Converter, Model CFA-1.

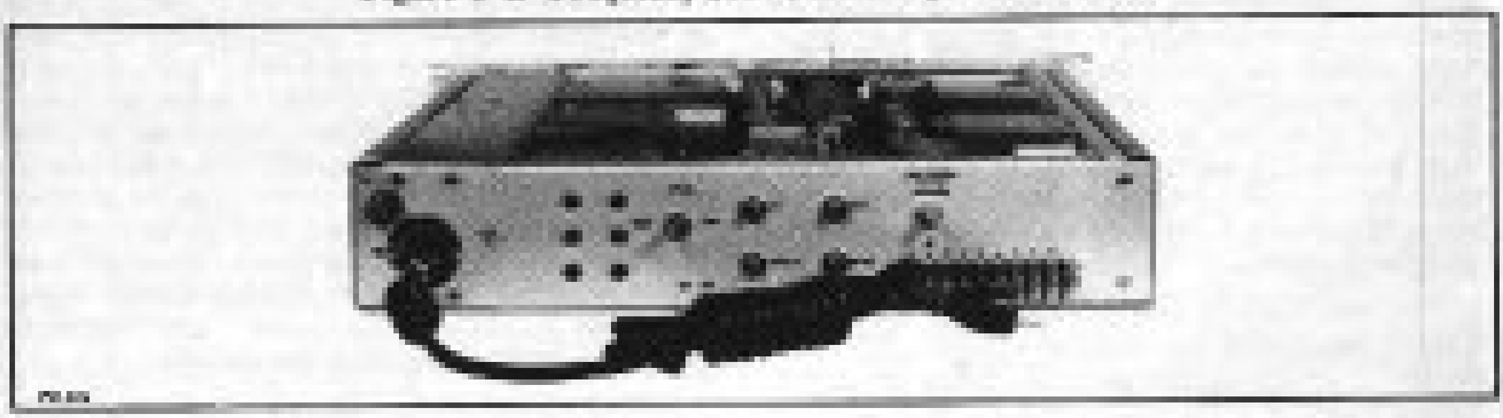


Figure 1-2. Frequency Shift Converter, Model CFA-1. Rear View

greatest degree of simplicity in operation. The front panel controls are:

1. Primary Power Switch.
2. Channel #1 ON/OFF Switch.
3. Channel #2 ON/OFF Switch.
4. Monitor Intensity.
5. Monitor Focus.
6. Mark/Space/Line Test Switch.
7. Mark Bias Control.
8. Threshold Control.

The rear panel controls are:

1. High/Low Speed Switch.
2. Line Current
3. Monitor Vertical Positioning.
4. Monitor Horizontal Positioning.
5. Sense Switch.
6. Pulse Restorer Bias Control. (R59)

d. The components are so mounted that troubleshooting and corrective maintenance may easily be accomplished.

e. Tube Complement: All JAN miniature and octal tubes as follows:

V1 - 6AU6, Tone Amplifier (Channel #1).
V2 - 6J6, Tone Limiter (Channel #1).
V3 - 12AU7, Tone Power Amplifier (Channel #1 & 2).
V4 - 6AU6, Tone Amplifier (Channel #2).
V5 - 6J6, Tone Limiter (Channel #2).
V6 - 6AL5, Discriminator Rectifier (Channel #1).
V7 - 6AL5, Discriminator Rectifier (Channel #2).
V8 - 6AL5, Clamp
V9 - 6AU6, Pulse Amplifier.
V10 - 6AU6, Pulse Amplifier.
V11 - 12AU7, Monitor D.C. and A.C. Amplifiers.
V12 - 6J6, Pulse Restorer.
V13 - 12AU7, Cathode Follower, Oscillator.
V14 - 6Y6G, Pulse Output.
V15 - 5Y3GT, Positive Supply Rectifier.
V16 - 6X4, Negative Supply Rectifier.
V17 - OB2, Voltage Regulator.
V18 - OA2, Voltage Regulator.
V19 - OB2, Voltage Regulator
V20 - OB2, Voltage Regulator.
V21 - 2BP1, Monitor.
V22 - 6AL5, Output Rectifier.

SECTION 2
THEORY OF OPERATION

1. GENERAL DESCRIPTION OF CIRCUITS

Because the frequency shift principle is in no way dependent upon amplitude modulation for the conveying of intellegence, it is possible to exploit every advantage inherent in frequency modulation systems. That this was done in the Model CFA will become evident in the discussion which follows: Figure 2-1 is a functional Block Diagram of the CFA showing the routing of signal from input to output. NOTE: For additional information regarding wave shapes refer to Fig. 4.

a. THE LIMITER-AMPLIFIERS.- (V1, V2, and V3 or V4, V5, and V3) Superimposed upon every carrier will be noise peaks, the degree of amplitude modulation of the carrier by these noise peaks being a function of the signal to noise ratio. It is the purpose of the limiter to rid an incoming signal of these peaks so that the remainder of the circuits will not interpret them as being mark or space pulses. The limiter, by the same token, rejects interference from nearby voice or music modulated signals.

For this reason, therefore, a twin set-up is utilized whereby each channel from the dual diversity receiver system passes through discreet limiter stage.

The limiter proper (V2 or V5) may be broken down into two triode stages, the first being a cathode follower and the second being cathode coupled to the first.

When a small positive signal swing appears at the grid of the first section, this positive voltage is translated through the cathode coupling to the second section. The effect is to quickly cut-off the second section so that any additional voltages such as noise peaks do not appear in the limiter output When a small negative signal swing appears at the grid of the first section, the first section is quickly cut off and, again, the noise peaks are eliminated.

The limiter proper (V2 or V5) is preceeded by an additional limiter-amplifier (V1 or V4) which operates at very low signal levels. The circuit is so designed that the tube easily reaches grid current saturation and plate current cut-off on positive and negative peaks respectively. The cumulative effect of these two stages (i.e., V1 & V2 or V4 & V5) in tandem is to remain "choked up", so to speak, as long as an audio tone of better than approximately 20 millivolts is present at the input. The power amplifier (V3) therefore sees only the "phase" portion of the original noise.

The power amplifier amplifies the limited audio

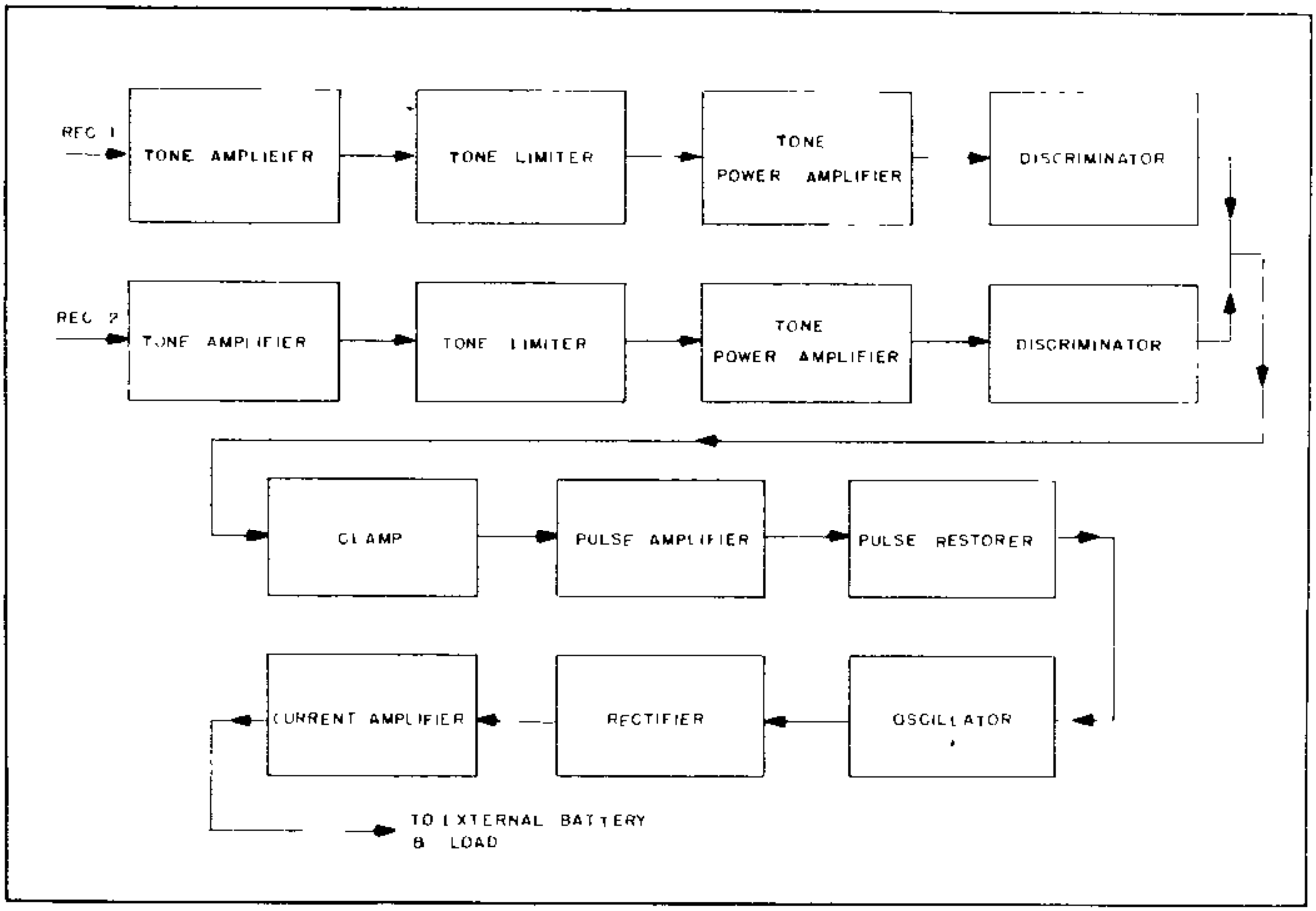


Figure 2-1. Functional Block Diagram

tone and feeds it to the discriminator resonant circuits.

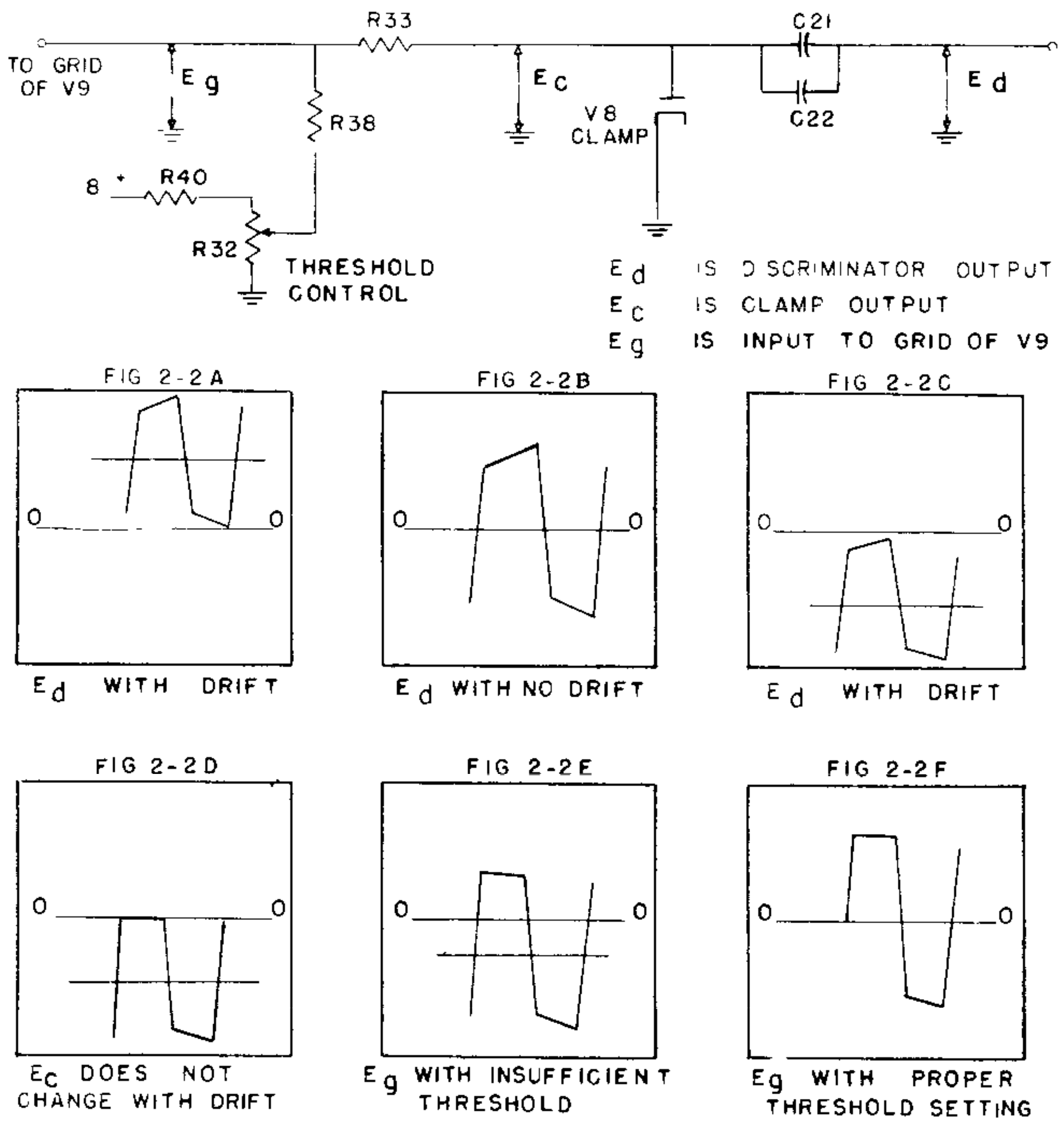
b. THE DISCRIMINATOR. - The discriminator consists of two resonant circuits, one resonated above and the other resonated below center frequency in such a manner that maximum shift and drift conditions may be met without exceeding the distance between the resonant peaks. The voltage across each circuit is a function of the tone frequency.

c. THE DISCRIMINATOR RECTIFIERS. - (V6 and V7) The tone voltage across each resonant circuit is rectified by the discriminator rectifiers and then added in the discriminator load (R92, R93, C17, and C18). A shift in frequency from mark to space would then cause a change in voltage across the resonant circuits. This change in voltage, which is proportional to the amount of shift, is rectified, diversity combined, filtered, and fed to the clamp. Its form approaches a square wave because the shift from one frequency to another is an abrupt one.

As an additional precaution against noise, a low pass filter or de-emphasis network is included in the form of C19 and C20.

d. THE CLAMP. - (V8) The voltage produced at the output of the discriminator load is symmetrical to an axis which may be positive or negative with respect to ground. The potential magnitude and polarity represented by this axis is a function of the degree and direction of drift. (Fig 2-2 AB & C) The object of the clamp is, to treat this drift produced voltage in such a manner that the remaining pulse circuits are unaware of its presence. Otherwise, the quiescent operating point of V9 would be shifted over a wide range thus producing varying degrees of bias distortion.

Observation of the Schematic Diagram Figure 6-6 will show that the clamp is connected so that it conducts whenever a positive potential appears at its plate. Imagine, for the moment, that the threshold control has been turned counter-clockwise to zero. It can then be seen that, due to the presence of the clamp, no positive voltage will ever appear at the grid of V9. C21 and C22 will permit the passage of no D.C. and the clamp allows the charging of these condensers in such a manner that the waveform which is passed will have its uppermost peak at ground potential. (Fig. 2-2D) When the threshold control is properly adjusted, a fixed positive potential will appear at



NOTE

(E_g SEEN WHILE V9 IS REMOVED FROM SOCKET.)
ALL PATTERNS SEEN USING HIGH IMPEDANCE SCOPE WITH DC AMPLIFIER (SUCH AS DUMONT 304 H WITH 2507 PROBE)

Figure 2-2. Illustration of the Clamp & Threshold Operation

the grid of V9 and the waveform from the clamp will be symmetrically superimposed on this voltage. Since the clamp output is a function of shift, then the amount of threshold necessary to symmetrically orient this output waveform with respect to ground will also be a function of shift. (Fig 2-2 E&F)

When keying stops or the signal drops out the threshold voltage serves to bring V9 into a state of grid saturation so that random noise or a nearby amplitude modulated signal will not force the teleprinter from its standby condition.

e. V9, THE PULSE AMPLIFIER (V9).- V9 is a high gain amplifier which reaches grid saturation and plate current cut-off at very low input voltages. Its output will then be an essentially square wave. The first pulse amplifier feeds an integrating network which serves to give its output a "saw-tooth" slope.

f. V10, THE SECOND PULSE AMPLIFIER (V10).- This tube operates essentially like the one which preceeds it. The Mark Bias Control, by shifting the input waveform with respect to ground, determines the length of the time axis between the points where this waveform approaches zero potential. These points are very nearly where V10 goes into grid saturation and plate current cut-off so that the width of the output waveform is then a function of the setting of the Mark Bias Control.

The output waveform then passes through a differentiating network so that the front and back edges of this square wave produce sharp positive and negative voltage pips.

g. THE PULSE RESTORER (V12).- The pulse restorer is a "one shot" multivibrator which, when keyed in a given direction, will remain in one state until an opposite impulse sends it into another state, where it will again remain. The sharp wave front from the differentiating network serves to key this stage. Due to the action of the threshold circuit, this stage will automatically receive a Mark pulse when keying stops or the signal drops out completely.

h. THE CATHODE FOLLOWER (½V13).- The cathode follower simply serves as an isolating stage between the oscillator and the pulse restorer. Its output is precisely like its input with the exception of a loss in signal amplitude.

i. THE OSCILLATOR ('V13).- A conventional Hartley circuit is used here, the stage being permitted to oscillate only when the cathode follower does not force the oscillator grid into the cut-off region. The reason for having provided this additional stage is to allow for complete D.C. isolation of the pulse circuit which feeds the teleprinter. This is done through transformer coupling to the oscillator output (T7) which is rectified by four crystal diodes and then filtered and fed to the pulse output stage.

j. THE PULSE OUTPUT (V14).- The Pulse Output stage operates at either grid saturation or plate current cutoff. The teleprinter constitutes the plate load, the current being adjustable by use of the series rheostat, R77.

k. THE MONITOR SECTION (VII AND V21).- A constant amplitude vertical sweep for the monitor is obtained by utilizing both the tone input to V3 and a part of the Oscillator output. Each horizontal plate is fed by an amplifier, both amplifiers deriving their inputs from the same point on the discriminator output. It is the difference voltage between these two amplifier outputs which produces a horizontal sweep.

As has already been discussed in the Clamp section (Para. #4), an average D.C. potential appears at the discriminator output when drift takes place. Since one of the Monitor amplifiers is a D.C. amplifier, its output will differ from the other amplifier by an amount proportional to this D.C. potential. (The gain of each amplifier is adjusted to be exactly equal to the other). It can be seen, therefore, that the greater the drift becomes, the more sweep voltage will be produced. When the tone input is being keyed about the discriminator center frequency, there will be no horizontal sweep voltage and only a vertical line will appear on the Monitor face. As drift occurs, the line will open to the left or right into a rectangle of varying horizontal dimension, depending upon the direction and degree of drift.

SECTION 3
INSTALLATION AND OPERATION

1. INSTALLATION

a. The Model CFA Frequency Shift Converter has been so designed that its installation and operation will require a minimum of effort from the user. Because of the wide permissible drift range, the receivers feeding the CFA need not be disturbed over long periods of time. All controls have been preset at the factory testing laboratory for nominal 850 cps shift, however, if it becomes necessary

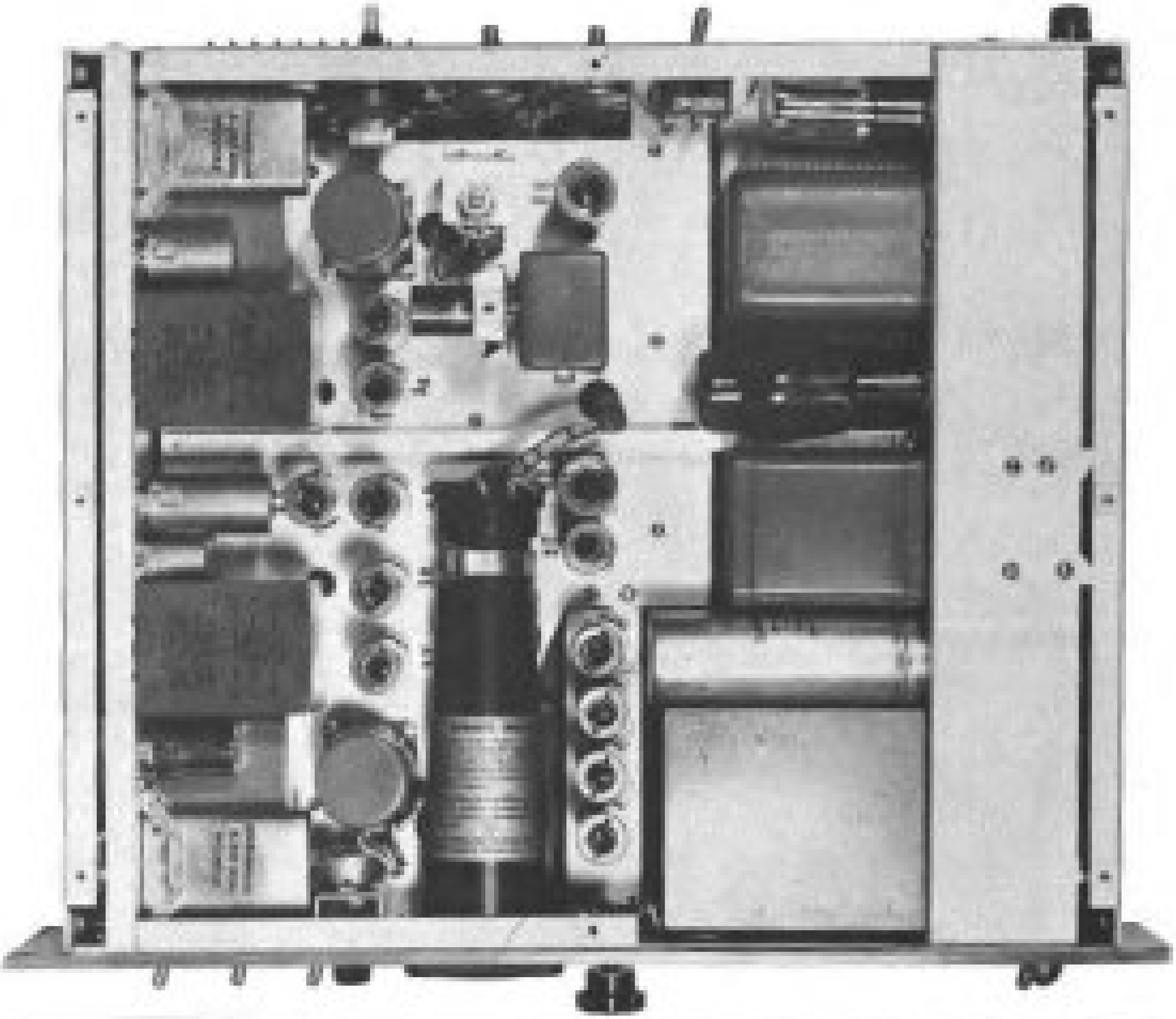


Figure 4-1. Frequency Shift Converter, Model CFA-1. Top View

VOLTAGE CHART

TUBE SYMBOL	FUNCTION	TYPE	PINS	VOLTS	PINS	VOLTS	PINS	VOLTS	PINS	VOLTS	PINS	VOLTS	PINS	VOLTS	PINS	VOLTS
V1	Tone Amplifier	6AU6	1	-4.4	2	+1	5	+80	6	+15	7	+1	3	AC 6.3		
V2	Limiter	6J6	1	+265	2	+220	5	0	6	0	7	+42	3	AC 6.3		
V3	Tone Amplifier	12AU7	1	+250	2	+36	3	+52	6	+250	7	+31	8	+48	4	AC 6.3
V4	Tone Amplifier	6AU6	1	-3.9	2	+1.1	5	+70	6	+13	7	+1.1	3	AC 6.3		
V5	Limiter	6J6	1	+265	2	+230	5	0	6	0	7	+35	3	AC 6.6		
V6	Tone Rectifier	6AL5	1	0	2	-22	5	+5	7	-22	4	AC 6.3				
V7	Tone Rectifier	6AL5	1	0	2	-22	5	+5	7	-22	3	AC 6.3				
V8	Clamper	6AL5	2	-.6	1	0	3	AC 6.3								
V9	Pulse Amplifier	6AU6	1	-.25	2	0	5	+4.5	6	+18	7	0	3	AC 6.3		
V10	Pulse Amplifier	6AU6	1	-48	2	0	5	+250	8	+53	7	0	3	AC 6.3		
V11	Monitor Amplifier	12AU7	1	+210	2	11.6	3	+13	6	+140	7	+6	8	+13	9	AC 6.3
V12	Pulse Restorer	6J6	1	-80	2	+205	5	-170	6	-145	7	-145	3	AC 6.3	4	AC 6.3
V13	Oscillator Cathode Follower	12AU7	1	-265	2	-150	3	-130	6	+285	7	-128	8	0	4	AC 6.3

V14	Pulse Generator	6Y6	3-8	+60	4-8	+60	5-8	0	7	AC 6.3						
V15	Rectifier	5Y3	4	AC 300	6	AC 300	2	+285	2-8	AC 5.0						
V16	Rectifier	6X4	7	AC 300	1	-310	6	-310	4	AC 6.3						
V17	Voltage Regulator	OB2	2	-255	5	-150										
V18	Voltage Regulator	OA2	4	-150	1	0										
V19	Voltage Regulator	OB2	7	0	5	+105										
V20	Voltage Regulator	OB2	2	+105	5	+210										
V21	Monitor	2BP1	2	-180	3	-175	4	-95	6	+165	7	+210	6	+13	9	+170
		2BP1	10	+165	12	AC 6.3	1	AC 6.3								

Figure 6-2. Tube Voltage Chart

CONDITIONS:

1. Line voltage of 110 @ 60 cps.
2. Both Channel Switches in ON position.
3. Both Channels fed simultaneously by a fixed Mark audio tone of about 3 Kc. at 1 volt RMS.
4. Sense Switch (S4) in plus condition.
5. Test Switch (S6) in Line condition.
6. Threshold Control (R32) set for 850 cps operation.
7. Bias Control (R45) set for minimum distortion or near its center point.
8. Speed Switch (S5) set for Low speed operation.
9. Line Current (R77) set for maximum current into a 2000 ohm load with an external source of 200 volts.
10. Voltmeter used should be a high impedance instrument having an input of 5 megohm or more.

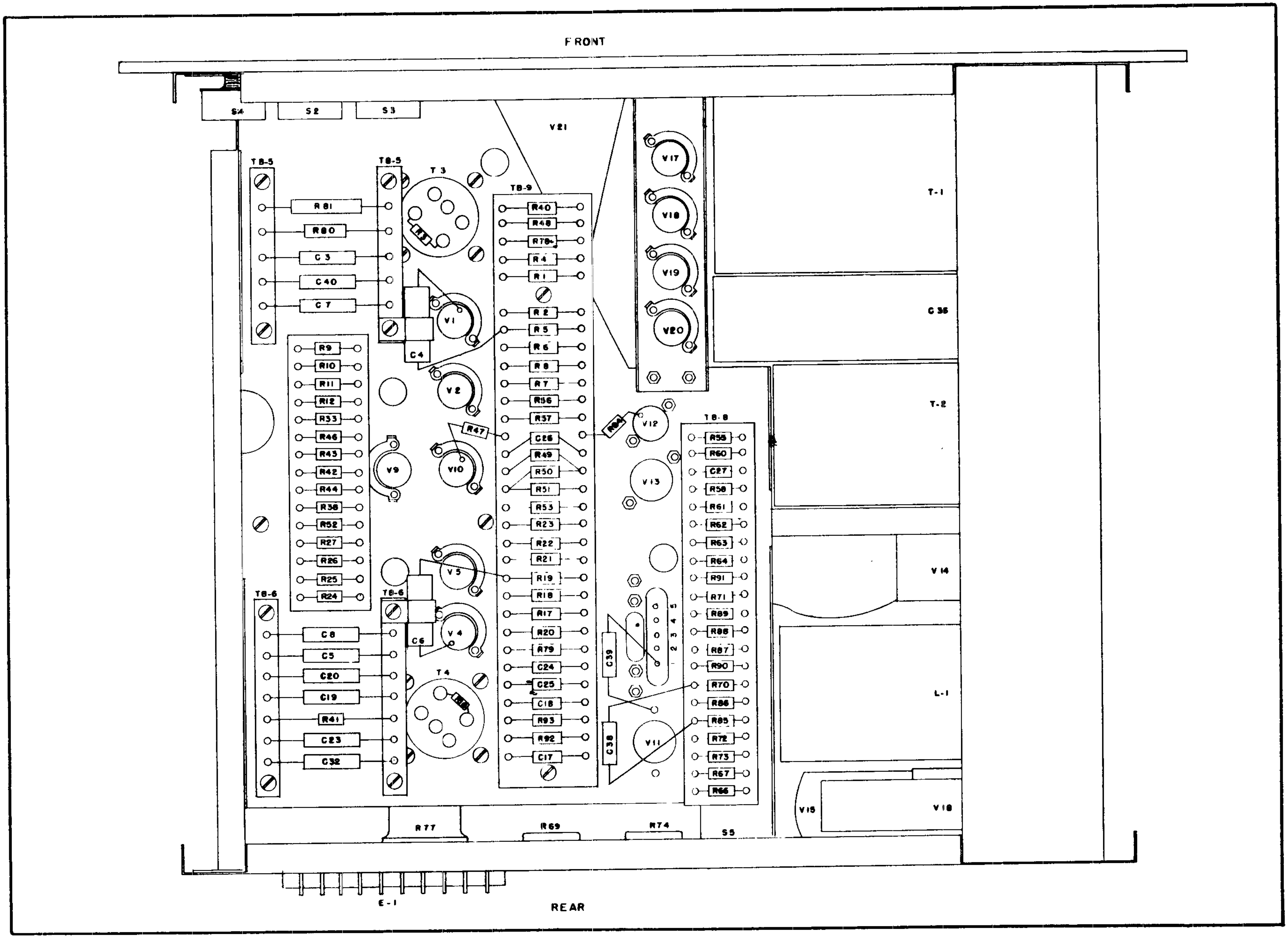


Figure 6-3. Component Layout-Bottom View. Model CFA-*.

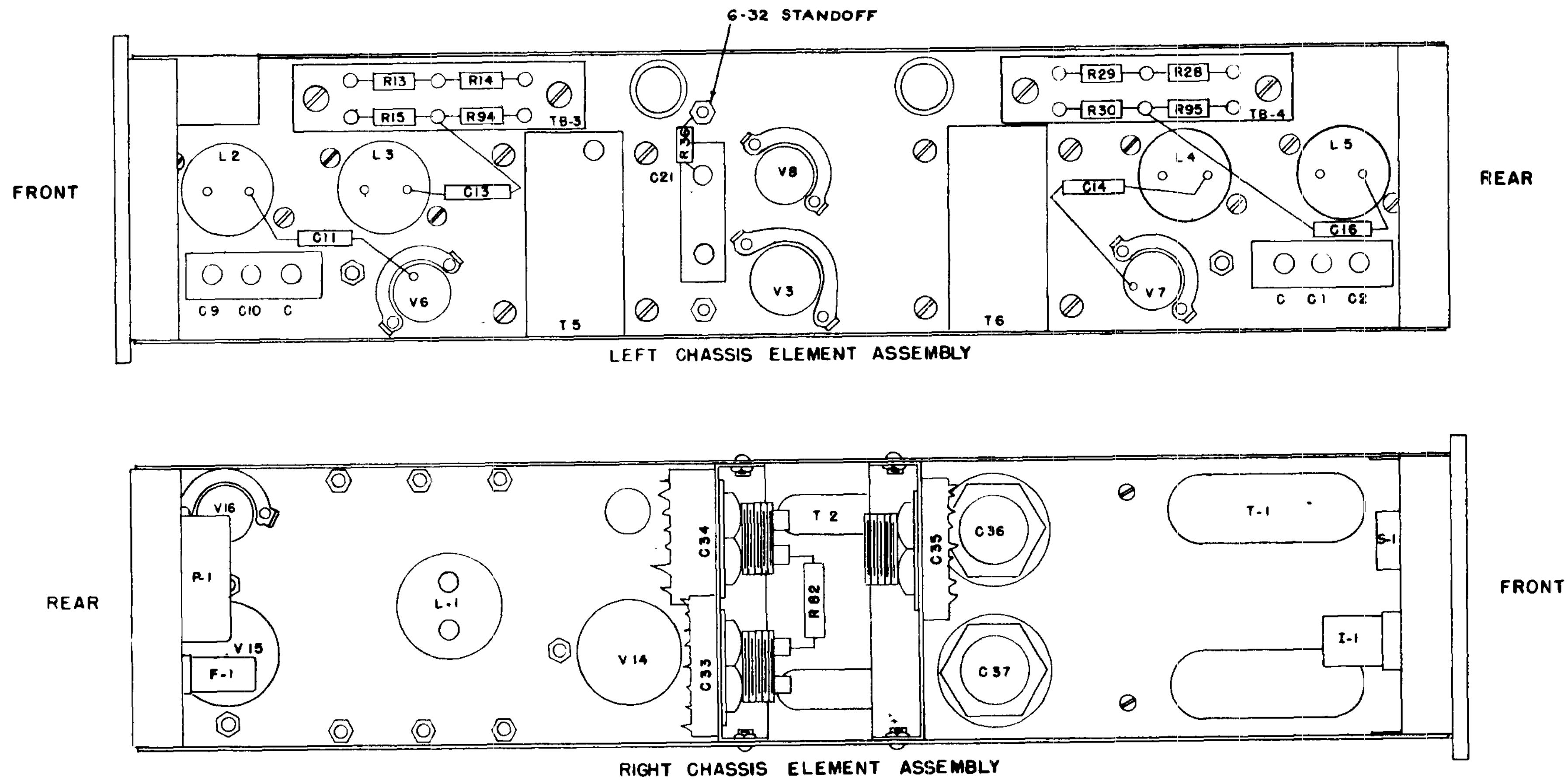


Figure 6-4. Component Layout-Left & Right Views. Model CFA-*.

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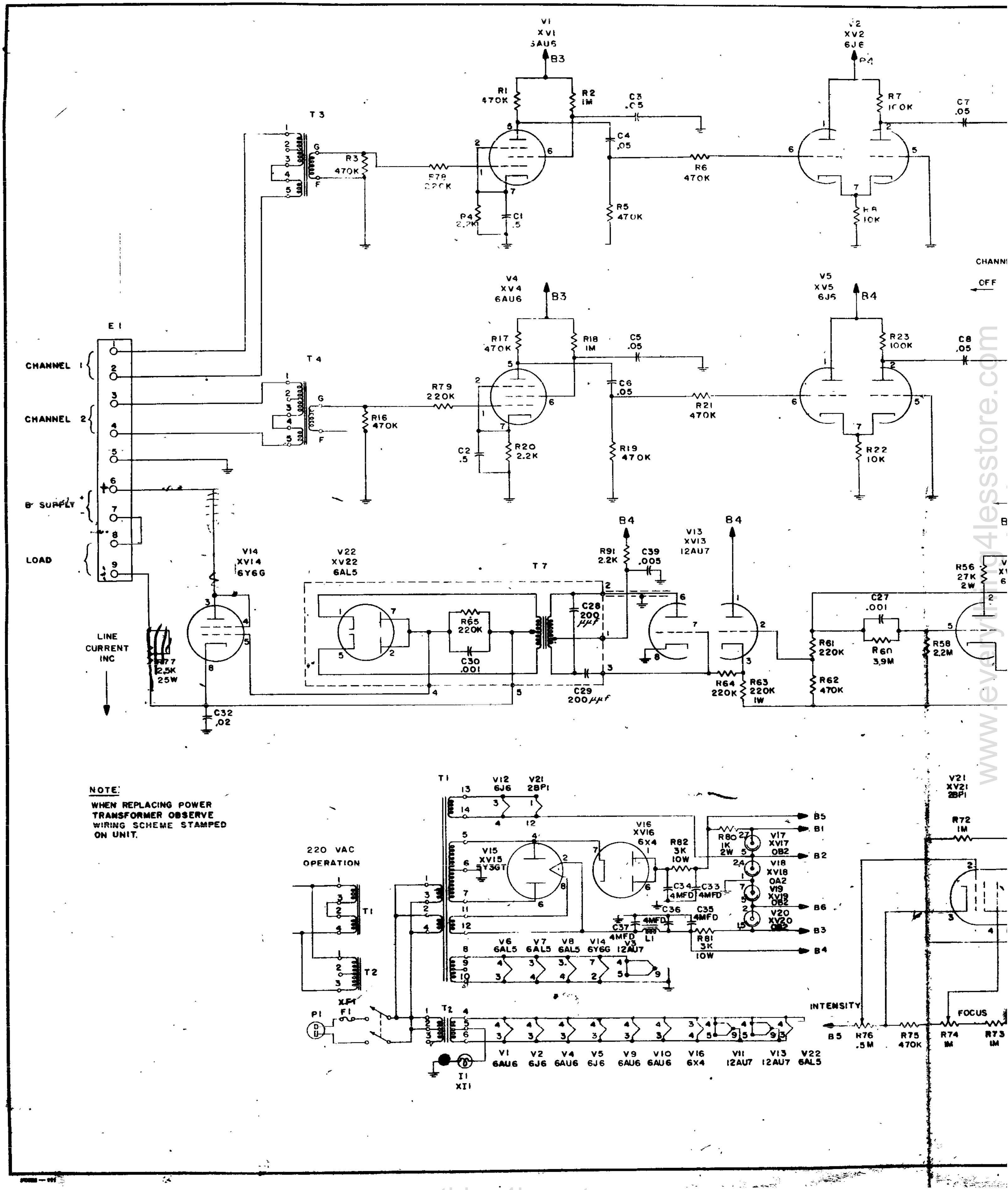
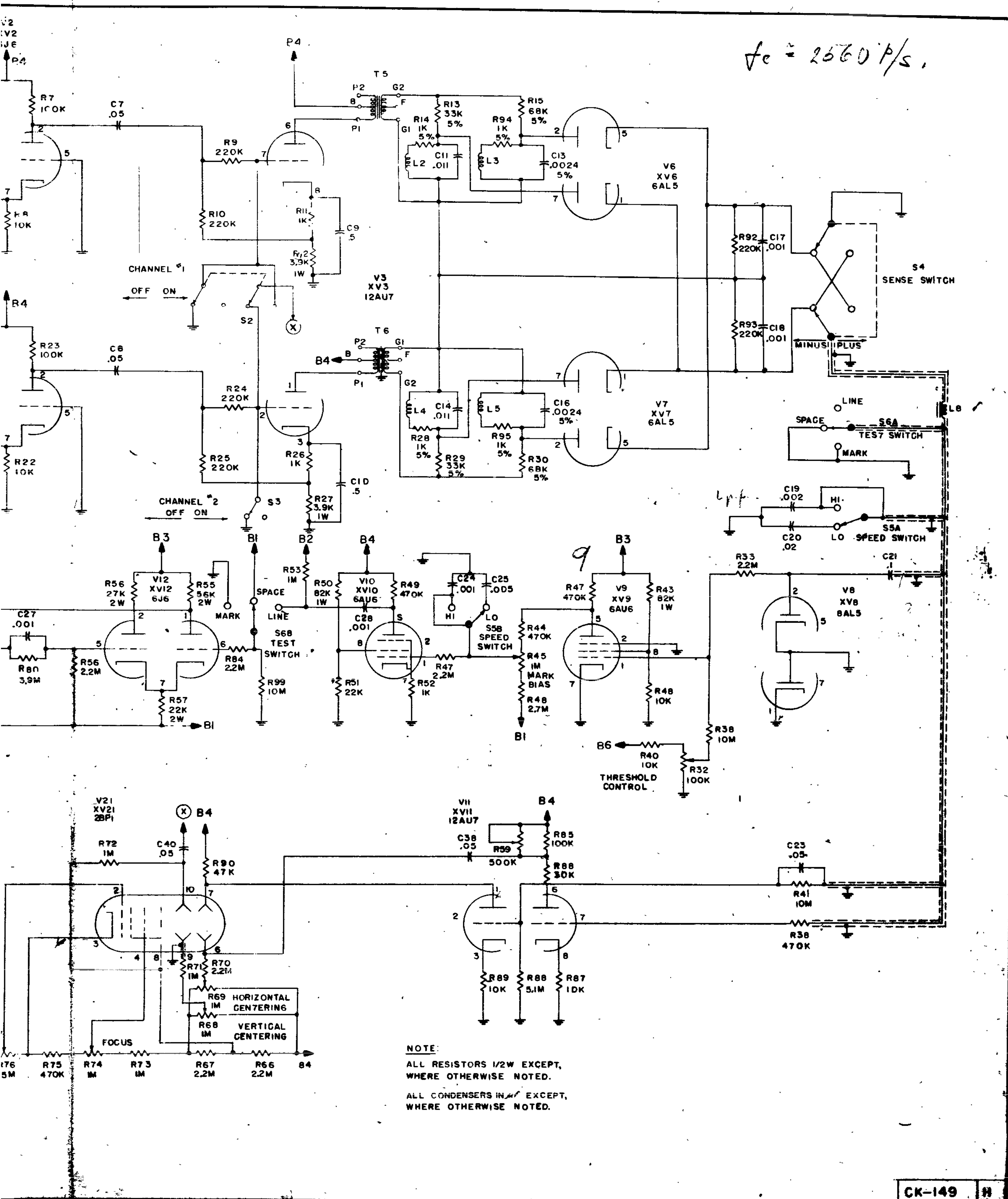


V1 XV1 6AU6
B3
R1 470K
R2 1M
C3 .05
C4 .05
T3
R3 470K
R78 220K
R4 2.2K
C1 .5
R5 470K
R6 470K
V2 XV2 6J6
R7 100K
C7 .05
R8 10K
CHANNEL
OFF
V4 XV4 6AU6
R17 470K
R18 1M
C5 .05
C6 .05
T4
R79 220K
R16 470K
C2 .5
R20 2.2K
R19 470K
R21 470K
V5 XV5 6J6
B4
R23 100K
C8 .05
R22 10K
E1
CHANNEL 1
CHANNEL 2
B SUPPLY
LOAD
LINE CURRENT INC
V14 XV14 6Y6G
R77 2.5K 25W
C32 .02
V22 XV22 6AL5
T7
R65 220K
C30 .001
C28 200 μμf
C29 200 μμf
R91 2.2K
C39 .005
V13 XV13 12AU7
R64 220K
R63 220K 1W
R61 220K
R62 470K
C27 .001
R60 3.9M
R58 2.2M
R56 27K 2W
NOTE:
WHEN REPLACING POWER TRANSFORMER OBSERVE WIRING SCHEME STAMPED ON UNIT.
220 VAC OPERATION
T1
T2
V12 6J6
V21 2BP1
V15 XV15 5Y3GT
V16 XV16 6X4
R82 3K 10W
R80 1K 2W
V17 XV17 OB2
V18 XV18 OA2
V19 XV19 OB2
V20 XV20 OB2
C34 4MFD
C33 4MFD
C36
C35 4MFD
C37 4MFD
L1
R81 3K 10W
B5
B1
B2
B6
B3
B4
V6 6AL5
V7 6AL5
V8 6AL5
V14 6Y6G
V3 12AU7
P1
XF1
F1
I1 XI1
V1 6AU6
V2 6J6
V4 6AU6
V5 6J6
V9 6AU6
V10 6AU6
V16 6X4
V11 12AU7
V13 12AU7
V22 6AL5
V21 XV21 2BP1
R72 1M
INTENSITY
FOCUS
B5
R76 .5M
R75 470K
R74 1M
R73 1M



NOTE:

ALL RESISTORS 1/2W EXCEPT, WHERE OTHERWISE NOTED.

ALL CONDENSERS IN μf EXCEPT, WHERE OTHERWISE NOTED.