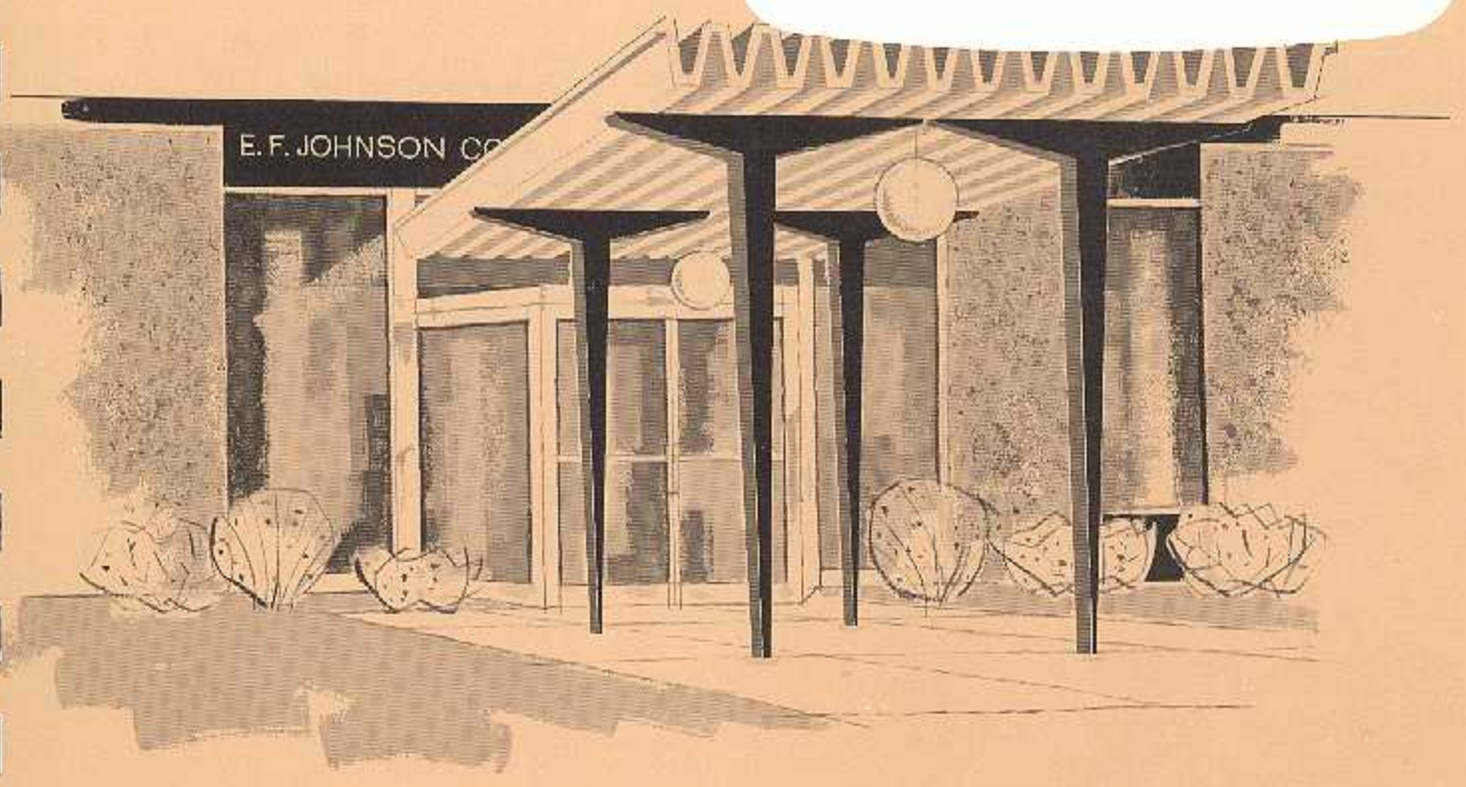
OPERATING MANUAL

VIKING 6N2 THUNDERBOLT AMPLIFIER



E. F. JOHNSON COMPANY
WASECA, MINNESOTA, U. S. A.

STANDARD WARRANTY

Adopted and Recommended by the Electronic Industries Association

The E. F. Johnson Company warrants each new radio product manufactured by it to be free from defective material and workmanship and agrees to remedy any such defect or to furnish a new part, except for electron tubes, in exchange for any part of any unit of its manufacture which under normal installation, use and service disclosed such defect, provided the unit is delivered by the owner to us or to our authorized distributor from whom purchased, intact, for our examination, with all transportation charges prepaid to our factory (return transportation charges also to be paid by owner) within ninety days from the date of sale to original purchaser and provided that such examination discloses, in our judgment, that it is thus defective.

This warranty does not extend to any of our radio products which have been subjected to misuse, neglect, accident, incorrect wiring not our own, improper installation, use of acid core solder, unauthorized modifications, or to use in violation of instructions furnished by us, nor extend to units which have been repaired or altered outside of our factory, nor to cases where the serial number thereof has been removed, defaced or changed, nor to accessories used therewith not of our own manufacture, nor to electron tubes.

The Radio Parts Distributor will assume the responsibility for replacement or exchange of any component part of a unit approved for remedy or exchange hereunder, through the factory Customer Service Department, without charge to the owner.

Defective electron tubes and executed service reports, carefully packed, should be returned prepaid directly to the tube manufacturer for adjustment at the following addresses. Ship power tubes via Railway Express.

NOTE: Tubes marked "E. F. Johnson Co.," regardless of manufacturer, should be returned to E. F. Johnson Co., Waseca, Minnesota.

(a) RCA tubes to: Adjustment Service, RCA at the nearest of the following addresses:

34 Exchange Place
Jersey City 2, N. J.

3601 South Adams St.
Marion, Indiana

6355 East Washington Blvd.
Los Angeles 22, California

(b) General Electric tubes to:
Adjustment Service
Owensboro Tube Works
General Electric Co.
Owensboro, Kentucky

(c) Amperex tubes to:
Amperex Electronic Corp.
230 Duffey Avenue
Hickville, Long Island
New York

(d) Eimac tubes to:
Eitel-McCullough, Inc.
San Bruno,
California

(e) Sylvania tubes to:
Sylvania Electric Products
Dept. EFJ
2001 North Cornell
Melrose Park, Illinois

(f) Penta tubes to:
Penta Laboratories, Inc.
312 North Nopal Street
Santa Barbara, California

This warranty is in lieu of all other warranties expressed or implied and no representative or person is authorized to assume for us any other liability in connection with the sale of our radio products.

JOHNSON VIKING 6N2 THUNDERBOLT AMPLIFIER

Model 240-362-1 (Kit Form)
240-362-2 (Assembled and Tested)

The successful operation of any radio equipment is largely dependent upon the operator's understanding of the equipment. This operating manual is made up of several parts, each with the purpose of making the operator more familiar with the equipment. It is strongly recommended that this manual be carefully read prior to attempting operation of the equipment.

The Viking 6N2 Thunderbolt should be given the good care usually accorded any other fine electronic instrument and in return will provide long trouble free service. Periodic cleaning, dust removal, tube checking, blower oiling, etc., will maintain the appearance and performance of the equipment.

WARNING

The voltages encountered in this piece of equipment are high enough to cause fatal injury. Practice safety rules until they are second nature. Always turn off the high voltage before making any adjustment inside the transmitter. Never depend on a bleeder resistor to discharge filter condensers. After the power is turned off, short circuit the high voltage circuit. Never operate the transmitter with any other than the recommended fuses in the primary circuit. The fuses will protect your equipment - in the case of accidental contact with the high voltage, they may save your life. If children have access to the open transmitter, always disable the primary circuit by removing the fuses, or the high voltage circuits by removing the rectifiers. Always remove the power cord plug from the power source when working inside the transmitter.

OPERATING MANUAL

Contents

		Page
A.	INTRODUCTION	
	1. Function	1
	2. Construction	1
	3. Power Requirements	1
B.	DESCRIPTION	
	1. VHF Amplifier	2
	2. Power Supplies	2
C.	INSTALLATION	
	1-4 Unpacking	2
	5. Power Transformer Installation	2
	6. Tube Installation	3
	7. Neutralization	4
D.	OPERATION	
	1. Meters, Controls and Fuses	5
	2. Connections	6
	3. Preliminary Checkout and Test	6
	4. Tuning Procedure	7
	5. Notes on FM Operation	8
	6. Notes on AM Linear Operation	8
	7. Notes on Use with the 6N2	9
	8. Notes on Use with the Challenger	10
	9. Notes on SSB or DSB Operation	11
	10. Notes on Use with the Communicators	12
	11. Notes on TVI	14
E.	TYPICAL OPERATING AND TROUBLE SHOOTING DATA	
	1. Trouble Shooting	14
	2. Typical Operating Data	17
F.	PARTS LIST	18
G.	ILLUSTRATIONS	

Figure

1	Parts Mounting - Bottom View
2	Finished Bottom View
3	Grid Circuit
4	Plate Circuit
5	Coaxial Cables
6	Resistor Board
7	Chassis Rail Assembly
8	Dial Drives
9	Cable Diagram
10	Top View
11	Rear View
	Schematic

A. INTRODUCTION

1. Function

The Johnson Viking 6N2 Thunderbolt is a self contained VHF power amplifier designed for amateur service. It may be used for CW telegraphy, FM phone, AM linear phone and SSB or DSB phone communication.

The maximum amplifier ratings are:

MODE	PLATE POWER INPUT
CW-FM - Class C or Class AB1	1000 Watts
AM - LINEAR	700 Watts
SSB-DSB - LINEAR	1200 Watts peak envelope power (PEP)

2. Construction

The complete 6N2 Thunderbolt amplifier including high voltage, regulated screen and regulated bias power supplies is contained in a cabinet 21" wide x 11 5/8" high x 16 7/8" deep. The total weight is 120 pounds. A perforated cadmium plated steel cabinet and panel result in a totally shielded enclosure with adequate ventilation.

All operating controls, meters and jeweled indicators are located on the front panel. The R. F. input receptacle, R. F. output receptacle, ground stud, power socket, linear bias adjust, fuses, and the linear bias control jack are located on the rear of the chassis.

To aid in eliminating spurious radiation which might result in interference to other services such as television broadcasting, the transmitter cabinet serves as an effective shield. Monel metal braid is used to bond and seal all possible openings between the one-piece cabinet and panel. The meters are shielded at the rear and have individual R. F. filters in each of the meter leads. All external connections such as the line cord and control cables are equipped with individual R. F. filters to maintain cabinet shielding integrity.

A blower is used to assure adequate air flow thru the 7034's and tank circuit components.

3. Power Requirements

The Viking 6N2 Thunderbolt is designed to operate from a 115 volt two wire or a 230 volt three wire 50-60 cycle single phase AC voltage source.

Typical power demands are:

MODE	CONDITIONS	WATTS
Any (STANDBY)	Plate switch OFF	100
CW or TUNE	Plate switch ON - no drive	380
LINEAR	Plate switch ON - no drive	750
TUNE	Fully loaded - 20 ma grid current	1000
CW	1000 watts plate input	1500
LINEAR	1000 watts plate input	1500

B. DESCRIPTION

1. VHF Power Amplifier

The VHF Power Amplifier (PA) uses two type 7034 (4X250B) power tetrodes (rated at 600 watts plate dissipation) together with a pi-network plate circuit. The pi-network plate circuit uses a hi-Q coaxial inductor on 2 meters, together with hi-Q silver plated variable capacitors for maximum efficiency and output. Bridge neutralization provides stable and simple operation on both bands.

The grid circuit is a dual band device with separate switched input links for each band. Three built-in resistive positions provide swamping of exciters with excess power.

Complete metering of all circuits provides easy tune-up and adjustment.

2. Power Supplies

Two power supplies are used to power the amplifier. A bias-filament supply uses a selenium rectifier to provide immediate grid bias. The plate supply delivers over 2000 volts at full load as well as supplying regulated screen voltage thru a series dropping resistor and voltage regulator tubes. The screen is self protecting due to proper design of associated circuitry.

C. INSTALLATION

1. Inspect all packages for damage due to mishandling or abuse during shipment.

2. Open all packages and inspect contents for hidden damage or missing parts. Remove amplifier from cabinet. Remove all packing material from inside the FINAL enclosure.

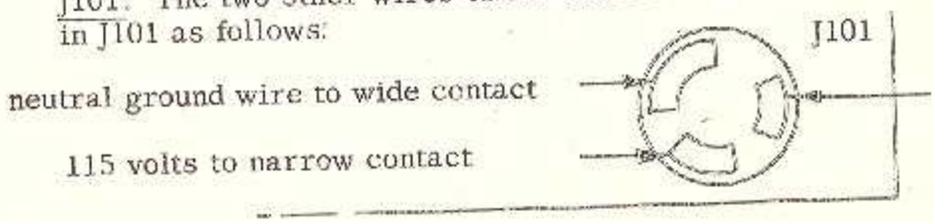
3. Report all claims for transportation damage immediately to the carrier and not to the E. F. Johnson Company

4. Report any missing parts to the distributor.

5. Power Transformer Installation

a. In wired units, the transformer was tested in the amplifier, removed, and shipped in a separate container to avoid shipping damage. All wired amplifiers are shipped wired for operation from a 3 wire, single phase 230 to 250 volt 50/60 cycle power source with a grounded neutral. It is preferable to operate this equipment from this type power source. If it is necessary to operate from a two wire, single phase 115 volt 50/60 cycle source, the amplifier may be converted from the 230 VAC circuit as described in this section.

The three wire cable connecting the 6N2 Thunderbolt to the 230 VAC power should be Underwriter Laboratory approved with current rating of 15 amperes (#12 wire size). The grounded neutral wire of the cable must be connected to the power plug P101 so that it contacts the wide contact of J101. The two other wires of the cable should each connect to a narrow contact in J101 as follows:



C. 5. b. Disconnect the leads from the 13 mfd 2750 volt (nominal W.V.) filter capacitor and remove it from the unit. Install the power transformer in the rear left corner on the top of the chassis so the four mounting studs fit into the holes provided and the five leads feed through the 1 1/8" diameter hole as shown in Figure 1. Secure the transformer to the chassis with a 1/4" lockwasher and a 1/4-20 hex nut on each stud. Make the following connections:

1. Connect the red lead with yellow tracer (H.V. center tap) to terminal 1 of FH104 (S). See Figure 1.

2. Connect the black wire with green tracer to terminal 1 of TS1.

3. Connect the white wire to terminal 2 of TS1.

4. Connect the black wire to terminal 3 of TS1.

5. Connect the black wire with red tracer to terminal 4 of TS1.

c. Conversion to two wire 115 VAC operation is accomplished by making the following changes:

1. Disconnect the white wire with brown tracer from terminal 4 of TS1 and connect this lead to terminal 1 of TS1 (rear terminal).

2. Disconnect the black lead from terminal 3 of TS1 and connect this lead to terminal 1 of TS1 (front terminal).

3. Disconnect the red lead with black tracer from terminal 4 of TS1 and connect this lead to terminal 2 of TS1.

4. Disconnect the white wire with black tracer from terminal 3 of TS1 and connect it to the grounded screw terminal on the end of TS1.

5. Connect the two narrow contacts of the power plug P101 together with a short length of No. 16 tinned wire (Be sure the power cord is completely disconnected from the power source.) The 115 volt power source has one lead at ground potential and the other lead 115 volts above ground and this polarity must be observed when connecting the power cord to P101. Connect the 115 volt power lead which is above ground to the two narrow contacts. Connect the grounded 115 volt power lead to the wide contact of P101. Use #10 wire size.

d. Install the 13 mfd filter capacitor and reconnect the two leads.

6. Tube Installation

Carefully install the two 3B28 rectifier tubes, V101 and V102, and the four voltage regulator tubes V105, V106, V107 and V108 in their sockets as shown in Figure 10.

Install the two 7034 (4X250B) tubes V3 and V4 inside the enclosure as follows: (These may already be installed.)

a. Insert the two tubes into the sockets (be sure to index properly).
b. Slip one of the air flow chimneys over each of the tubes.

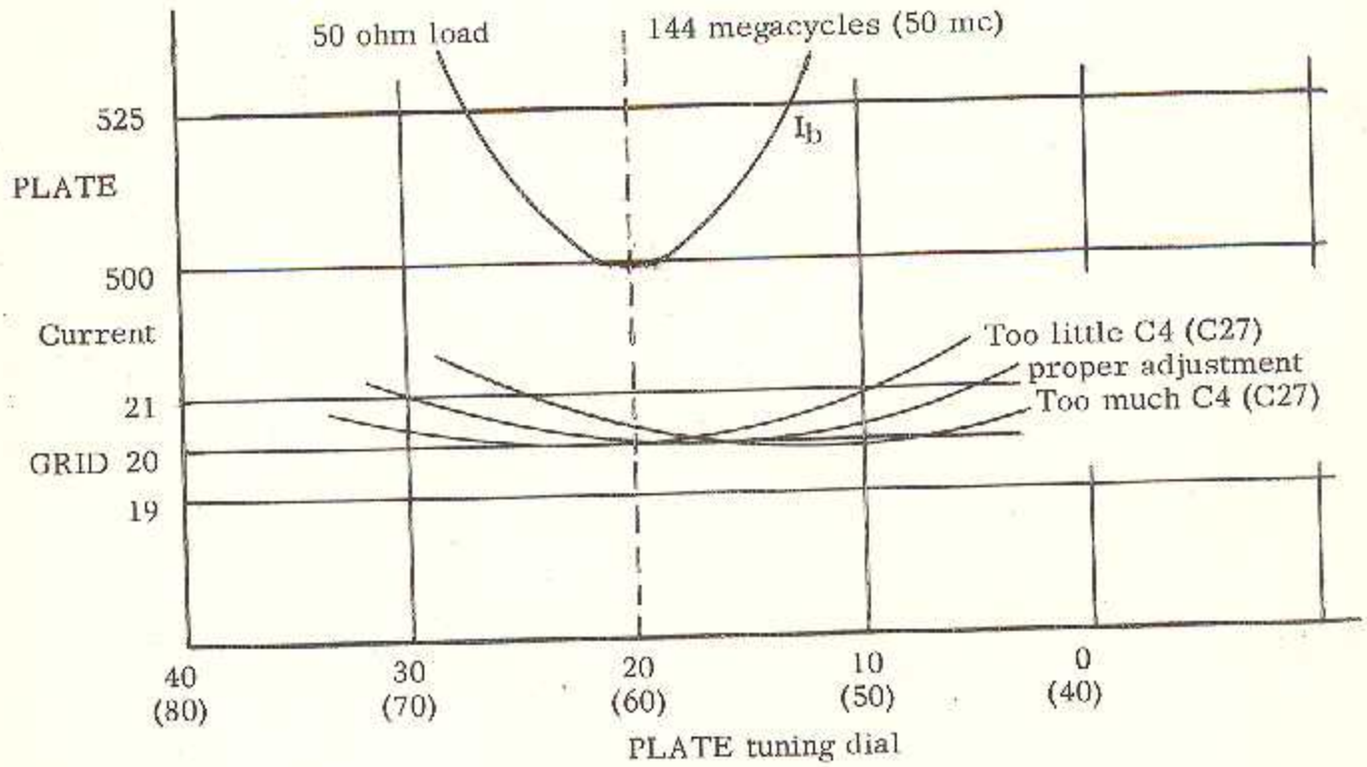
C. 6. c. Slip the plate connector (E1) over the tubes (see Figure 4).
d. Fasten E1 to C11 and C12 using two 6-32 x 1/4" screws and lockwashers. Do not tighten.
e. Insert a 8-32 x 1/2" screw and lockwasher into each tube clamp. Carefully tighten the clamps (keep twisting strain on the tubes to a minimum).
f. Solder L10 to the teardrop on E10 (may already be soldered in place).
g. Tighten the screws fastening E1 to C11 and C12.

7. Neutralization

Factory wired 6N2 Thunderbolts are already neutralized and should not be readjusted.

Each band has an individual neutralization adjustment. The 2 Meter adjustment must be done first. The 6 Meter adjustment will not affect the 2 Meter adjustment. When properly neutralized, the grid current change with PLATE tuning will be symmetrical with plate current change.

TYPICAL GRID and PLATE CURRENT versus PLATE TUNING



Procedure:

1. Set: C4 to minimum capacity. See Figure 11.
C27 to 50% capacity.
MODE to TUNE.
GRID INPUT and BAND to "2".
2. Tune and load to 600 watts input with 20 ma of grid current.
3. Check neutralization and adjust C4 until neutralized. Keep GRID TUNING peaked.
4. Turn MODE to CW and load to 1000 watts input with 20 ma of grid current. Readjust neutralization as necessary.
5. Repeat on 6 meters with GRID INPUT to "6" and adjusting C27.

D. OPERATION

1. Meters, Controls and Fuses

a. PLATE CURRENT - POWER INPUT meter (M2) indicates the plate current of the amplifier and the power input for a plate voltage of 2100 volts. When operating near or at the legal maximum input (1000 watts) the actual power input is: (plate current - ISS) times plate voltage.

b. The MULTI-METER (M1) indicates the GRID current, SCREEN current, R.F. OUT (radio frequency) volts, D.C. PLATE voltage, and ISS (Screen supply current) as selected by the METER switch located below the meter. The top scale reads currents (60 ma. full scale) and the bottom scale is in Kilovolts for plate voltage measurement. The R.F. OUTPUT is only relative volts.

c. The FIL switch controls the filament and bias voltages. The filament switch must be turned on only when the plate switch is in the off position. One minute must be allowed for heating of the rectifier filaments before the plate switch is placed in the ON position.

d. The PLATE switch controls the high voltage and screen voltage. It must be in the OFF position when the filament switch is turned on.

e. The MODE switch selects the proper bias and screen voltage for CW, TUNE and LINEAR operation. The CW position is used for Class C operation of the 6N2 Thunderbolt amplifier. The TUNE position is used for tuning and loading of the amplifier. The LINEAR position is used for AM, SSB and DSB operation of the amplifier.

f. The BAND switch adds the six meter plate coil (L6) in series with the two meter coaxial line for six meter operation.

g. The GRID INPUT selects either the 2 meter link, the 6 meter link or any one of three resistive conditions of grid circuit.

h. The GRID TUNING controls the grid circuit tuning capacitor.

i. The PLATE tuning controls the plate circuit tuning capacitor.

j. The COUPLING controls the variable loading capacitor to obtain the desired plate current (loading).

k. The 6N2 Thunderbolt has four fuses (F101, F102, F103, F104) located at the rear of the amplifier chassis. The fuses protect the following circuits.

(1). F101 protects all AC power primaries.
(2). F102 protects the high voltage transformer primary.
(3). F103 protects the blower and the filament-bias transformer primary.
(4). F104 protects the high voltage transformer secondary.

l. J102 (on the rear of the chassis), in the LINEAR position of the MODE switch provides control of blocking and operating bias. An external set of SPST relay contacts (usually available in the exciter) transfers the bias from blocking to operate. Blocking bias is used during standby periods to cut off the amplifier thus reducing power consumption and plate dissipation and eliminating diode noise in the receiver when a TR switch is used.

m. The LINEAR bias adjust (R114) is located on the rear of the chassis. The static plate current is set to 200 milliamperes with this control with the MODE switch at LINEAR. (No grid drive).

D. 2. Connections

a. Ground Connections

Caution: For safety reasons, it is very important that all equipments be grounded to earth with heavy conductors.

Both the Viking 6N2 Thunderbolt and the exciter chassis should be bonded together by a heavy copper wire or strap. The same type wire or strap should be used to connect the chassis to an earth ground. The length of the ground wire should be as short as possible avoiding lengths which are a quarter wavelength long on any of the operating frequencies. If the ground lead must be long, it is desirable to make its length a 1/2 or full wave long on the operating frequencies. In some installations, it may be advisable to install more than one ground wire.

NOTE: Be sure the four cabinet tie rods and 20 screws (with lockwashers) attaching the cabinet are tightened securely.

b. Antenna Connections

Connect a RG-8/U coaxial feed line to the output receptacle J2 (receptacle toward outside of chassis) on the rear of the unit. Use a type PL259 plug. If a low pass filter is inserted in the feedline, use only a short length of coaxial line between the transmitter and filter.

c. Exciter Connection

The connection between the exciter and the 6N2 Thunderbolt should be a 42" length of RG-8/U or multiple thereof.

d. Antenna Relay

The antenna relay should be controlled at the exciter.

e. Power Cord - See Section C5.

3. Preliminary Checkout and Test

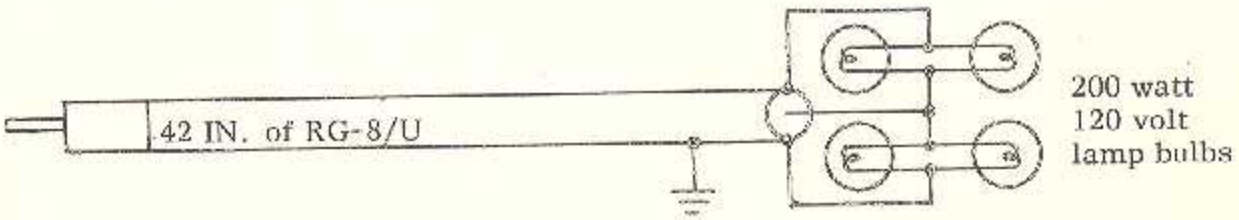
a. Make certain the tubes are properly seated and the plate caps connected.

b. Place in cabinet and secure screws.

c. Turn PLATE switch to OFF and FIL switch ON. The blower should start immediately and the OA3 VR tube should light up orange with the MODE switch at TUNE and CW.

d. Connect a dummy antenna* and test on 6 meters. Follow TUNING PROCEDURE D4.

*A dummy load for 6 meter operation can be made using four 200 watt 120 volt lamp bulbs. Connect the four bulbs in parallel (keep leads very short) and connect the lamps to the 6N2 Thunderbolt thru a short length (42 in.) of RG-8/U coaxial cable. Use an antenna on 2 Meters.



D. 3. Practice in tuning with a lamp load is a valuable aid in familiarization with the operation of the amplifier.

e. Ground the center contact of P102 (phono type plug) and plug P102 into J102. Turn MODE to LINEAR and set the LINEAR static Plate current to 200 ma. with R114. See Section Dlm.

4. Tuning Procedure

CW TELEGRAPHY is normally run with the MODE switch at CW (Class C).

Tune-up is as follows:

a. Connect exciter output to J1 (use 42" coaxial cable).

b. Ground all units together and to earth (see D2).

c. Connect a 50-70 ohm antenna (dummy load recommended for initial tune-up, see D3) to J2.

d. Set the 6N2 Thunderbolt controls as follows:

1. PLATE switch to OFF.
2. FIL switch to ON.
3. MODE to TUNE.
4. METER to GRID.
5. BAND to "6" or "2". Never switch with PLATE switch ON.
6. COUPLING - see page 17. ← Use only between 30 and 70 on 2 Meters.
7. PLATE tuning - see page 17. ← Use only between 0 and 50 on 2 Meters.
8. GRID TUNING - see page 17. * CAUTION!! *
9. GRID INPUT to "6" or "2".

e. Plug in power. (Blower should run).

f. Tune-up exciter and GRID TUNING (tune GRID TUNING for maximum) to give 30 ma. of GRID current in the 6N2 Thunderbolt.

g. Turn PLATE switch ON and quickly tune PLATE tuning (big knob) for resonance (plate current dip) as indicated on PLATE CURRENT METER.

h. Adjust the COUPLING and PLATE tuning until about 650 watts (with 25 ma. of grid current) input is secured at resonance. After each incremental adjustment of COUPLING (coupling increases with increasing numbers), the PLATE TUNING is adjusted for resonance (plate current dip). Tuning for dip should always be the last adjustment.

i. Switch MODE switch to CW and readjust COUPLING and PLATE tuning to obtain 1000 watts input with 20 ma. of GRID current.

NOTE: If the amplifier is tuned to the proper values of plate and grid current in step h, little or no readjustment will be necessary when the MODE switch is turned from TUNE to CW.

j. Turn MODE switch to TUNE. Note and record GRID current, SCREEN current and PLATE current. These are the values to tune to in step h for future tune-ups. Record values on page 22 for future tune-ups.

D. 4. k. Keying the exciter will operate the amplifier.

1. CW Telegraphy in the LINEAR (class AB1) position of the MODE switch.

If the exciter used has insufficient output to drive to 16-20 ma. of grid current in the CW position of the MODE switch, CW telegraphy should be run in the LINEAR position. Zero grid current is necessary for 1000 watts input telegraphy. (Zero grid current means driving the grid just to the grid current region, i.e. 0 to 1 ma. of grid current). See Section D1m.

5. Notes on FM Operation

FM phone operation is the same as CW telegraphy. (20 ma. of grid current for 1000 watts input in the CW position or 0-1 ma grid current in the LINEAR position of the MODE switch.)

6. Notes on AM LINEAR Operation

700 watts of AM linear can be run using exciters with as little as 6 watts output.

Once the linear is tuned up to peak output with a single tone (carrier only) all that is necessary to change to AM linear is to reduce the input to the linear to the point where the output is 1/2 its peak value.

The R.F. OUT position of the METER switch is a RF voltmeter and makes adjustment easy. Note the R. F. OUT volts with single tone zero grid current (0 to 1 ma.) and peak loading (do not over-couple). Then reduce the grid drive until the RF OUT reading is 1/2 its peak value. Plate input should be between 650-700 watts (do not exceed 700 watts).

The 6N2 Thunderbolt is designed for easy tune-up. To change from CW to AM LINEAR tune up to 1000 watts input with 20 ma. grid current in CW position (GRID INPUT at "6" or "2"), turn GRID INPUT to R1, R2, or R3 (as necessary - keep exciter resonated) turn MODE to LINEAR. Plate input should be 650 to 700 watts (if above 700 watts in R3 position reduce exciter output or the value of R1 can be increased or decreased using 2 watt carbon resistors). Modulate exciter normally.

CAUTION

The useful range of the FINAL tuning and COUPLING controls is limited on 2 meters.

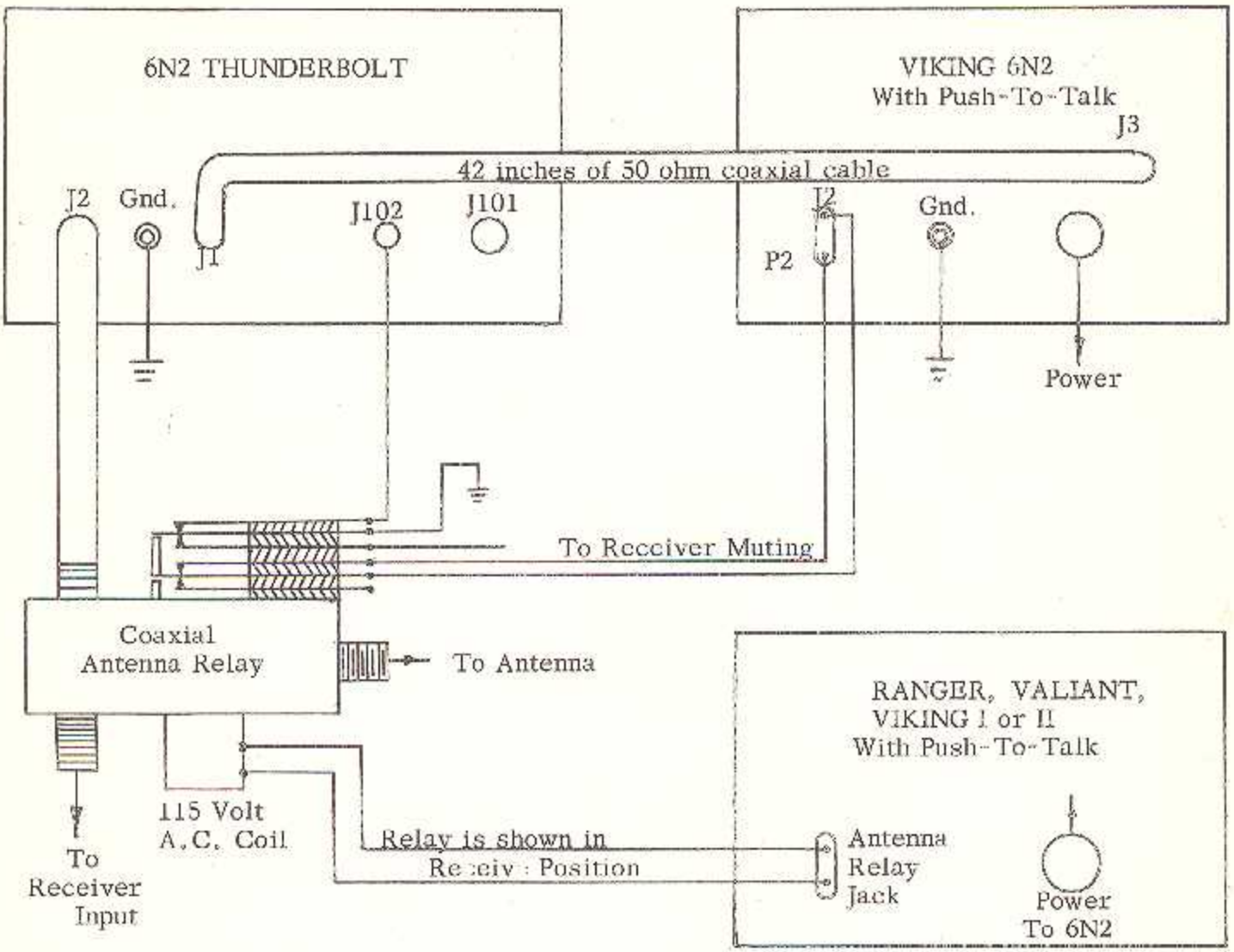
The FINAL tuning should be used only between 0 and 50 on 2 Meters. It is possible to double between 50 and 60 and as this doubling is lightly loaded, it is hard on tubes and components.

The COUPLING control should be used only between 30 and 70 on 2 Meters.

Be certain the antenna, feedline and balums are capable of handling 700 watts of RF energy. Vertical quarter-wave antennas should have a ball on the end to prevent corona.

Always keep the amplifier fully loaded. Do not operate with light loading (COUPLING). Do not overcouple as the efficiency goes down and the plate dissipation rises rapidly. Overcoupling is indicated by failure of the RF output to increase with increased COUPLING. Both light and overcoupled loading will shorten tube life.

D. 7. Notes on Use with the Johnson Viking 6N2 Transmitter as exciter.



Push-To-Talk operation is recommended and is shown above.

6 Meter Operation

CW

a. Connect as shown above.
b. Tune and load 6N2 and 6N2 Thunderbolt as per section D4. (GRID INPUT to R1)

Phone

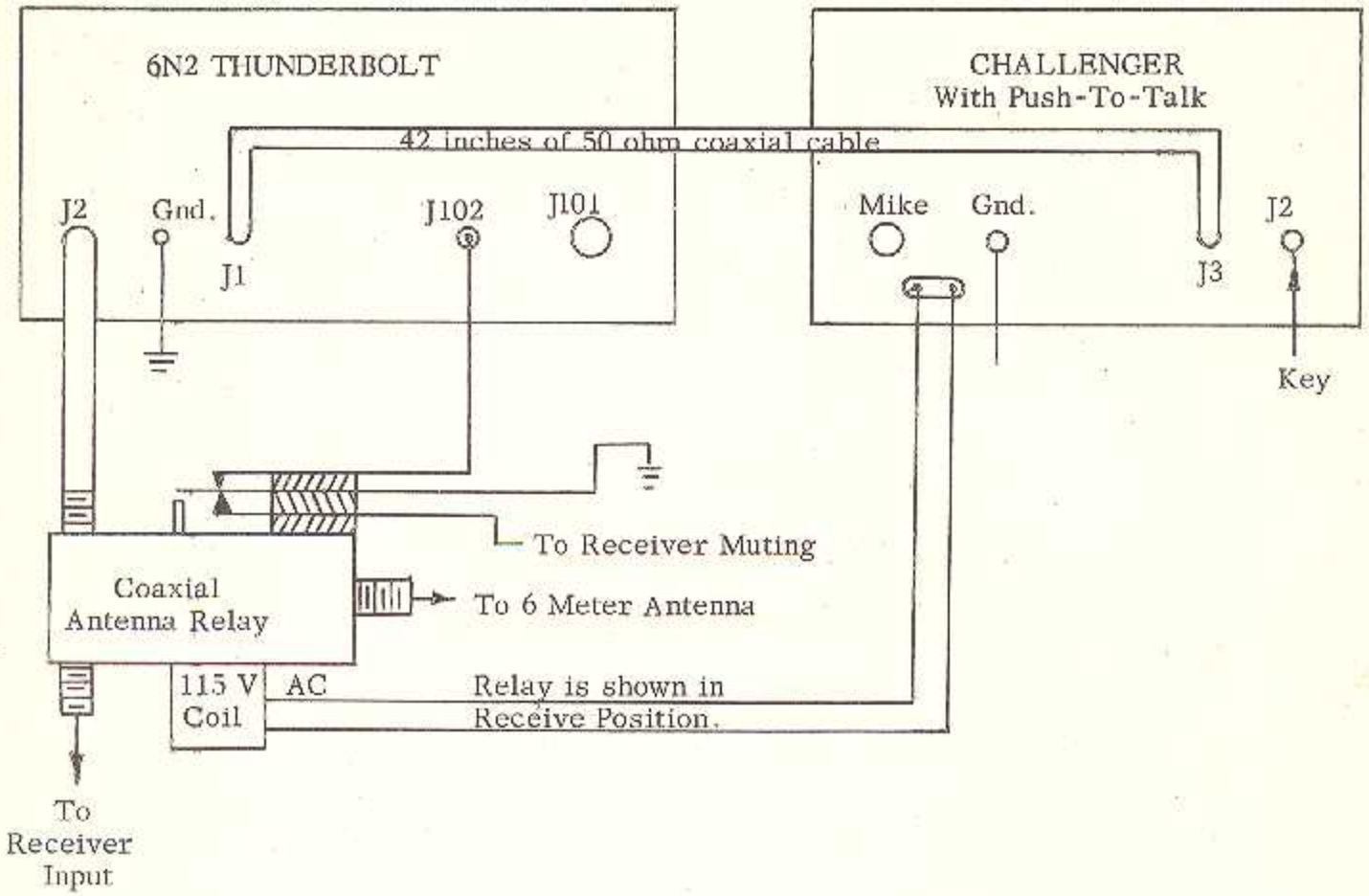
c. Turn GRID INPUT to R3 and MODE to LINEAR. (See Section D1m).
d. Adjust 6N2 COUPLING AND FINAL TUNING for 700 watts input in the 6N2 Thunderbolt.
e. Modulate 6N2 normally (A check of modulation on a scope to determine audio gain setting is recommended).

2 Meter Operation

Same as 6 Meter operation except:

a and b. CW - set GRID INPUT to "2" - set 6N2 FINE COUPLING to "10".
c and d. PHONE - set GRID INPUT to R1.

D. 8. Notes on Use with the Johnson Viking Challenger Transmitter as exciter.



6 Meter operation with the Johnson Viking Challenger (Modified for Push-To-Talk) is as follows:

CW Operation

a. Connect as shown above.

b. Tune and load the Challenger and 6N2 Thunderbolt as per section D4 (1000 watts plate input with 20 ma. of grid current).

Phone Operation

c. Perform steps a and b.

d. Tune Challenger to 150 ma. plate current in the CW position.

e. Switch to PHONE.

f. Turn MODE to LINEAR. (See Section Dlm).

g. Press Push-To-Talk button. The 6N2 Thunderbolt plate input should be 650-700 watts. If over 700 watts, readjust GRID TUNING or the Challenger LOADING and PLATE tuning slightly to reduce input. Keep Challenger PLATE tuning dipped.

D. 8. h. Modulate Challenger in normal manner.

9. Notes on SSB or DSB Operation

The Johnson Viking 6N2 Thunderbolt uses voltage-regulated bias and screen supplies and a well regulated plate voltage supply to assure good linearity and low distortion. Although the 6N2 Thunderbolt is very "clean", the on-the-air signal can be no better than the signal supplied by the exciter.

A SSB exciter should be loaded to rated input when it is used to drive a linear amplifier in order that the inherent signal-to-noise and suppression characteristics of the exciter be fully realized. This requires an attenuator or "swamping" load to absorb excessive power when the exciter produces more output than needed to excite the linear amplifier. The 6N2 Thunderbolt operates in Class AB1 (zero grid current) up to a peak envelope power input of 1200 watts. Do not drive into the grid current region (limit audio level to the point where grid current just starts to flick upward on audio peaks).

The linearity of any linear amplifier is largely dependent upon the loading and it is important, therefore, that a linear amplifier be properly loaded. Fortunately the plate impedance is almost identical for Class C and Class AB1 operation. Therefore when loaded properly in CW position (1000 watts input with 20 ma. of grid current) loading is also proper for the LINEAR position (plate input will run about 1200 watts for grid drive just to point where a trace of grid current shows on meter). See Section D1m.

When the loading is too light, the amplifier is driven into saturation prematurely and the output is considerably reduced. If the coupling is too heavy, saturation is no problem but the output will be below that of proper coupling. To establish correct loading, the transmitter may be tuned up at the anticipated operating frequency with the MODE switch in the CW position. The power amplifier should be loaded up to 1000 watts input using the regular CW tuning routine and with normal grid current of 20 ma. Both Grid tuning and Plate will be left unchanged from this point on. Swamp out excess exciter power and turn MODE switch to LINEAR.

SSB performance may be tested using only a cathode ray oscilloscope having an adjustable horizontal sweep and an audio signal generator. The audio signal generator may be a simple oscillator operating at a fixed frequency between 250 and 1000 cycles.

If a SSB transmitter is modulated with 1000 cycle tone, the output would appear as a continuous wave signal 1000 cycles removed from the original carrier frequency. If the transmitter system for suppressing the carrier is then deliberately upset, an AM sideband will appear at the same frequency but out of phase with the SSB sideband. By adjusting the degree of imbalance in the sideband suppression system and the amount of audio applied thru the exciter audio input jack, an oscilloscope waveform (two-tone pattern) can be produced which appears as a series of positive and negative halves of sine waves, the bottoms of the waves coinciding on a common base line. This scope pattern with rounded tops and bottoms and with intersections forming an "X" are indicative of linear output of the system.

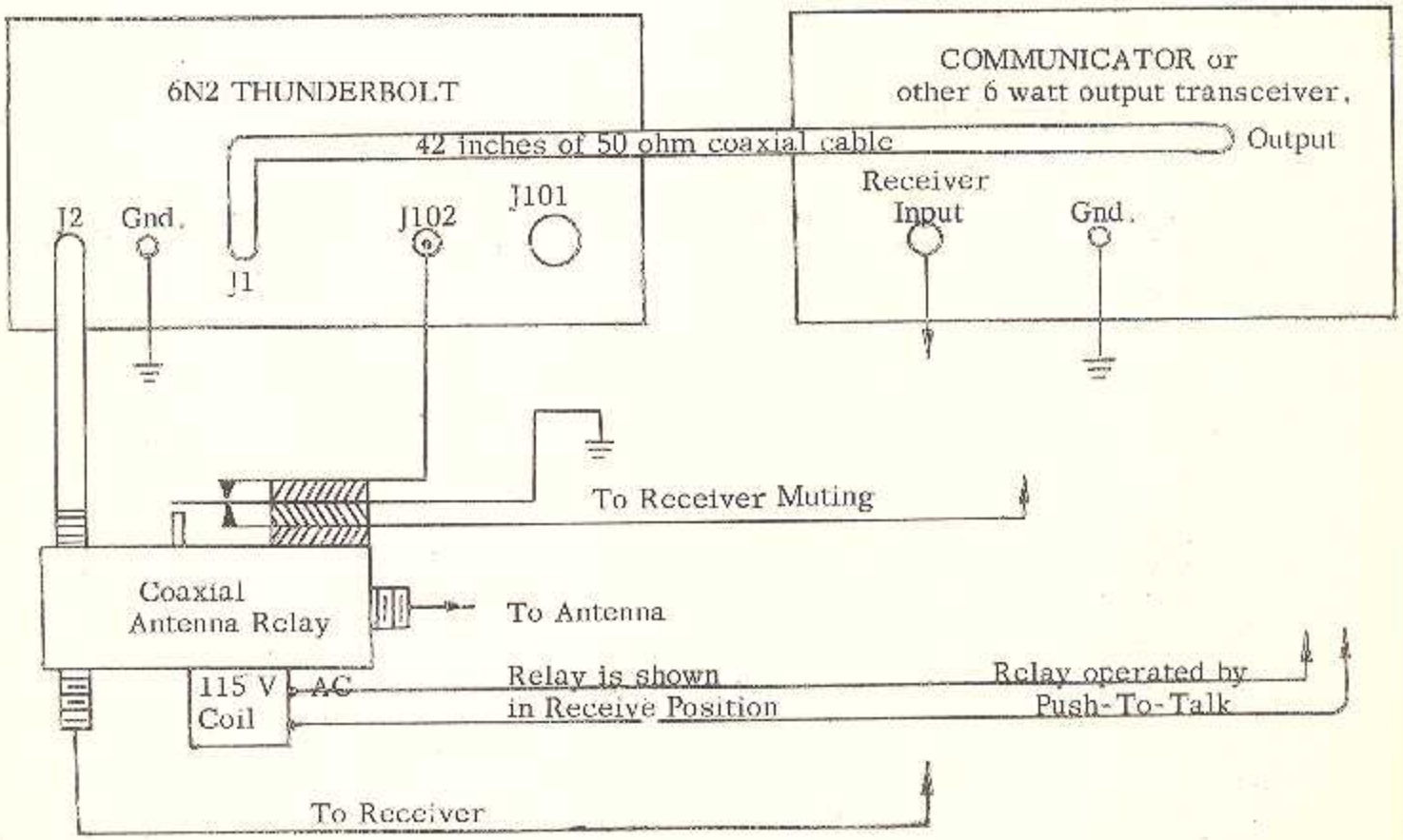
Adjust the power amplifier loading in accordance with the preceding instructions. With the SSB exciter feeding the transmitter in the SSB mode of operation, inject carrier and at the same time introduce the audio signal to the exciter audio input.

D. 9. Feed a sample of the amplifier output directly to the vertical plates of a cathode ray oscilloscope. Set the internal horizontal sweep to approximately four times the audio modulation frequency. Adjust the amplitude of the RF sample so it fits conveniently in the scope face. Vary the exciter audio control and carrier injection so that the test pattern described is produced. If the halves of sine waves do not meet in the center of the scope, too little audio is being applied. If the tops and bottoms of the wave forms are cut off, too much carrier is being injected. Increase carrier injection and audio to the point where the wave forms are beginning to be slightly distorted by flattening on the tops and bottoms. Plate current at this point of saturation should be about 420 ma. under conditions of proper loading.

Leave the test set-up as is. Substitute the microphone for the audio oscillator previously used. Readjust the exciter to eliminate the carrier component of its output. Speak into the microphone in a normal manner and adjust the audio control while watching the scope. It will be easy to note the point where peaks start to be clipped. THIS IS THE LIMIT OF AUDIO INPUT. Note the plate current peak reading where clipping just begins with this particular transmitter and do not exceed this current. The indicated peak current will vary depending upon the operator's voice.

10. Notes on Use with Communicators.

6 watts of power output from a 6 or 2 meter exciter will drive the 6N2 Thunderbolt to a full kilowatt input for CW telegraphy or FM phone operation. The Communicators do not have provision for telegraphy or for control of an antenna relay (however, a little ingenuity on the part of the amateur can easily remedy this). 700 watts AM LINEAR phone can also be run.



D. 10. Tuning Procedure

a. Remove R1 (200 ohm 10 watt resistor) from the grid circuit (see Figure 3) and replace with two 1000 ohm 2 watt carbon resistors in parallel (makes a 500 ohm 4 watt unit).

b. Connect exciters (transceiver) as shown above.

c. Read Section D1 thru D5 carefully. (See Section D1m.)

6 Meter CW Operation

d. Tune exciter and 6N2 Thunderbolt as per section D4 (GRID INPUT at "6", MODE at CW, 1000 watts input with 20 ma. of grid current).

6 Meter Phone Operation

e. Turn GRID INPUT to R1 and MODE to LINEAR. AM carrier level should be 600 to 700 watts. If carrier level is over 700 watts turn to R2 or R3 to reduce carrier level below 700 watts.

f. Modulate in normal manner (a check of modulation on a scope to determine audio gain setting is recommended).

2 Meter CW Operation

a. Perform steps a, b and c above.

b. Set - MODE at TUNE.
GRID INPUT to "2".
METER at GRID.
BAND at "2".
COUPLING as shown on page 17.
PLATE tuning as shown on page 17.

c. Tune exciter and GRID TUNING (tunes sharply, see page 17) for maximum GRID current in the 6N2 Thunderbolt (0 to 5 ma. is sufficient).

d. Turn PLATE switch to ON and quickly tune PLATE tuning for resonance (dip in plate current).

e. Turn MODE to LINEAR and load 6N2 Thunderbolt to 1000 watts input with a GRID current of 0 to 1 ma. Key the exciter for telegraphy.

Note; Screen current is a sensitive indicator of plate circuit resonance.

2 Meter Phone Operation

f. Turn GRID INPUT to R1 and MODE to LINEAR. AM carrier level should be 600-700 watts. If carrier level is over 700 watts, turn to R2 or R3 or reduce exciter output slightly.

g. Modulate in normal manner (a check of modulation on a scope to determine audio gain setting is recommended).

D. 11. Notes on TVI

Many hams have taken for granted that simply because the 6 meter band is adjacent to Channel 2 it is impossible to use 50 mc. without extensive neighbor trouble. This need not be true. The 6N2 Thunderbolt is extensively shielded. The major problem is TV set front-end overload. The cure is a good high pass filter at the TV sets. They may be made as per the July 1954 QST article or purchased commercially (models which reject 52 mc. and below).

Suggested (necessary) reading on 6 and 2 meter TVI is as follows:

a. 50 MC TVI - It's Causes and Cures - Ladd, QST, June and July 1954

b. Television Interference - Phil Rand

c. ARRL Handbook - TVI chapter.

E. TYPICAL OPERATING AND TROUBLE SHOOTING DATA

1. Trouble Shooting

a. Schematic, photographs and charts aid greatly in trouble shooting and are furnished in this section for reference. Particularly useful are the typical operating voltages, current readings and resistance measurements. Use these charts and listings to save time in locating trouble.

b. Some precautions to be observed are:

1. Be careful while making high voltage measurements. Do not take chances.

2. Never depend on bleeder resistors to discharge capacitors. After turning equipment off, discharge each filter capacitor with a screw driver which has a well insulated handle.

3. All power supplies must be off and discharged when making ohm meter measurements with the ohmmeter.

The best procedure to follow is to attempt to isolate the trouble to a section of the equipment such as:

a. High Voltage supply

b. Bias Voltage supply

c. Exciter

d. Antennas

e. Auxiliary circuits such as antenna transfer, relay circuit, meter circuit, etc.

A thorough understanding of the schematic diagram and circuitry will prove an invaluable aid in locating any trouble. Once the trouble is localized the primary offenders would be tubes. They should be checked or a good tube substituted in the equipment. Frequent reference to the voltage and resistance charts will also aid in a swift and accurate analysis of the trouble.

E. 1. c. Voltage and resistance check list

Resistance Values, may be useful in trouble shooting.

All resistance measurements are to ground, unless otherwise noted, and may vary ± 10% in value. Power plug P101 and bias control plug P102 removed from sockets. Refer to Figures for location of measurement points. Turn R114 fully clockwise (from rear).

Test Point	Resistance (ohms)
BIAS - pin 1 of XV105	5200
High Voltage - pin 4 of XV101 (shorting switch closed)	35
High Voltage - pin 4 of XV101 (shorting switch open)	24000
GRID - C7 - MODE switch at CW	14000
GRID - C7 - MODE switch at LINEAR	4000
SCREEN - C13 - MODE switch at CW	11500
SCREEN - C13 - MODE switch at TUNE	25300
SCREEN - C13 - MODE switch at LINEAR	13300
High Voltage Transformer, T101	
Black wire to black-red wire	.6
White wire to black-green wire	.6
Red-yellow wire to red wire	120
Red-yellow wire to red wire	120
High Voltage Filter Choke, L101	
Between two leads, max.	65
Low Voltage Choke, L102	
Black to black wire, ± 15%	290
Filament-Bias transformer, T102	
Brown to brown wire	65
Green to green wire	practically zero
Yellow to yellow wire	practically zero
Black to black wire	4.5

Voltage Values

WARNING! The voltages encountered in this equipment are high enough to cause fatal injury. Exercise extreme caution when making the following checks.

Place a grounding hook, with an insulated handle, on the rectifier tube caps whenever working inside the cabinet with the primary power plug in its socket and the PLATE switch OFF. All measurements are with respect to chassis ground, without grid drive or plate voltage, and may vary plus or minus 10 percent.

E. 1. c. Keep the PLATE switch OFF. Connect an earth ground to the chassis. Turn FIL to ON. The blower should start, if it doesn't start turn off FIL immediately (The 7034 tubes need air to prevent overheating even with filament power). The OA3 VR tube should light up orange in the TUNE and CW positions of the MODE switch.

Test Point	MODE switch position	Voltage
C7	LINEAR	-80
C7	TUNE	-75
C7	CW	-75

Plate voltage: Place unit in the cabinet and make all connections. With the amplifier operating in the CW mode (20 ma. grid current and 1000 watts input) the plate voltage should read 2000 to 2300 volts depending upon the line voltage.

Screen voltage can be checked by viewing the VR tubes or more accurately at the bottom terminal of R120.

d. The Screen Supply current (ISS) is set with the sliders on R120. Set the sliders on R120 as follows:

1. Top slider (violet lead) to 6200 ohms, measured from the top terminal to the slider. Tighten carefully.

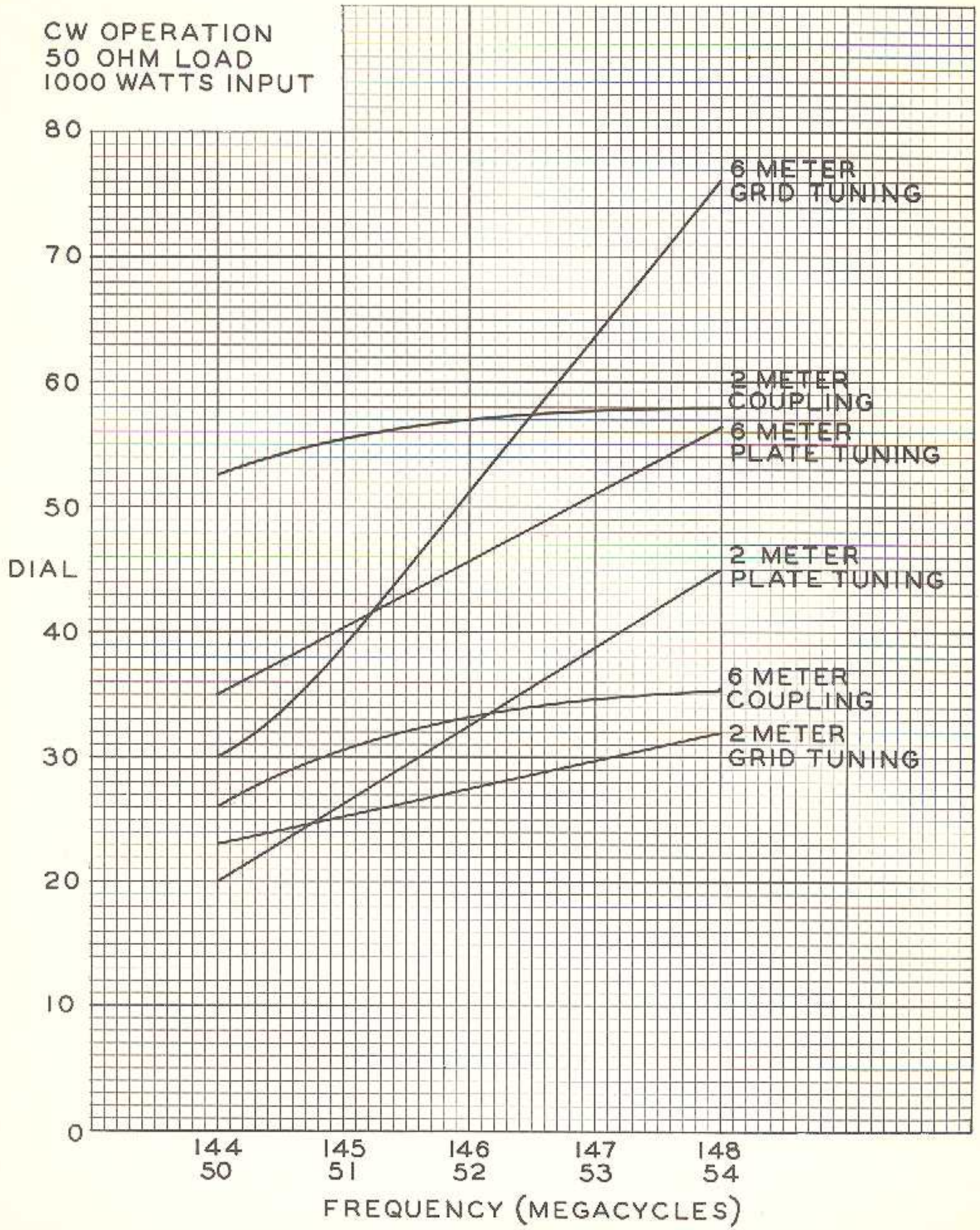
2. Bottom slider (red lead) to 8000 ohms, measured from the top terminal to the slider. Tighten carefully.

ISS current for 115 volt or 230 volt line and no drive should be 40 ma. in CW position and 28 ma. in LINEAR position.

TYPICAL OPERATING VALUES

50 Ohm Load Line Voltage = 230 or 115 Volts	CW		TUNE		AM LINEAR		SSB or DSB	
2 Meter (144 MC)	Transmit	No Excitation	Transmit	No Excitation	Transmit Carrier	With Blocking Bias	Transmit Two Tone	Without Blocking Bias
PLATE current	530	40	310	40	350	38	450	200
GRID current	20	0	20	0	0	0	0	0
SCREEN current	30	0	0	0	-4	0	-4	-4
R.F. OUT	44	0	15	0	16	0	--	0
Volts (Plate)	2000	2200	2050	2200	2000	2200	2000	2100
ISS	32	40	36	40	28	30	28	28
SCREEN Voltage	255	255	150	150	360	360	360	360
Bias Voltage	-78	-75	-78	-75	-55	-55	-55	-55

2. TYPICAL OPERATING DATA



VIKING 6N2 THUNDERBOLT AMPLIFIER

Parts List

Part No. or Drawing No.	Item No.	Qty.	Description
22.1536	B101	1	Blower
16.1001-15	BKT6	1	Bracket, component, 2 1/2"
16.1001-16	BKT2	1	Bracket, component, 2 1/2" with extra hole
16.1001-12	BKT3	1	Bracket, component, 1 7/8"
16.1001-17	BKT4	1	Bracket, component, 1 7/8" with 1/2" hole
16.82-27	BKT7	1	Bracket, 3 7/8", panel support
16.82-29	BKT9a, b	2	Bracket, H.V. shorting switch
17.1104	BKT1	1	Bracket, 1 5/32", panel support
16.1452	BKT5	1	Bracket, plate assembly
23.1348	CH1	1	Chassis
23.1128-2	CH2	1	Cabinet
17.853-2	CH3a, b,	2	Chassis rail
23.1127-9	CH4	1	Panel
17.1091	CH5	1	Bottom plate
23.1333	CH6	1	Top plate
22.1182-2	CH7a,b	2	Bracket, meter shield
22.1181-2	CH8a, b	2	Shield, meter
17.1084-2	CH9	1	Enclosure - left side
17.1084-1	CH10	1	Enclosure - right side
18.750	CH11	1	Mounting board, resistor, transite
17.1040-11	CH12	1	Grid compartment bottom cover
22.1413	CR	1	Crystal diode, 1N294
22.4012-10	C16a, b	2	Capacitor, 3 mmfd ± 10% mica
22.4025-5	C18a, b	2	Capacitor, 10 mmfd ± 5% mica
22.1184	C1, 2, 3	3	Capacitor, .001 mfd 600 volt disc
148-6-8	C4, C27	2	Capacitor, 100S8 variable
22.4018-5	C5	1	Capacitor, 5 mmfd mica
167-102-7	C6	1	Capacitor, variable, 25L15
22.1587	C7, 13, 20, 26	4	Capacitor, .001 mfd feedthru with nuts (unassembled)
16.1415	C9	1	Capacitor, flat plate
22.827	C21, 22, 23, 24, 31, 33, 34, 35, 36	10	Capacitor, .005 mfd ceramic disc
22.1050	C11, 12	2	Capacitor, 1000 mmf, 5 KV ceramic
22.1506	C14, 15	2	Capacitor, 500 mmf, 6 KV ceramic disc
23.1359-2	C29	1	Capacitor, board assembly, 13 mfd, 2700 VDC
167-154-4	C19	1	Capacitor, 250L15 special variable
22.765	C25a, b	1	Capacitor, dual 15-15 mfd, 150 V
22.1097	C32	1	Capacitor, .01 mfd ceramic disc
22.4033-10	C8a, b, C10	3	Capacitor, 22 mmfd ± 10% mica
23.1009-4	D1	1	Drive, .307 diameter
23.1009-5	D2	1	Drive, .630 diameter
23.1160-2	D4, D5	2	Pulley, outside hub, 1 1/4" diameter
23.1246-1	D8, 3	2	Knob, 1 5/8" diameter

Parts List

Part No. or Drawing No.	Item No.	Qty.	Description
23.907-12	D9	1	Knob, 100-0 skirted, 180°
23.907-19	D10	1	Knob, 100-0 skirted, 300°
13.123-12	D6, 7, 11, 12	5	Bearing, panel, 3/8-32
18.751-3	D13, 14	2	Shaft, 1/4" dia., 7 1/4" long, phenolic
18.751-2	D15, 16	2	Shaft, 1/4 ' dia., 3 1/2" long, phenolic
23.907-14	D18, 25	2	Knob, single index
23.1341	D17	1	Rod, 1/4" dia. aluminum with C washer
13.760-2	D19, 20, 21, 29	4	Coupling, rigid metal shaft
116-290-5	D22	1	Knob, 4" dia.
13.883	D23	1	Potentiometer shaft cover
23.544-2	D24	1	Jewel assembly, red
42.49-148	D26	5 ft.	Cord, dial, .040 nylon
23.544-3	D27	1	Jewel assembly, green
22.1276-8	D28	1	Cable clamp 1/2"
23.1345	E1	1	Plate connector
18.763	E2	5	Dielectric-grid bypass capacitor
16.1432	E3	1	Grid strap
16.1099	E4	1	Contact spring
22.747	E5, 6	2	Hood, coax., UG-106/U
22.1309	E7	1	Hood, coax., UG-177/U
10.19-1	E8a, b, c	3	Insulator, 1" cone
32.118	E9a, b	2	Chimney
135-44	E10	1	Feedthru ceramic
16.51-5	E11a, b	2	Plate connector, 9/16" dia.
23.1411	E12	1	145 MC stop circuit
22.742	F103	2	Fuse, 5 ampere
22.1397-10	F101, 102	4	Fuse, 10 ampere, Slow-blow
22.739-2	FH101, 102 103	3	Post, fuse extractor
22.113-1	G1, 2, 3, 4	4	Grommet, 9/16" rubber
71.43-097	G8	65"	Gasket, 3/16" round metaltex
22.1475-2	G9, 10, 11, 12	4	Button, polyethylene, rest
18.764	G5	1	Gasket, blower
23.1335-1	H	1	Harness, cable
	HW		Hardware envelopes
13.155-121	HW	2	Spacer, aluminum, 3/8" dia. x 1 1/8" long
10.156-1	HW	4	Spacer, steatite, 1/2" long, 6-32 tap holes
14.43-3	HW	1	Spacer, aluminum, 1/2" dia. x 7/8" long
22.21	I101	1	Lamp, 120 V., candelabra base #6S6 pilot
22.375	I102	1	Lamp, 6.3 V., #44 pilot
22.746	J1, 2	2	Connector, 83-1R coax.
22.1429-1	J101	1	10 amp, 3 prong male flush base plug
22.1096	J102	1	Phono jack

VIKING 6N2 THUNDERBOLT AMPLIFIER

Parts List

Part No. or Drawing No.	Item No.	Qty.	Description
23.1346	L5	1	2 meter plate assembly
16.1437	L6	1	Inductor, 6 meter plate
16.1433	L1	1	Inductor, 2 meter grid
23.1372	L2	1	Inductor, 6 meter grid and link assembly
16.1417	L10	1	Choke, R.F., plate
23.1000	L106	1	Choke, 4.7 uh R.F.
16.1181-5	L104, 105	2	Choke, R.F. line filter
16.1181-3	L111, 112	2	Choke, R.F. filter
542-5001-001	L101	1	Choke, 5-25 HY H.V. filter
22.749	L102	1	Choke, .095 amp., 15 HY L.V. filter
22.1317	L9, 8, 7	3	Choke, VHF (red)
22.1400-2	M1	1	Meter, grid current - voltmeter
22.1399	M2	1	Meter, plate current - watts
22.1430-1	P101	1	Connector body, 10 amp. 3 wire female
22.1095	P102	1	Phono plug
22.1589	R1, 2, 3	3	Resistor, Koolohm, 200 ohm ± 10% 10 W-NI
22.7077-10	R4, 5, 115	3	Resistor, 15,000 ohms ± 10% 2 W. carbon
22.7019-10	R6	1	Resistor, 56 ohm ± 10% 2 W. carbon
22.1431	R101, 102, 103, 104, 105, 106	6	Resistor, 4000 ohms 50 watt, Ohmite
22.1442-1	R107, 108	2	Resistor, 1.5 megohm ± 1% 2 W.
22.6073-10	R109	1	Resistor, 10,000 ohm ± 10% 1 W. carbon
22.7033-10	R110	1	Resistor, 220 ohm ± 10% 2 W. carbon
22.6019-10	R111	1	Resistor, 56 ohm ± 10% 1 W. carbon
22.7063-10	R112	1	Resistor, 3900 ohm ± 10% 2 W. carbon
22.7071-1-	R113	1	Resistor, 8200 ohm ± 10% 2 W. carbon
22.1396	R114	1	Potentiometer, 5000 ohm 4 W.
22.6049-10	R116	1	Resistor, 1000 ohm ± 10% 1 W. carbon
22.914-3	R117, 118, 119	3	Resistor, 0.82 ohm wire
22.1599-2	R120	1	Resistor, 20,000 ohm 50 W. wire wound adj.
22.1009	SR	1	Selenium rectifier
22.1574	SW5	1	Switch, grid selector, 1 pole, 5 position
22.761-2	SW104	1	Switch, 2 pole, 6 position (meter)
22.1455	SW101, SW102	2	Switch, DPST (with internal tooth lockwasher and 3 nuts)
22.1573	SW103	1	Switch, 3 pole, 3 position
22.1537-1	SW7a	1	Switch index assembly
22.1537-2	SW7b	1	Ceramic switch wafer
22.1466-2	T101	1	Transformer, H.V. plate
22.1534	T102	1	Transformer, filament, bias SNC P3998
22.789-1	TS1	1	Terminal strip, 4 terminal, barrier
22.790-1	TS9	1	Marker strip, terminal
22.740-3	TS8	1	Terminal strip, 3 terminal

VIKING 6N2 THUNDERBOLT AMPLIFIER

Parts List

Part No. or Drawing No.	Item No.	Qty.	Description
22.1588	V3, 4	2	Tube, 7034 or equivalent
595-4001-001	V101, 102	2	Tube, 3B28
22.1109	V108	1	Tube, VR150-OD3
22.1110	V107, 106	2	Tube, VR105-OC3
22.1438	V105	1	Tube, VR75-OA3
71.32-170	W1	18"	Cable, RG-8/U coaxial
71.32-180	W2	8"	Cable, RG-58/U coaxial
	W		Wire and tubing
147-610-14	XI102	1	Bracket, dial light, min. bay.
147-620	XI101	1	Bracket, dial light, 115 V. candelabra base
122-224-1	XV101, 102	2	Socket, 4 prong steatite
22.1274	XV107, 108, 105, 106	4	Socket, molded octal
124-114	XV3, 4	2	Socket, Kel-F molded air system
124-113-11	XC1, XC2	2	Screen bypass capacitor
2-240-362		1	Operating Manual

CALIBRATION CHART

AM, SSB AND DSB OPERATION

Static Plate Current _____

Frequency						
Plate Tuning Dial						
Coupling						
Grid Input						
Grid Tuning						
Band-Mode						
Antenna						
Notes						

CW CLASS C OPERATION

Frequency						
Plate Tuning Dial						
Coupling						
Grid Input						
Grid Tuning						
Band-Mode						
Antenna						
Notes						

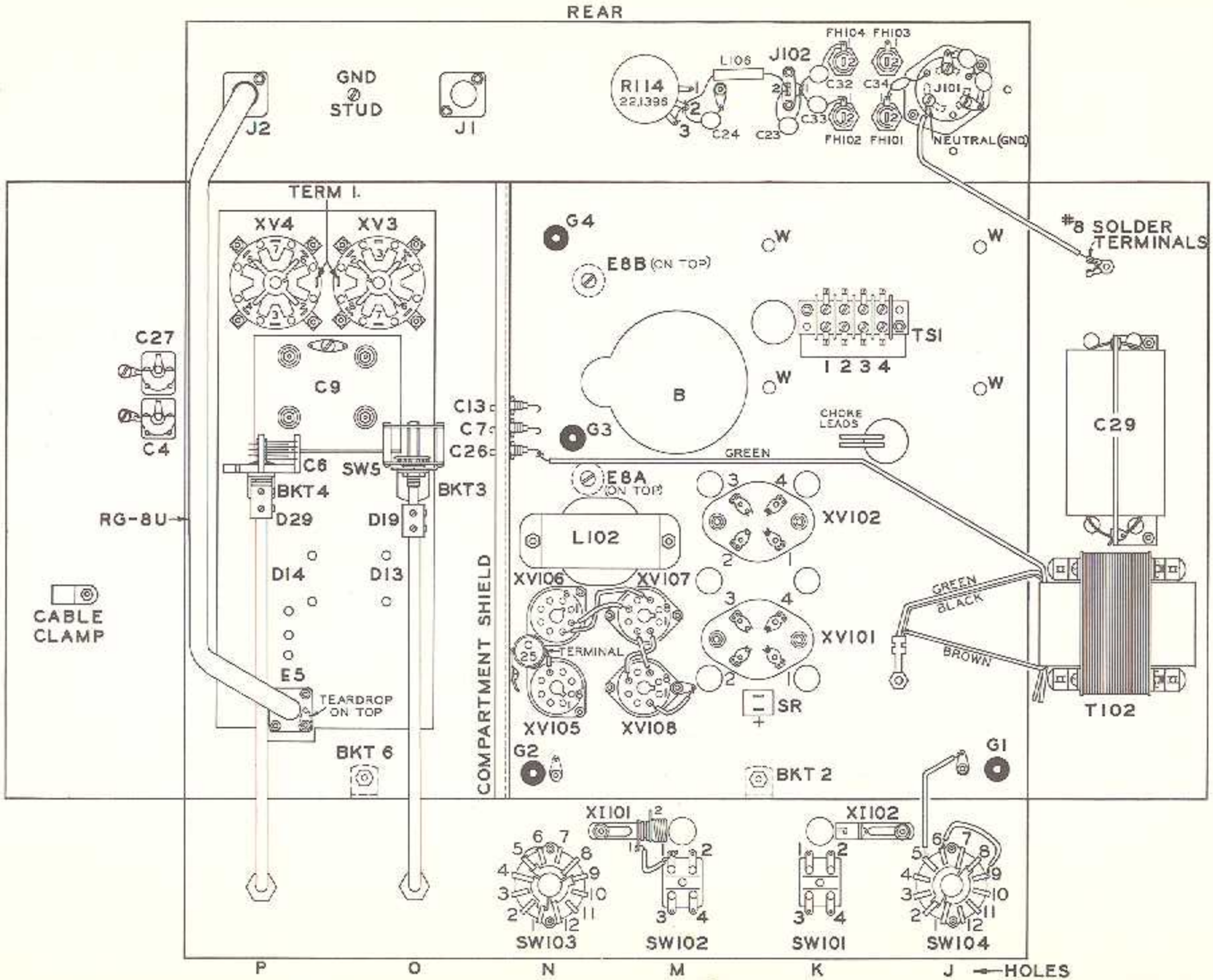


FIGURE I. PARTS MOUNTING

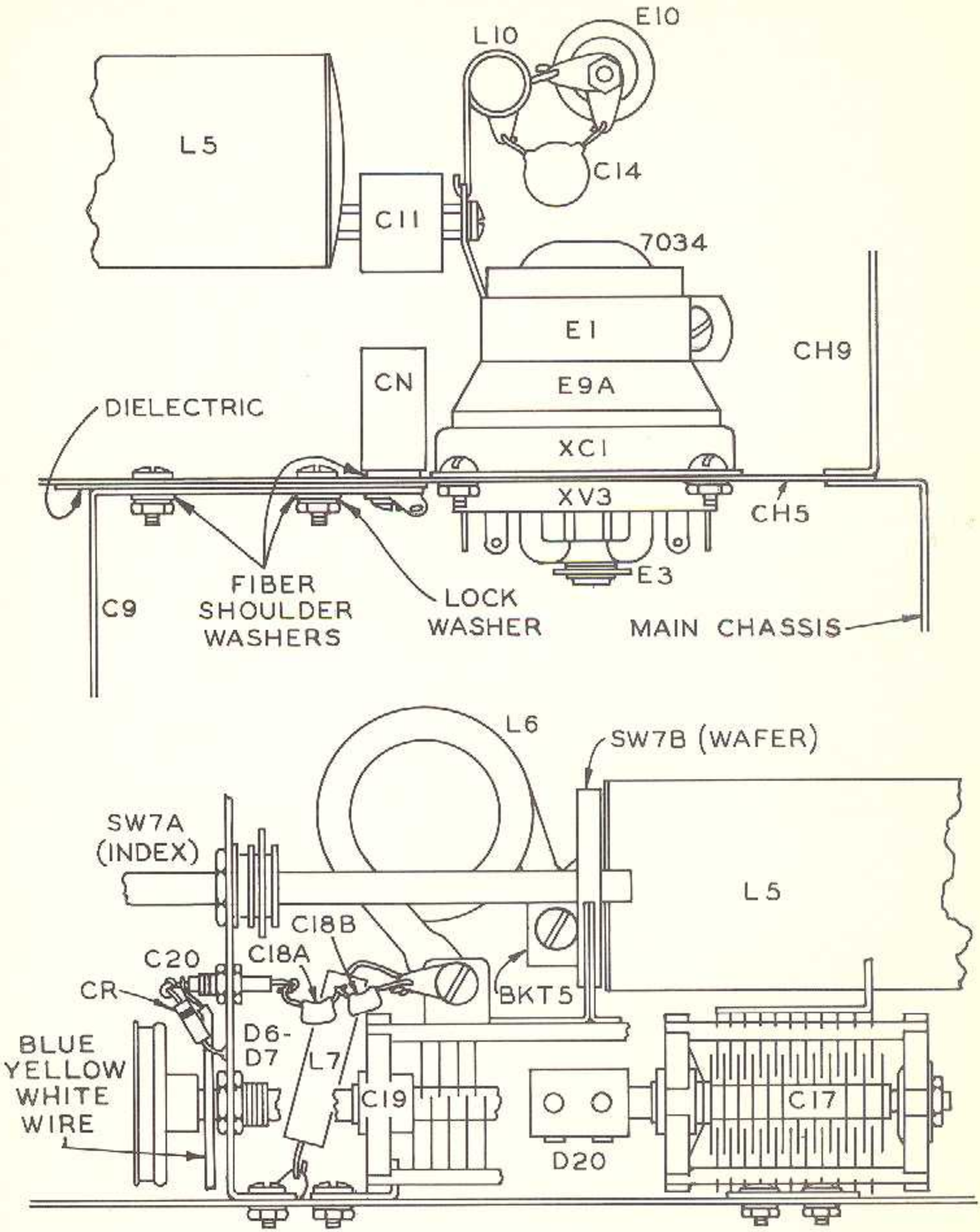


FIGURE 4: PLATE CIRCUIT

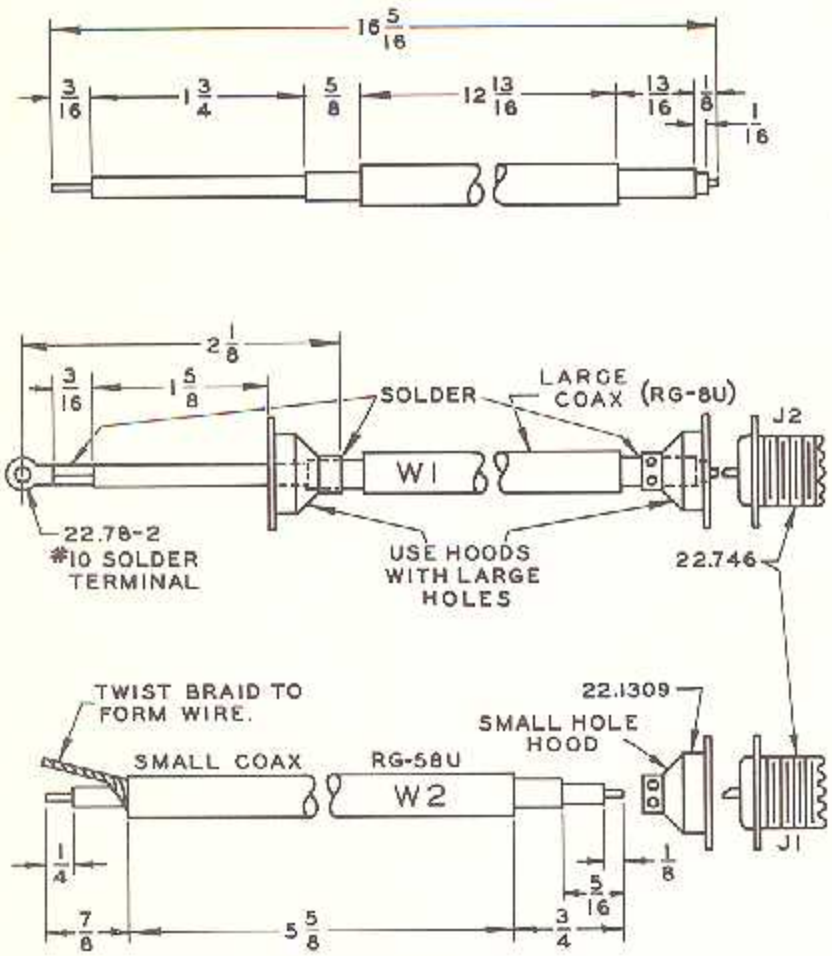


FIGURE 5: COAXIAL CABLES

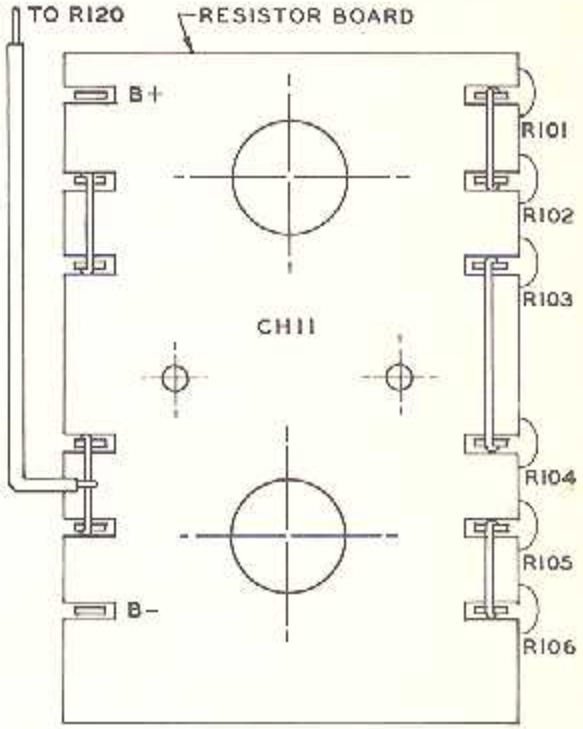


FIGURE 6.

RESISTOR BOARD ASSEMBLY
(REAR VIEW)

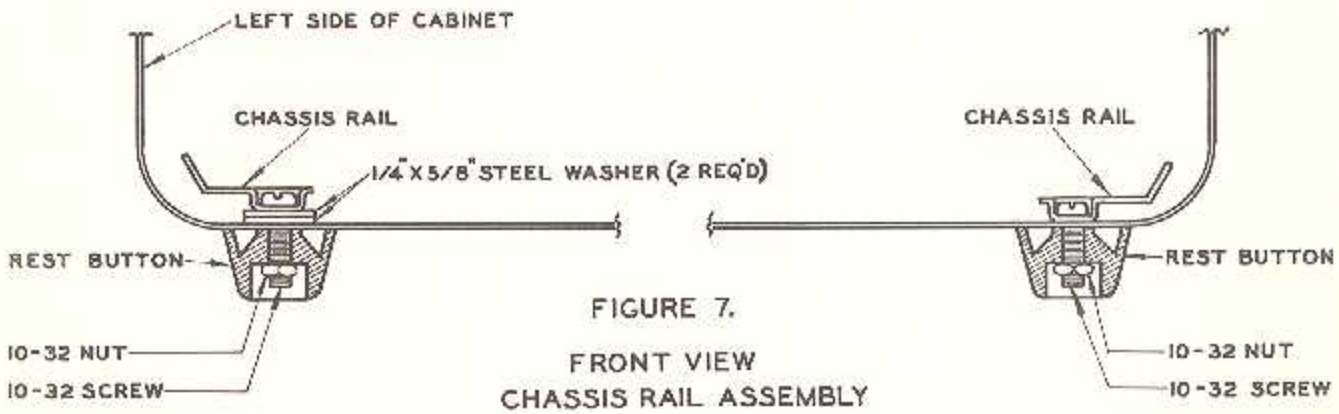
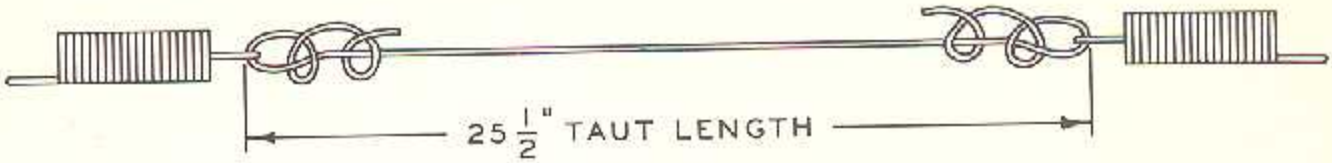


FIGURE 7.

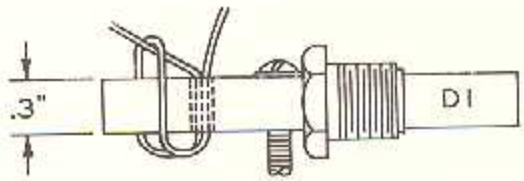
FRONT VIEW
CHASSIS RAIL ASSEMBLY

PLATE DIAL DRIVE

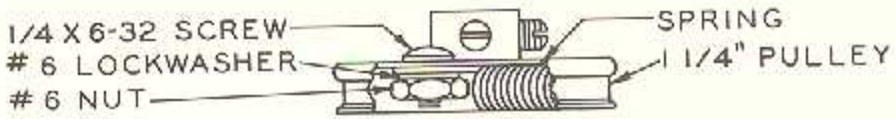
STEP 1: TIE SPRINGS ON CORD.



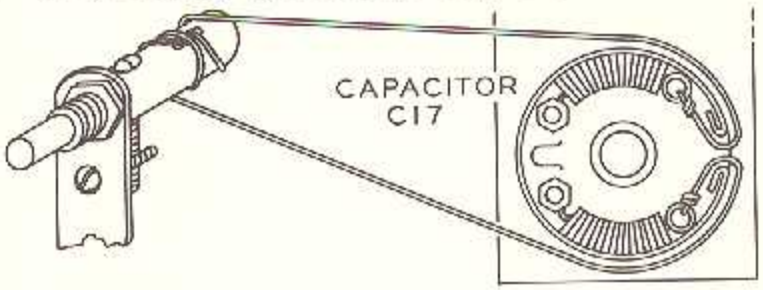
STEP 2: FOLD STRING AT CENTER, INSERT FOLDED END THRU HOLE IN DRIVE, BRING LOOP UP OVER DRIVE WITH ONE END EACH SIDE OF LOOP.

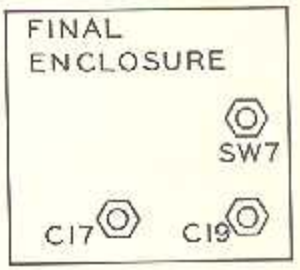


STEP 3: BOLT SPRINGS TO PULLEY. (SEE NEXT TWO PICTURES.)



STEP 4: STRETCH SPRINGS AND SLIP PULLEY OVER C17 SHAFT.



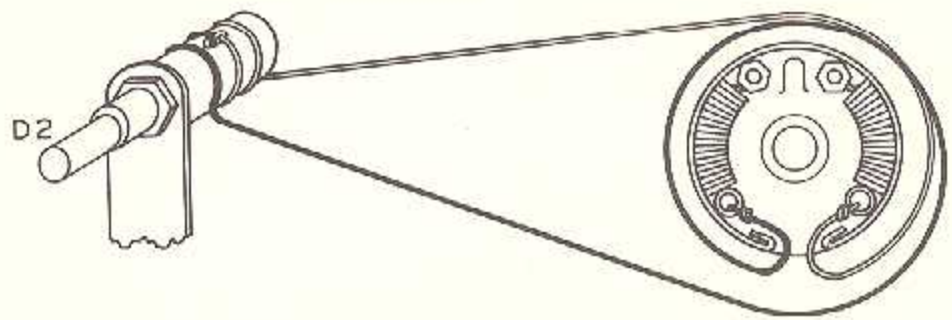


STEP 5: TURN CAPACITOR TO FULL MESH (MAXIMUM CAPACITY), THE DRIVE FULLY CCW AND TIGHTEN SETSCREWS ON PULLEY.

COUPLING DIAL DRIVE

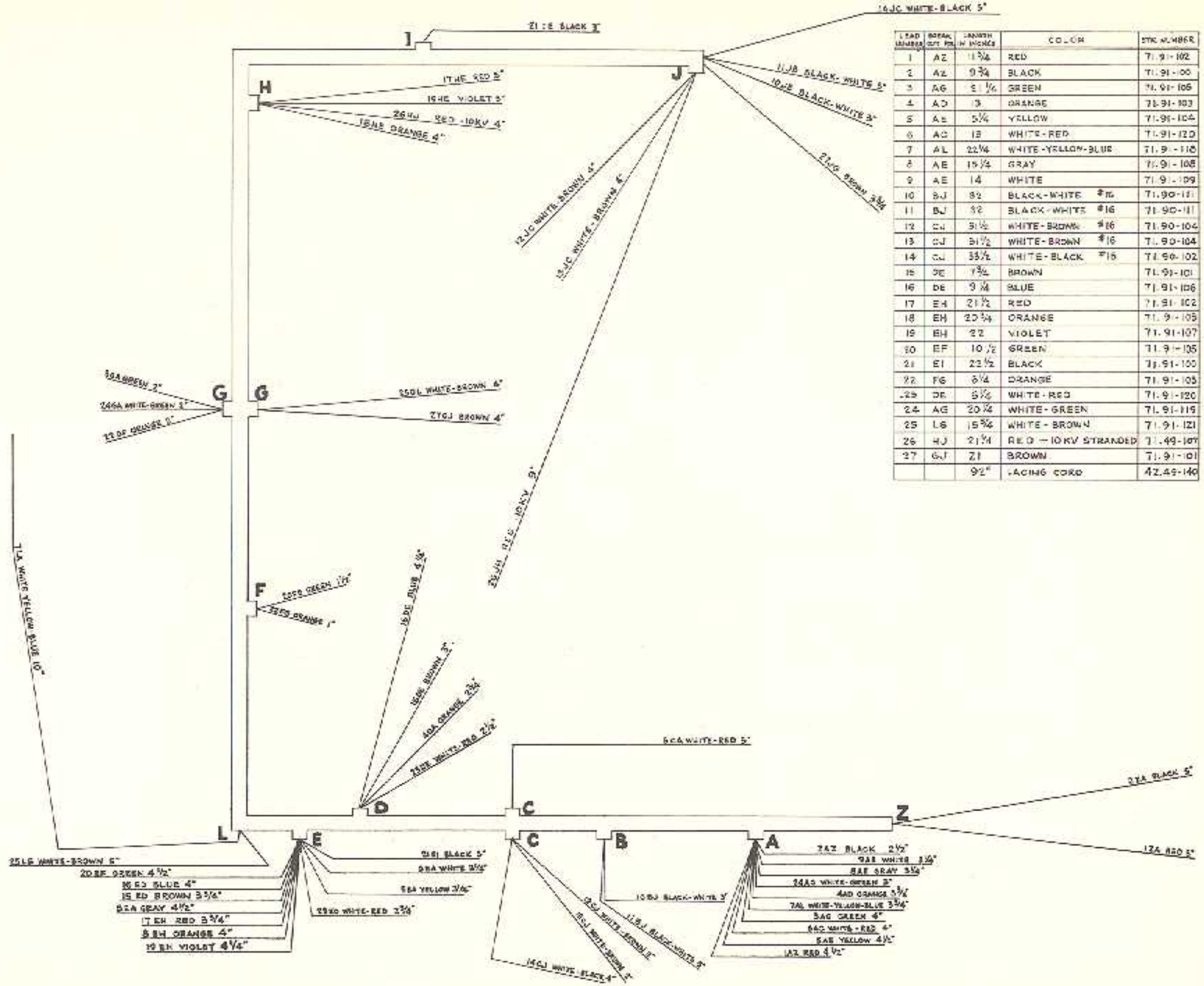
STEP 6: REPEAT STEP 1. (20" TAUT LENGTH), STEP 2. (5/8 DIA. DRIVE) AND STEP 3.

STEP 7: SAME AS STEP 4. EXCEPT USE PICTURE BELOW, TIGHTEN SETSCREWS.



C19 FULLY CCW

FIGURE 8: DIAL DRIVES



LEAD NUMBER	BORAL CUT FOR	LENGTH IN INCHES	COLOR	STK NUMBER
1	AZ	11¾	RED	71-91-102
2	AZ	9¾	BLACK	71-91-100
3	AG	21½	GREEN	71-91-106
4	AD	13	ORANGE	71-91-103
5	AE	5¼	YELLOW	71-91-104
6	AG	13	WHITE-RED	71-91-120
7	AL	22¼	WHITE-YELLOW-BLUE	71-91-118
8	AE	15¾	GRAY	71-91-108
9	AE	14	WHITE	71-91-109
10	BJ	82	BLACK-WHITE #16	71-90-111
11	BJ	82	BLACK-WHITE #16	71-90-111
12	CJ	91½	WHITE-BROWN #16	71-90-104
13	CJ	91½	WHITE-BROWN #16	71-90-104
14	CJ	33½	WHITE-BLACK #16	71-90-102
15	DE	7¾	BROWN	71-91-101
16	DE	9¼	BLUE	71-91-106
17	EH	21½	RED	71-91-102
18	EH	20¾	ORANGE	71-91-105
19	EH	22	VIOLET	71-91-107
20	EF	10½	GREEN	71-91-135
21	EI	23½	BLACK	71-91-100
22	FG	8¼	ORANGE	71-91-105
23	DE	5½	WHITE-RED	71-91-120
24	AG	20¾	WHITE-GREEN	71-91-119
25	LG	15¾	WHITE-BROWN	71-91-121
26	HJ	21¾	RED — 10KV STRANDED	71-49-107
27	GJ	27	BROWN	71-91-101
		92"	LACING CORD	42-49-140

FIGURE 9: CABLE DIAGRAM

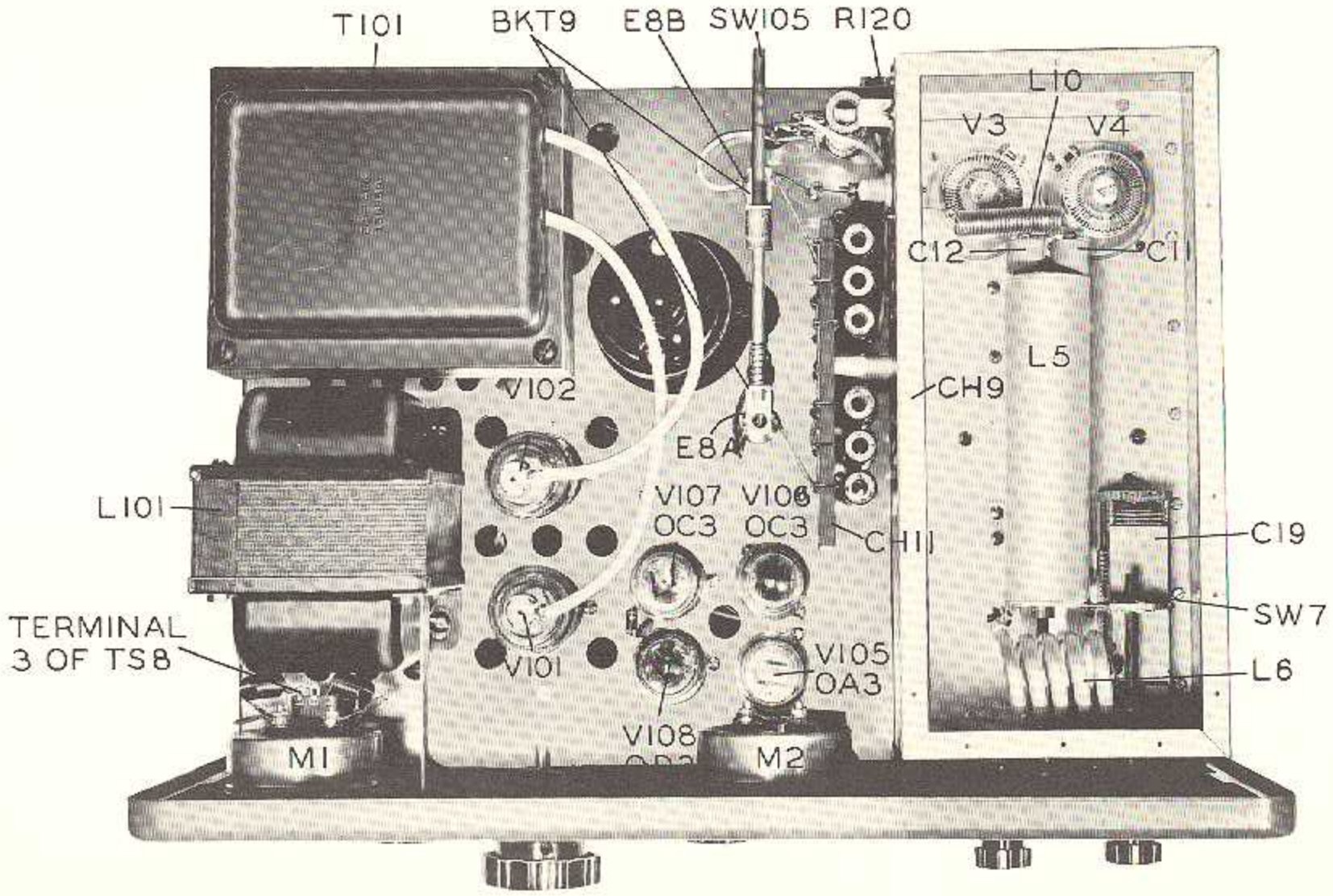


FIGURE 10: TOP VIEW

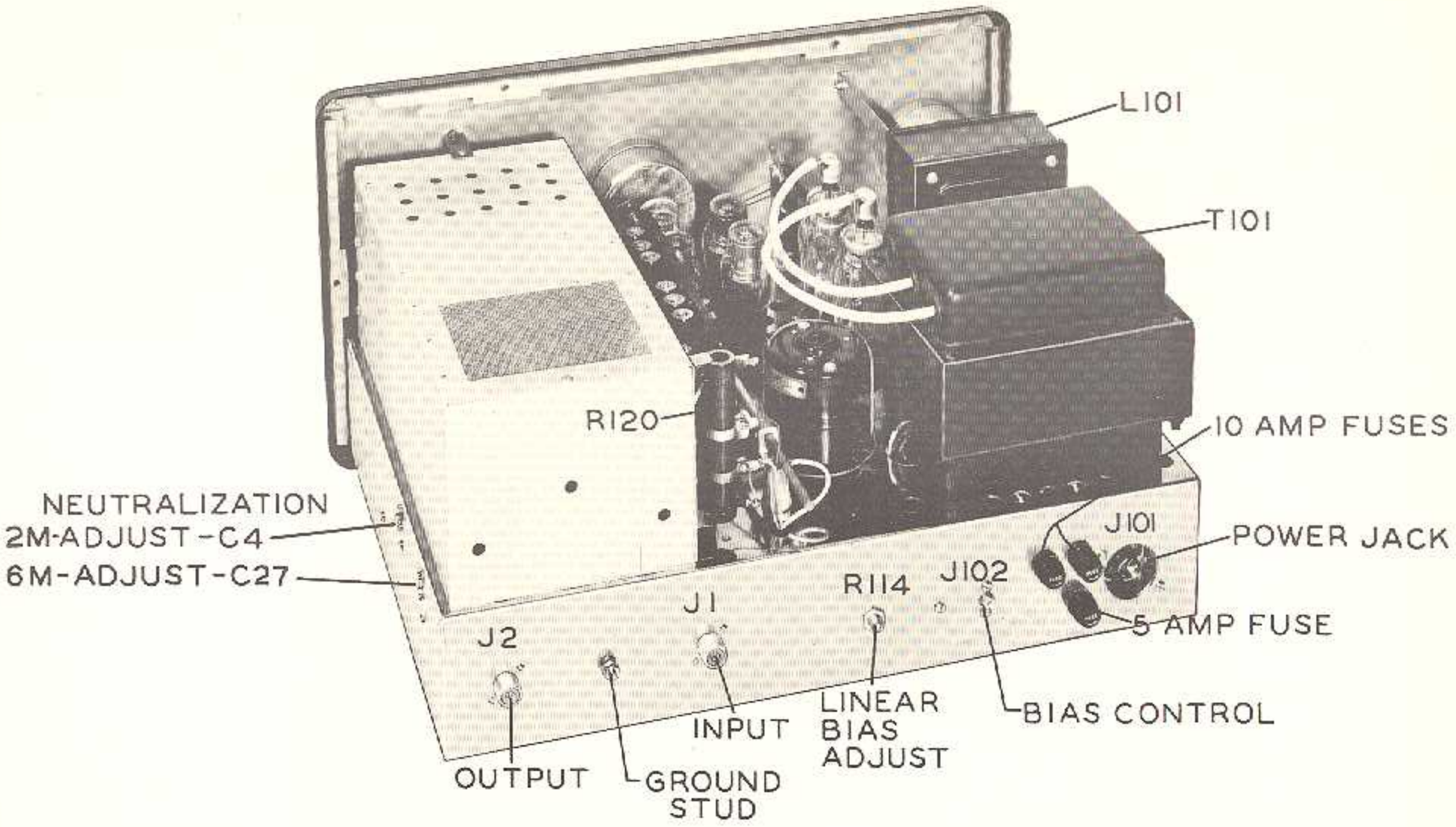
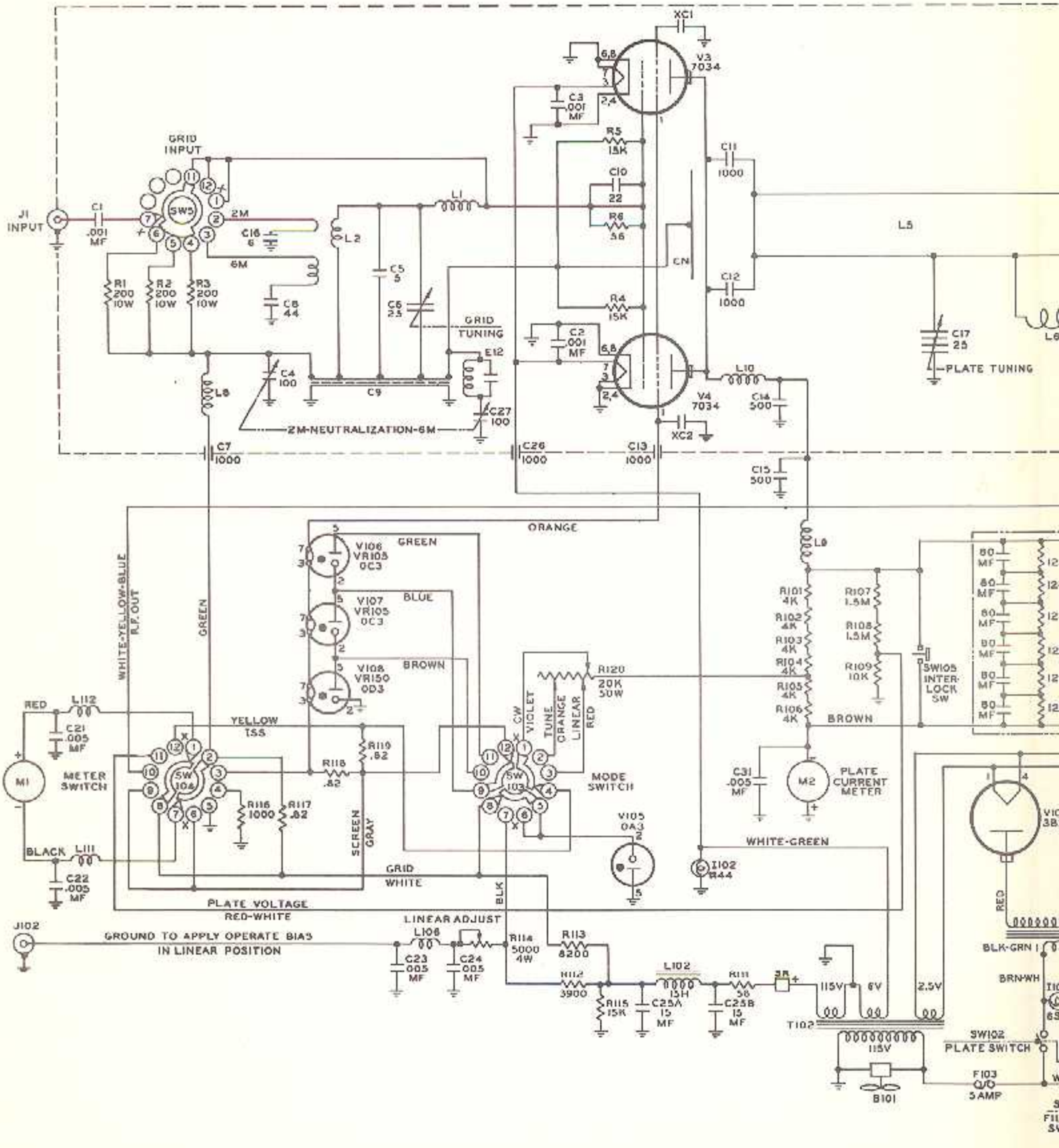
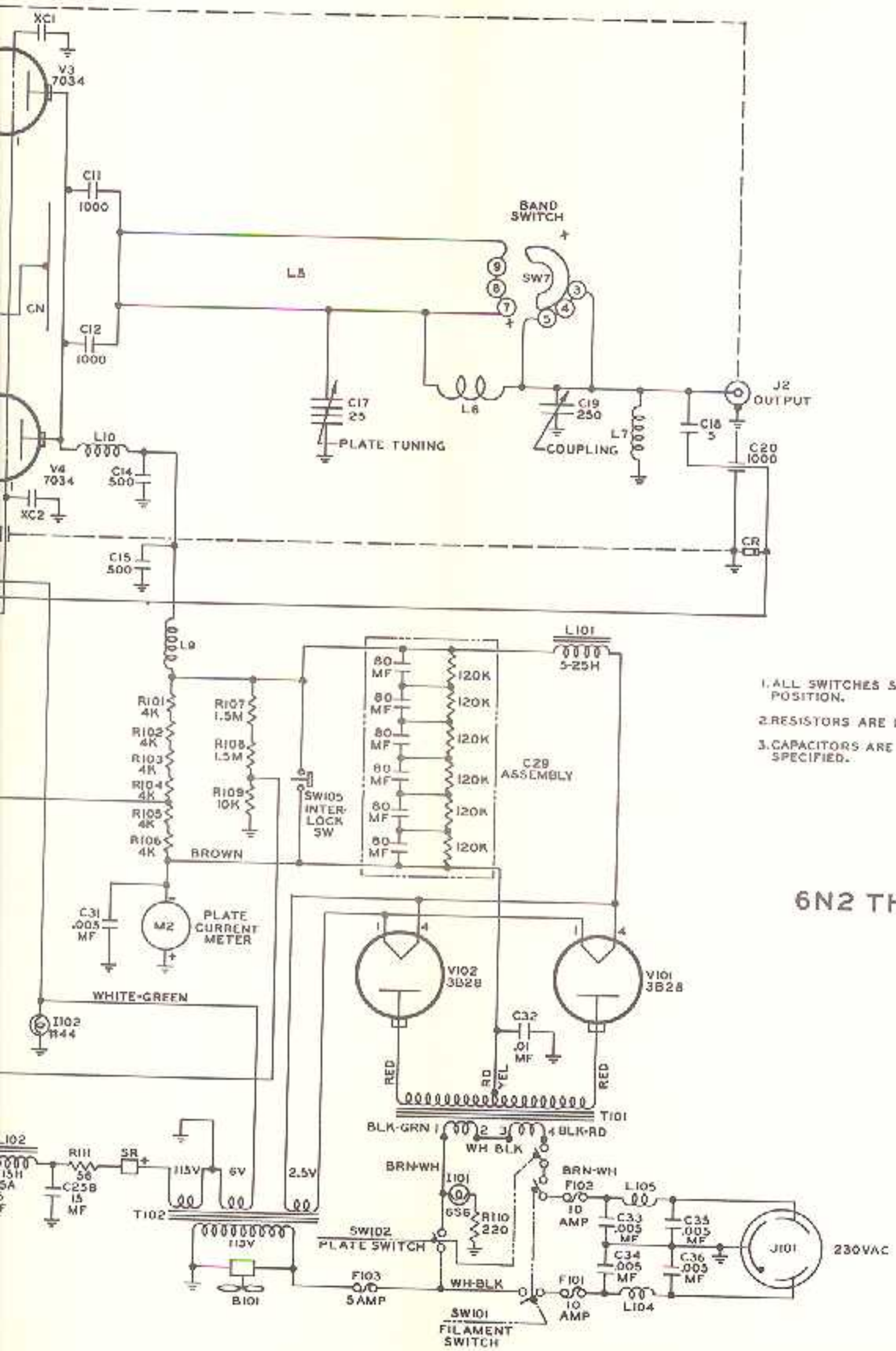


FIGURE 11: REAR VIEW


J1 INPUT
C1 .001 MF
GRID INPUT
SW5
2M
6M
C16 6
L2
L1
C5 5
C6 25
GRID TUNING
C4 100
C9
E12
C27 100
2M-NEUTRALIZATION-6M
L8
C7 1000
C26 1000
C13 1000
XC1
V3 7034
V4 7034
XC2
C3 .001 MF
C2 .001 MF
R5 15K
R6 56
R4 15K
C10 22
C11 1000
C12 1000
CN
L5
C17 25
PLATE TUNING
L10
C14 500
C15 500
L9
ORANGE
GREEN
WHITE-YEL-LOW-BLUE
R.F. OUT
V106 VR105 0C3
V107 VR105 0C3
V108 VR150 0D3
BLUE
BROWN
R120 20K 50W
CW VIOLET TUNE ORANGE LINEAR RED
R101 4K
R102 4K
R103 4K
R104 4K
R105 4K
R106 4K
R107 1.5M
R108 1.5M
R109 10K
SW105 INTER-LOCK SW
80 MF
RED
L112
C21 .005 MF
M1
METER SWITCH
YELLOW
TSS
R119 .82
R118 .82
SW 104
SW 103
MODE SWITCH
R116 1000
R117 .82
SCREEN GRAY
V105 0A3
I102 R44
WHITE-GREEN
C31 .005 MF
M2
PLATE CURRENT METER
BLACK
L111
C22 .005 MF
GRID WHITE
BLK
PLATE VOLTAGE RED-WHITE
J102
GROUND TO APPLY OPERATE BIAS IN LINEAR POSITION
LINEAR ADJUST
L106
C23 005 MF
C24 005 MF
R114 5000 4W
R113 8200
R112 3900
R115 15K
L102
15H
C25A 15 MF
C25B 15 MF
R111 56
3A
T102
115V
6V
2.5V
BLK-GRN
BRN-WH
SW102 PLATE SWITCH
F103 5 AMP
B101



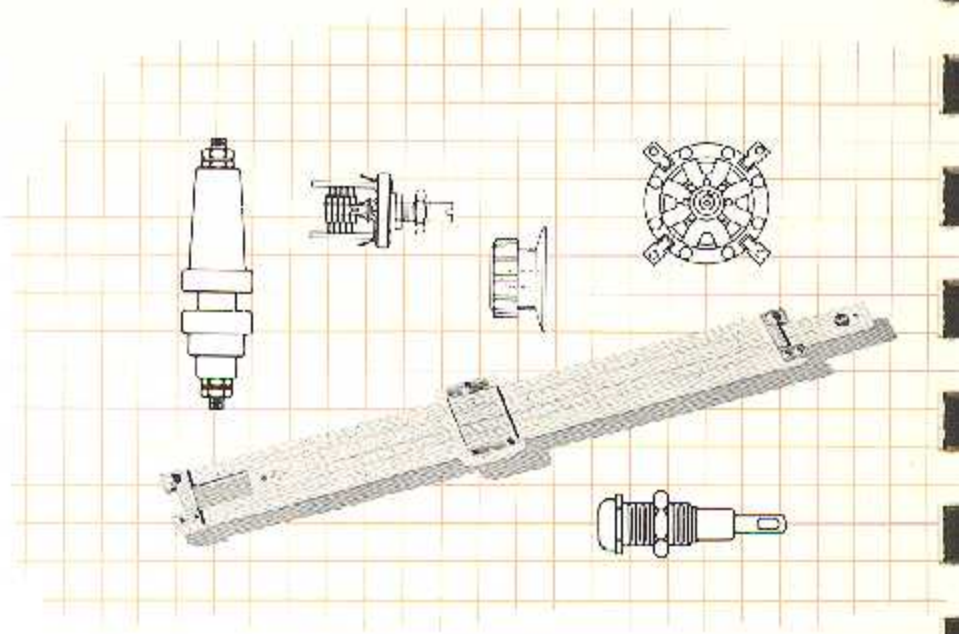
1. ALL SWITCHES SHOWN FROM REAR IN COUNTERCLOCKWISE POSITION.
2. RESISTORS ARE IN OHMS UNLESS OTHERWISE SPECIFIED.
3. CAPACITORS ARE IN MICRO-MICROFARADS UNLESS OTHERWISE SPECIFIED.

6N2 THUNDERBOLT

8-23-63

Detailed Literature...

Complete descriptive literature is available on all E. F. Johnson Company product lines. For detailed specifications and prices, see your distributor or write for current literature.



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