

SETTINGS P 14415

JOHNSON *Commercial*

BROADCAST AND
RADIO-ELECTRONIC
EQUIPMENT



**INSTRUCTION MANUAL
JOHNSON VIKING I
RADIO
TRANSMITTER**

JOHNSON

VIKING I

TRANSMITTER KIT



**150 WATTS CW INPUT
135 WATTS AM PHONE INPUT
BANDSWITCHING 10-160 METERS**

E. F. JOHNSON COMPANY

a famous name in Radio!

WASECA, MINNESOTA



CATALOG 705

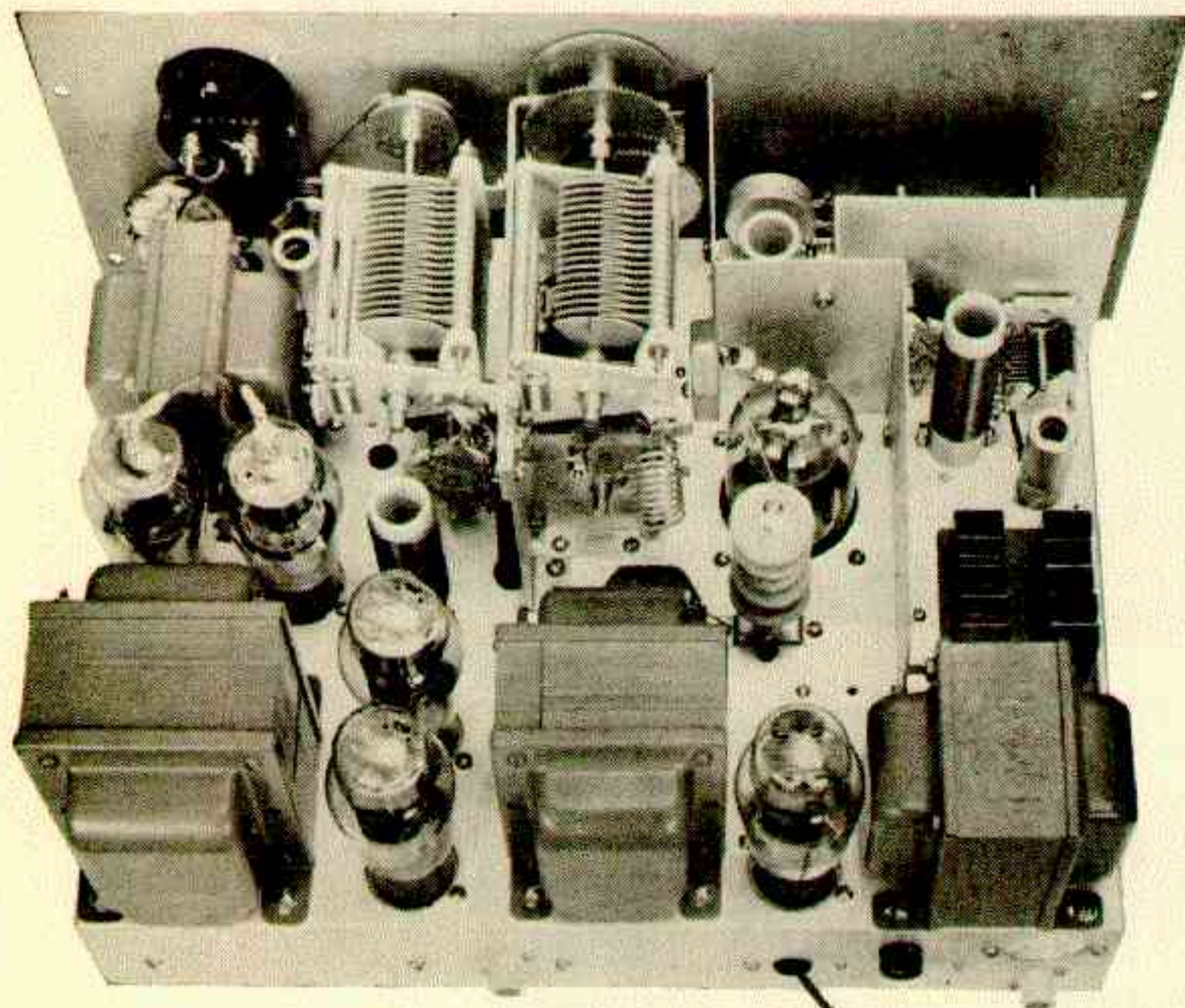
the JOHNSON VIKING I

- Amplitude Modulation
- Band Switching
- 100 Watts Phone Output
- 115 Watts CW Output
- VFO Input Provision
- Dual Power Supplies
- Self-Contained
- Pi-Network Coupling

- Tube line-up:
- | | |
|-------------------------|---------------------|
| 6AU6 crystal oscillator | 6AU6 driver |
| 6AQ5 buffer/doubler | 807 pp modulators |
| 4D32 final amplifier | 5R4 HV rectifiers |
| 6AU6 voltage amplifier | 5Z4 LV rectifier |
| | 6AL5 bias rectifier |

The JOHNSON Viking I is more than a transmitter kit in the popular sense. It is a competently designed and engineered transmitter furnished unassembled but complete in every detail, including wiring harness and ample assembly instructions. Full output is available on amateur bands 160, 80, 40, 20, 15 and 11-10 meters. The complete output frequency range of the unit is:

Band	Low Freq. Limit	High Freq. Limit	Band	Low Freq. Limit	High Freq. Limit
160	1.8 mcs.	2.4 mcs.	20	9.8 mcs.	15.0 mcs.
80	2.9 mcs.	4.4 mcs.	15	15.0 mcs.	21.8 mcs.
40	5.2 mcs.	8.0 mcs.	10	21.0 mcs.	30.0 mcs.



POWER SUPPLIES — The low voltage power supply furnishes 300 volts for exciter and speech amplifier plates. In addition to the 5Z4 rectifier a 6AL5 diode rectifying the tapped secondary winding furnishes well regulated fixed bias for the final amplifier, modulator and the 6AQ5 buffer/doubler. The 600 volt supply with parallel 5R4 rectifiers furnishes plate and screen voltage for the 4D32 and 807 modulators. High vacuum rectifiers in both supplies eliminate the need for hash suppression and time delay circuits. Available for 115 volt 50/60 cycle ac operation only. Delivering full output on phone, line power consumption is 375 watts. Primary fusing protects the equipment from accidental overloads.

The JOHNSON transmitter has nearly uniform output throughout its range, exciter design such that a minimum number of crystals is required. The pi-section output stage enables the transmitter to be matched to antennas with impedances in the range of from 50 to 600 ohms without the necessity of an external antenna coupler. The final tank coil is a variable inductor with excellent insulation and wound with a variable pitch so that its Q is high throughout the entire range. The inductor, together with the band-switching exciter eliminates the necessity of changing coils entirely. Sufficient audio gain and power are available to 100% modulate the transmitter's maximum input using a crystal microphone.

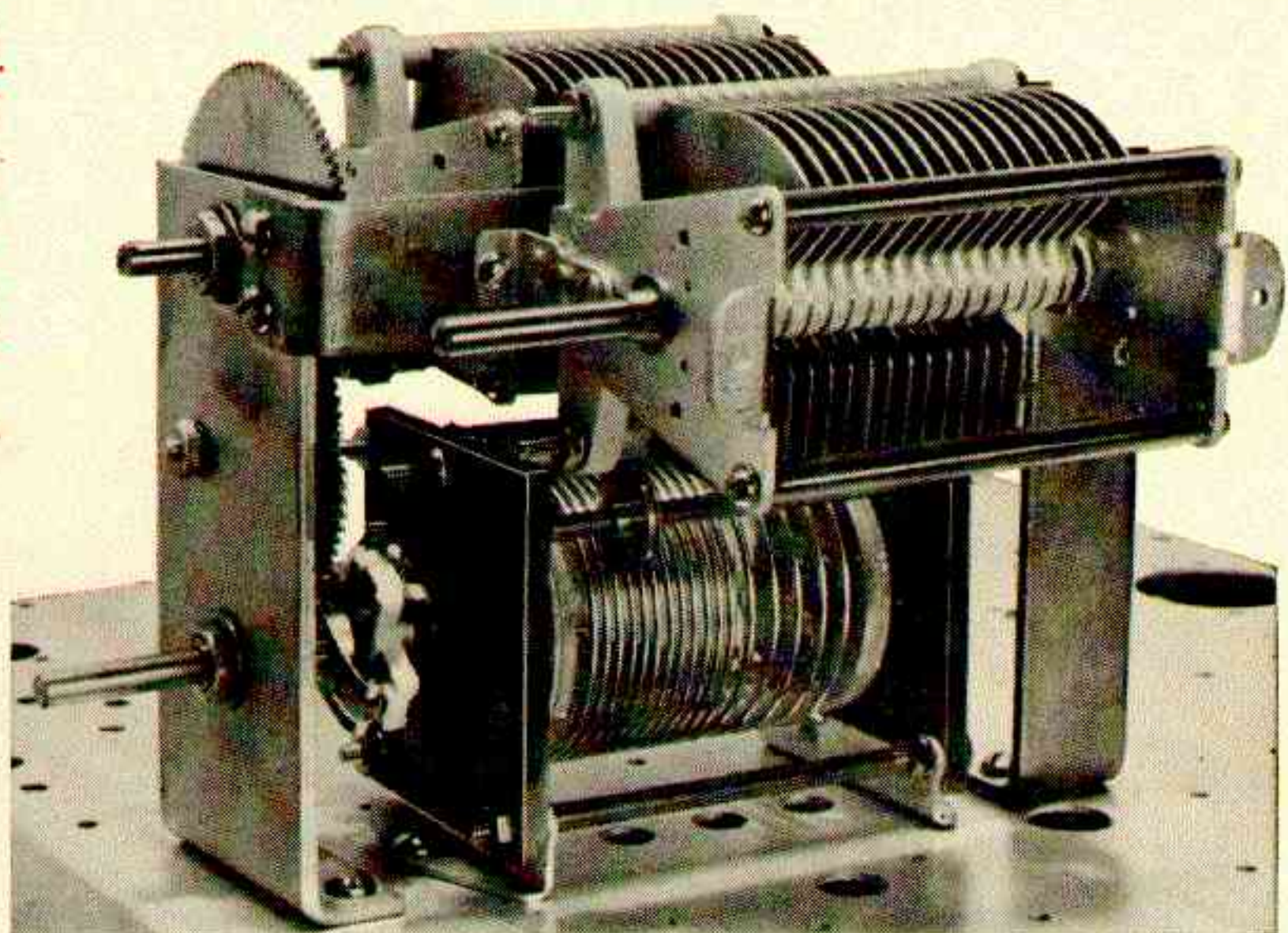
RF SECTION — The transmitter's rf section consists of a 6AU6 crystal oscillator driving a 6AQ5 buffer/doubler which in turn drives the 4D32 final amplifier. The oscillator utilizes a JOHNSON crystal selector assembly which permits the selection of any one of ten crystal frequencies from the front panel. An eleventh position on the crystal switch allows use of an external VFO. The 6AQ5 buffer/doubler output is adequate to drive the 4D32 to full output on all bands. A potentiometer in the screen of the 6AQ5 gives smooth front panel control of amplifier excitation. The fact that neutralization is not required, makes the versatile pi-section tank circuit the logical choice. The beam power 4D32 output tube requires only 600 volts plate voltage. Parasitics have been completely suppressed.

While not capable of as much input as a 4D32, an 829B will work very nicely in the final stage. It will deliver at least 95 watts of CW output, 85 watts on phone while input is kept within the manufacturers' ratings.

KEYING — Both the 6AQ5 buffer and the 4D32 final amplifier have fixed bias in excess of cut-off so that oscillator cathode keying may be used.

METERING — Metering of the transmitter is provided by a milliammeter used as a millivoltmeter and switched across permanently connected shunts so there is no possibility of circuits being opened accidentally by meter switching.

transmitter kit



Continuous Tuning Final Tank

SPEECH AMPLIFIER AND MODULATOR—The tube line-up of the speech amplifier is a 6AU6 driving a 6AU6 which in turn drives the transformer coupled push-pull 807 modulators. Frequency response has been limited to the center of the speech range. Degenerative feed-back and degeneration in the cathode of the second 6AU6 assist in keeping response substantially flat. The extremely simple design of the audio amplifier/modulator assures the realization of good audio quality. Full output of the modulator is also available at nominal 500 ohms impedance for driving a high power modulator.

EXCITER—A rather unique crystal oscillator circuit is used in the Viking I. In this oscillator a Pierce circuit uses the screen of the 6AU6 as a plate. The output of the oscillator is electron coupled to the plate of the 6AU6. This circuit has low crystal current and is a good frequency multiplier. The amount of excitation required from a VFO is slight.

Considerable flexibility is realized from the exciter design even though only two tubes are used and the circuit band-switching. On the 160, 80, and 40 meter bands the 6AQ5 is used as a buffer, as a doubler or tripler on 20, 15 and 10 meters. If crystals are used in the manner recommended below and their frequencies properly chosen, there is almost no possibility of obtaining output from the exciter which falls outside the amateur bands.

VFO REQUIREMENTS—When used with an external VFO the transmitter is very easy to drive. Only six volts of 7.5 mc. RF is required for full output at 30 mcs., less for the 14 and 7 mc. bands. Two volts of 1.75 mc. VFO output is ample excitation for 1.75 and 3.5 mc. output.

An octal socket on the rear of the chassis provides 6.3 volts ac at 0.6 amperes for VFO filaments and 30 milliamperes at 300 volts dc unregulated for VFO plate voltage. The 240-122 Viking VFO simply plugs into the transmitter and is ready to operate. The VFO may be keyed from the transmitter.

Xtal Freq.	Output Band						
	160	80	40	20	15	10	11
1.8-2.0 mc	✓	✓	✓				
3.5-4.0 mc		✓	✓	✓	✓		
7.0-7.3 mc			✓	✓	✓	✓	
14-14.4 mc				✓		✓	
6.7-6.85 mc							✓

The chart above indicates the crystals which may be used for full output on the amateur bands covered by the transmitter.

Economy of space without appreciable loss of efficiency is the virtue of variable inductor tuning of the amplifier. Separate coils, sufficiently large to handle the final's circulating current, would consume a prohibitive amount of cabinet space. Plug in coils would compromise the transmitter's flexible design. The final tank tuning condenser is ganged to the variable inductor maintaining a nearly constant L/C ratio across the tuning range. Additional series inductance is switched into the circuit in order to cover the 160 meter band. The output coupling condenser consists of a 350 mmf. variable and additional fixed capacity which can be switched in parallel so that low impedance loads can be matched to the amplifier. The maximum capacity of the coupling capacitor is 2,000 mmf. The output terminal is a chassis type coaxial connector.

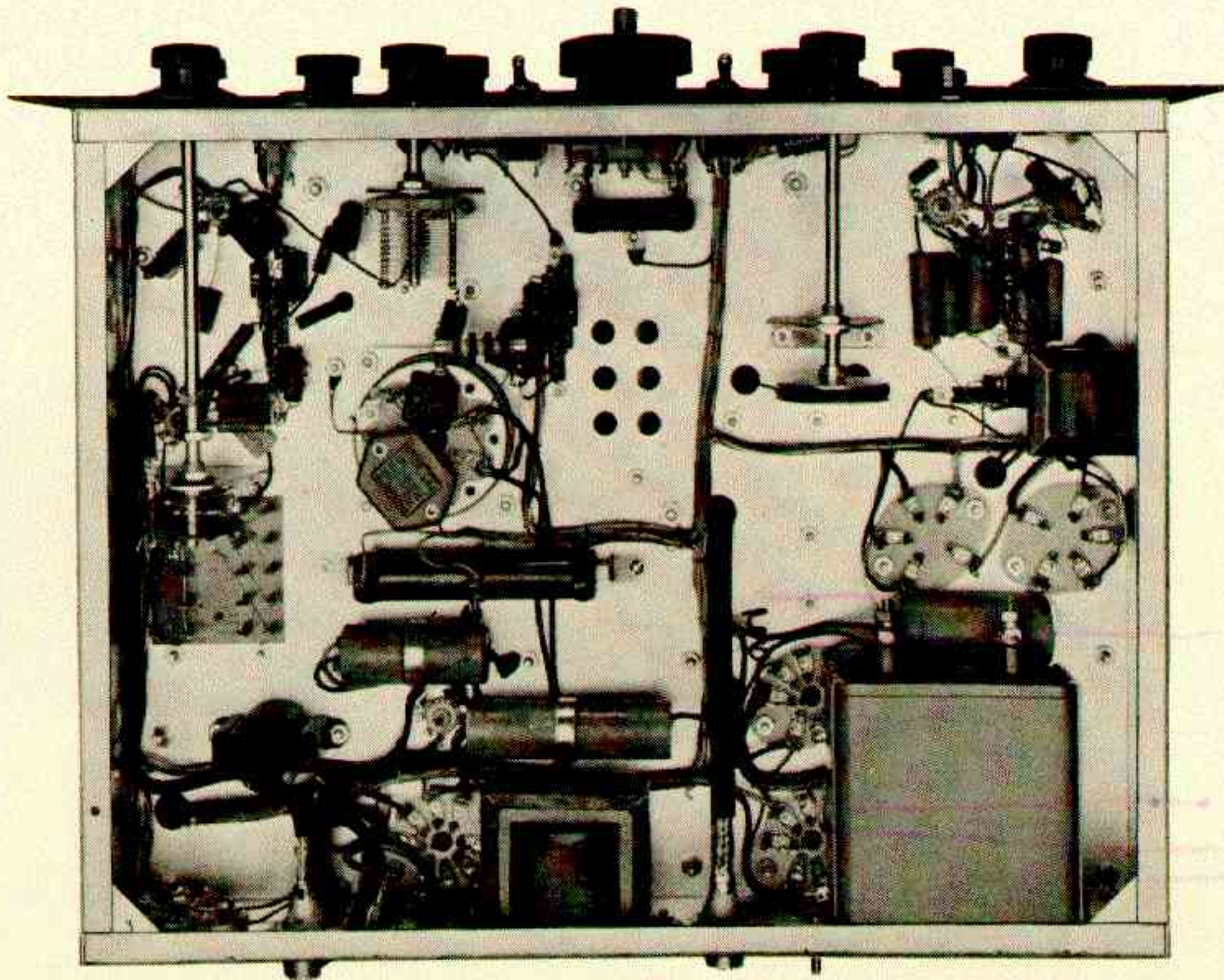
ANTENNAS—The pi-section tank circuit of the Viking I can be loaded into random length single wire antennas permitting operation on several bands without any change in the antenna system. The coupler is designed to match low impedance loads such as are encountered when using coaxial transmission lines as well as the high impedance of an end fed half wave.

ASSEMBLY—Here is a kit where either the novice or the "old timer" can get performance equal to that of our laboratory models. It was designed as a kit and no particular skill or dexterity is required in its assembly. A wiring harness containing all the ac and dc power leads is furnished reducing the possibility of incorrect wiring and giving the appearance of a factory assembled job. RF leads are short and direct. The 13 x 17 x 3 chassis and panel are punched at the factory. No drilling or other metal work is required. Complete to the last detail the parts furnished include brackets, dial cord, solder lugs, washers, spacers, wire, grommets and all other small hardware items.

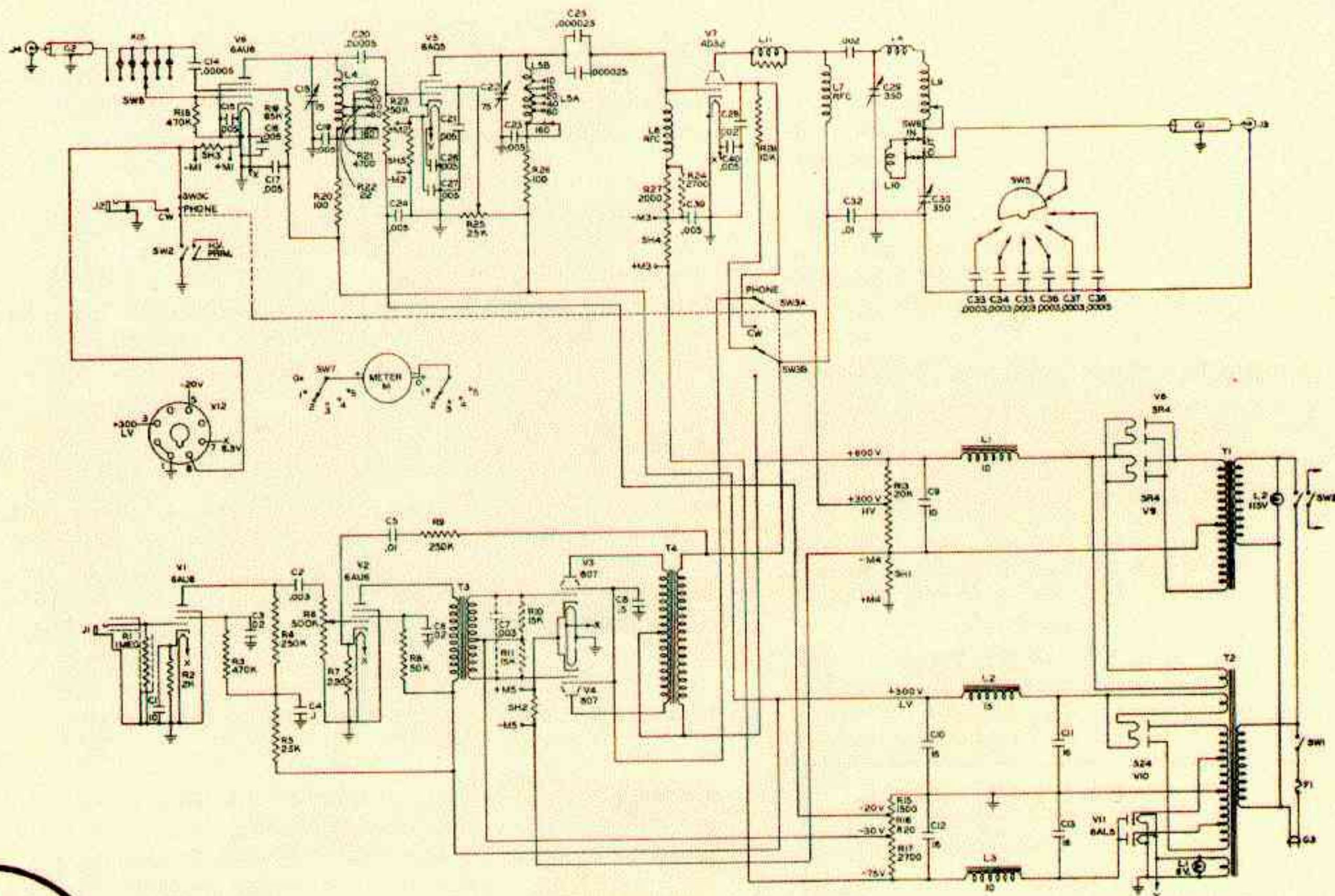
APPEARANCE—Microphone input connector, keying jack and all controls are conveniently located on the front panel. The VFO input receptacle, extractor fuse post and output terminal are located on the rear of the chassis. The transmitter is housed in a dark maroon wrinkle finished desk cabinet, 11³/₈" x 15" x 21". Panel is 8³/₄" x 19" with matching two tone finish. The skirted knobs furnished were designed especially for the kit and accent its finished, commercial appearance.

Amateur Net complete less tubes, crystals, key, mike

\$209⁵⁰



Chassis bottom view



Schematic Diagram



E. F. JOHNSON COMPANY

WASECA, MINNESOTA

The New Johnson Viking VFO Kit

COMPANION UNIT FOR VIKING 1
OR ANY OTHER TRANSMITTER

FEATURES:

- ★ Accurate Frequency Calibration
(All Bands—160 thru 10 meters)
- ★ 5" Calibrated Dial with 6:1 Reduction
- ★ High Stability—Cleanest Keying
- ★ Simple Assembly—Build It in an Evening



Here's good news to all amateurs—the JOHNSON VFO KIT, for use with the Viking 1 or other transmitters. The new JOHNSON VFO is a precision instrument engineered to the same high standards of appearance and performance which characterize the Viking 1 Transmitter.

ADEQUATE OUTPUT

More than adequate VFO output is provided to drive the Viking 1 and other transmitters, to full excitation on all bands, 10 thru 160 meters. VFO output is 8 to 10 volts on the 7.0 to 7.425 MC range and 5.5 to 7.5 volts on the 1.75 to 2.0 MC range.

The transmitter oscillator stage is utilized as an isolating RF amplifier or frequency doubler when it is driven by the VFO.

TUBE COMPLEMENT

The tube complement consists of a 6AU6 electron coupled oscillator and an 0A2 regulator. Good isolation between the oscillator and output circuit, and nearly perfect screen grid voltage regulation account for very clean keying and overall stability of the VFO. Tank circuits are temperature compensated.

SEPARATE OSCILLATOR TANKS

Two entirely separate oscillator tanks are used so that a frequency multiplication of only four need be used to cover the 10 meter band with maximum frequency calibration spread and accuracy, minimum frequency drift, and unusually excellent keying characteristics.

TWO CONTROLS

1. A frequency control driving a 5" dial calibrated directly **in frequency**—including all bands 160 meters thru 10 meters. A smooth drive with a 6:1 reduction makes frequency setting easy.
2. A bandswitch control with four positions:

Plate Off	VFO Output
160, 80, 40 meters	1.75–2.00 mc
40, 20, 15, 10 meters	7.0–7.425 mc
11 meters	6.7–7.0 mc

Has built-in tilting bracket

Keying can be done in three different ways:

1. Keying with VFO alone
2. Keying the transmitter alone
3. Keying both the VFO and transmitter simultaneously.

The latter is highly satisfactory and provides perfect "break-in" operating conditions on all bands.

POWER SUPPLY REQUIREMENTS

All voltage requirements are amply supplied from the VFO supply socket on the Viking 1 Transmitter. No other power supply required. All necessary cables and plugs are furnished. If the JOHNSON VFO is used without the Viking 1, power supply requirements are 250 to 300 v, unregulated at 15 ma and 6.3 v at .3 amp., ac or dc, which is usually available from existing transmitter power supplies.

BUILD IT IN AN EVENING

Assembly is very simple. A special tank assembly board is provided so that component mounting and wiring will be exactly like the original model, resulting in nearly perfect tracking of frequencies with the calibration markings over the whole dial range. Instruction manual contains complete details and schematics for use with transmitters other than the Viking 1.

EASILY CALIBRATED

Frequency calibration is simple. A 5" dial graduated directly with frequency markings is provided. The oscillator tank frequencies are adjusted to the dial calibration by means of JOHNSON miniature air variable condenser padders at the low ends and similar miniature variables used as trimmers on the high ends of the frequency ranges.

Frequency adjustment instructions are provided for three methods of calibration:

1. Using a secondary standard signal generator.
2. Using crystals in transmitter as frequency standards.
3. Using WWV signal at 10 mc.

A receiver with a BFO is the only additional equipment required for the original calibration.

JOHNSON VIKING VFO KIT, complete, less tubes, in dark maroon finished cabinet to match Viking 1. Size 7"x6⁷/₈"x6¹/₁₆". Amateur Net. . . . \$42.75

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JOHNSON . . . a famous name in Radio!
E. F. JOHNSON CO., WASECA, MINNESOTA



Viking I Transmitter Installation and Operation

The successful operation of any radio equipment is largely dependent on the operator's understanding of the equipment. This operating instruction manual is set up in several parts, each with the purpose of making the operator more familiar with the Viking I. The main parts are:

A	Initial Installation	Page 3
B	Theory of Operation	Page 5
C	Viking I Tuning Details	Page 9
D	Pi Network Tuning and Harmonic Suppression	Page 15
E	Trouble Shooting	Page 20
F	Photographs, Charts, and Schematic Diagrams	Page 25
G	Parts List	At rear of book

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 fuse in the primary circuit. The fuse will protect your equipment, in the case of accidental contact with the high voltage, it may save your life. If children have access to the transmitter, always disable the primary circuit by removing the fuse or the high voltage circuits by removing the rectifiers.

STANDARD WARRANTY

Adopted and Recommended by the
Radio Manufacturers 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 in exchange for any part of any unit of its manufacture which under normal installation, use and service discloses such defect, provided the unit is delivered by the owner to us or to our authorized radio dealer or wholesaler from whom purchased, intact, for our examination, with all transportation charges prepaid to our factory, 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, 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.

Any part of a unit approved for remedy or exchange hereunder will be remedied or exchanged by the authorized radio dealer or wholesaler without charge to the owner.

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.

A Initial Installation

- 1 NOTICE! The regulations of the Federal Communications Commission require a suitable license for operation of this equipment. Refer to publications of the Federal Communications Commission or the American Radio Relay League for the latest rules governing station and operator licensing.
- 2 Be sure to return the enclosed warranty registration card. This will register your transmitter at the factory and facilitate correspondence referred to your transmitter serial number.
- 3 Remove loose packing material and the packages of parts inside of the cabinet. Inspect the transmitter for any indication of damage. Report any damage to the transportation company immediately.
- 4 The wired Viking I will arrive with several shipping supports which should be removed:
 - a The transformer blocks and cross support piece
 - b The wood piece and chassis hooks under the cabinet
 - c The fiber washers under the finishing washers on the panel
- 5 Attach knobs to the shafts. The setscrew may be anchored securely in place (after the knob has been properly positioned) by first tightening down, loosening slightly, and retightening. The knob-dials should be put on and positioned as follows:
 - ✓ a CRYSTAL - a 10-0 dial. The 0 located on the maximum counterclockwise position.
 - ✓ b OSCILLATOR - a 100-0 dial. The 0 located on the maximum capacity (low frequency) position.
 - ✓ c BAND - the 160 80 40 20 15 10 dial. The 160 located on the maximum counterclockwise switch position.
 - ✓ d BUFFER - a 100-0 dial. The 0 located on the maximum capacity (low frequency) position. The buffer condenser can be seen through the 4D32 socket X7 shell with the aid of a flashlight.
 - ✓ e DRIVE - a 10-0 dial. The 0 located on the maximum counterclockwise potentiometer position.
 - ✓ f C W-PHONE - a single marker dial. The marker located on C W with the switch in the counterclockwise position.
 - ✓ g FINAL - the large spinner knob. No special positioning is required.
 - ✓ h 160 - a single marker dial. The marker located on OUT with the switch in the counterclockwise position.

- Check the tube numbers since we have less capacity - but on reading found what I need on pages 10 and 11.*
- ✓ i COUPLING - the 7-1 dial. The (1) located on the maximum counterclockwise switch position. (maximum capacity position)
 - ✓ j FINE COUPLING - a 100-0 dial. The (0) located on the (maximum capacity) position of the variable condenser.
 - ✓ k AUDIO - a 10-0 dial. The 0 located on the maximum counterclockwise potentiometer position.
 - ✓ l METER - the MOD PLT GRID BFR OSC OFF dial. The OFF position located on the maximum counterclockwise switch position.

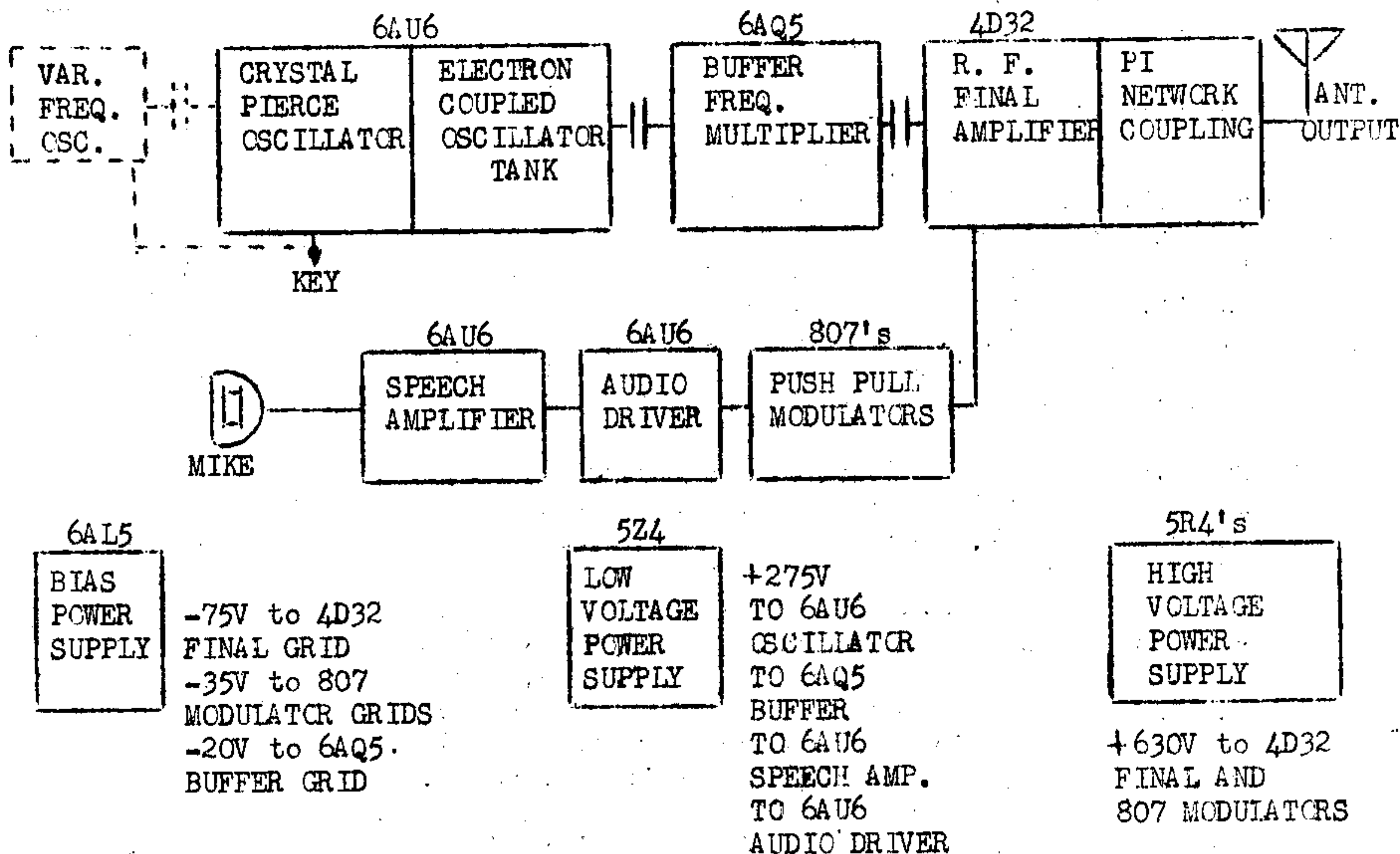
6 Insert tubes as follows (the socket locations can be determined from the designations by referring to Figure 1 at the rear of this book):

- a The 6AQ5 buffer in X5 with a 2 1/4" shield
- b A 6AU6 oscillator in X6 with a 1 3/4" shield
- c A 6AU6 speech amplifier in X1 with a 1 3/4" shield
- d A 6AU6 audio driver in X2 with a 1 3/4" shield
- e The 6AL5 bias rectifier in X11
- f The 5Z4 L.V. rectifier in X10
- g Two 5R4 H.V. rectifiers in X8 and X9
- h Two 807 modulators in X3 and X4, connect plate caps. The polarity of the caps with respect to the 807 will be determined later.
- i The 4D32 in X7. Attach plate cap

The Viking I should now be ready for its initial operation but do not attempt to turn it on until the theory of Operation and Tuneup sections have been studied.

B Theory of Operation

1 The Viking I block diagram



2 The general specifications, frequency coverage, and main features of the Viking are covered in the brochure at the front of this book.

3 The OSCILLATOR: The "crystal" switch will select any of 10 crystal positions on the crystal board or connect the 6AU6 grid to the VFO receptacle at the left rear of the chassis (the VFO is the 0 position). The Pierce Oscillator part of the 6AU6 will oscillate efficiently with most crystals in the range of 1.75 mc to 7.5 mc. The plate of the 6AU6 is electron coupled to the oscillator which makes this stage a good frequency doubler on the high frequency range of the Viking I. The tuning range of the oscillator tank is that of the indicated wavelength on the 160, 80, and 40 meter positions; is the 40 meter range on the 20 and 15 meter switch position; and 20 meter range on the 10 meter bandswitch setting. The approximate frequency coverage of either the oscillator or buffer stage can be determined from the tuning curves on the sheet following page 14. Oscillator cathode current is indicated on the "osc" position of the meter switch. A drop in oscillator current can be expected when a crystal is

switched into the oscillator circuit. The Viking I oscillator stage becomes simply an amplifier or frequency multiplier when a VFO is used. It is necessary to isolate the Viking I 6AU6 oscillator grid with a blocking condenser of 50 mmfd to 150 mmfd in the connection between the Viking I and the VFO if a DC path exists in the VFO output.

- 4 The BUFFER: Frequency multiplication takes place in the 6AQ5 buffer stage on the 20, 15, and 10 meter band positions. Straight through operation is used on all lower frequency bands. The buffer stage output magnitude is controlled by the "drive" screen grid potentiometer control. Buffer tuning is best indicated by the 4D32 final "grid" current, while the oscillator tank tuning is best indicated by the buffer cathode current read in the "bfr" meter switch position. The "grid" current must be held below 15 ma at all times. 9 to 12 ma is adequate to drive the 4D32 to full output. Buffer no signal current is limited by a fixed bias of approximately 25 volts applied to the 6AQ5 grid.
- 5 The R.F. POWER AMPLIFIER: The grid circuit of the final 4D32 has a fixed bias of 75 volts with an additional 20 to 30 volts of self bias added by the drive signal. Under no-signal conditions the 4D32 is completely cut off. The tank of the 4D32 is part of a pi network matching-coupling circuit. The main tuning inductor, L9, and geared condenser, C29, tune the range of 80 through 10 meters. The "160 in-out" switch adds an additional auxiliary coil to cover the 160 meter band. Frequency coverage is shown on curve 1 of the sheet following page 14. The screen and plate current of the 4D32 is read in the "plt" meter switch position. Note that the final grid current is not included in the "plt" reading. The screen grid voltage of the 4D32 is obtained from the high voltage divider-bleeder resistor when the "cw-phone" switch is in the "cw" position and from the modulator output through a 10,000 ohm resistor in the "phone" position.
- 6 The PI NETWORK ANTENNA COUPLING: The complete pi network consists of the main tuning inductor, L9, as the series element; the main tuning condenser, C29, as the input shunt element; and the output shunt capacitance made up of a variable condenser, C30, labeled "fine coupling" and a group of fixed mica condensers, C33 through C38, switched in parallel with C30 by a switch labeled "coupling". This combination provides a continuous output capacity range of 20 to 2000 mfd. The pi tuning-coupling network is designed to match the 4D32 into antenna resistances of nominally 50 to 600 ohms and tune out several hundred ohms of antenna reactance over the frequency range of the Viking I. The range of antenna impedance matching extends roughly from 25 to 2000 ohms at frequencies higher than 7.0 mc. In general high impedance loads will require small output coupling capacities (advanced settings). Reactance cancellation take place automatically when the "final" control is tuned to the proper plate current dip with the meter switch in the "plt" position. The net tank plate reactance is dependent on the load characteristics and the output coupling capacity but the plate current dip indicates that the 4D32 plate is loading into a resonating tank. The plate current dip becomes less and less pronounced until the final 4D32 is properly loaded. A dip of about 15 to 30 ma should always be maintained when the final is properly loaded. Advancing the

coupling controls beyond the 20 ma dip point usually causes over-coupling resulting in inefficiency and poor harmonic suppression.

- 7 THE MODULATOR: The modulator consists of a pair of 807's operating in class AB2 push-pull, driven by a transformer coupled 6AU6 driver, and a 6AU6 resistance-capacitance coupled speech amplifier. The "audio" gain is a potentiometer control of audio input to the driver stage. Negative feedback between the modulation transformer secondary and the cathode of the driver stage does much to correct transformer distortion, minimizes audio resonance tendencies, and allows a degree of overmodulation limiting by the saturation characteristics of the audio transformer with a minimum of distortion. When the "cw-phone" switch is in the "cw" position the secondary of the modulation transformer is shorted and the screens of the 807 tubes are opened. The "phone" position removes the short and applies screen voltage from the high voltage bleed-divider tap to the 807's. Sections of the high voltage primary "plate" switch and the "cw-phone" switch are interconnected in the keying circuit so that the keying circuit is opened whenever the "plate" is off and the "cw-phone" switch is in the "phone" position. This eliminates oscillator interference while listening to a station operating on the same frequency as the Viking I. Frequency characteristics provide excellent quality with ordinary crystal communication microphones. If an increased low frequency response with a limiting of high frequencies is desired, a .002 or .003 mfd condenser can be put across the 807 grids as indicated on the schematic diagram by C7. The 15,000 ohm resistors R10 and R11 should be used only when the mike used has a very high output.
- 8 The POWER SUPPLIES: The Viking I has three separate power supplies:
- A. The 6AL5 BIAS SUPPLY furnishes approximately 75 volts bias to the 4D32 grid circuit, 35 volts bias to the 807 modulator grids and 25 volts bias to the 6AQ5 buffer-frequency multiplier.
 - B. The 5Z4 LOW VOLTAGE SUPPLY furnishes power to all filaments and 260 to 280 volts (loaded) to the RF exciter and 6AU6 audio amplifier stages. The L.V. power transformer is rated at 95 ma. D.C. at the high potential terminals.
 - C. The HIGH VOLTAGE SUPPLY furnishes 620 to 660 volts (loaded) to the 4D32 final amplifier and 807 modulators. The parallel 5R4 tubes and 10 henry choke input filter provide good regulation in the operating range of the Viking I. The B-side of the H.V. supply is above ground potential by the 4D32 meter shunt voltage (100 millivolts full scale).
- 9 METERING: The cathode currents of the oscillator, buffer, and modulator may be read on the meter when the meter switch is placed on the indicated position. The 4D32 power amplifier combined screen grid and plate currents are read in the "plt" position, and the 4D32 grid current is read in the "grid" position. All shunts are cut for 100 mv drop for a full scale meter indication. The "osc" or "grid" currents are read on the lower 0-25 ma scale, the "bfr" current on the upper scale (assuming 50 ma full scale), and the "plt" and "mod" current on the ma 0-500 upper scale. } n.d.

10 KEYING of the VIKING I is done in the 6AU6 oscillator cathode circuit. The keying circuit is broken by the H.V. switch (off position) on phone operation as previously described under "Modulator", so the RF exciter tune up must always be done in the "cw" position of the cw-phone switch. As may be expected with any conventional oscillator keying, the quality of the keyed character may depend slightly on the oscillator tank tuning when "straight through" operation is used. The oscillator tuning control can be adjusted for clean stable keying.

11 VFO EXCITATION: The "0" position of the crystal selector switch connects the VFO receptacle at the rear of the chassis directly to the 6AU6 oscillator grid through approximately one foot of RG59U cable. An isolating condenser of 50 to 150 mmfd is necessary between the VFO and Viking I input unless the VFO has a capacity coupled output (the Johnson VFO may be directly coupled). 6 volts of 40 meter RF at the grid of the Viking I 6AU6 oscillator stage will drive the final to full excitation on 10 meters. The lower frequency bands require less VFO output. The VFO frequency range should be nominally the same as the crystal frequencies which would normally be used. There is a danger of overdriving the 6AU6 with a VFO. Grid blocking actually reduces the effectiveness of the stage to the point where it attenuates the input signal greatly rather than passing or amplifying the input signal or generating the required harmonics.

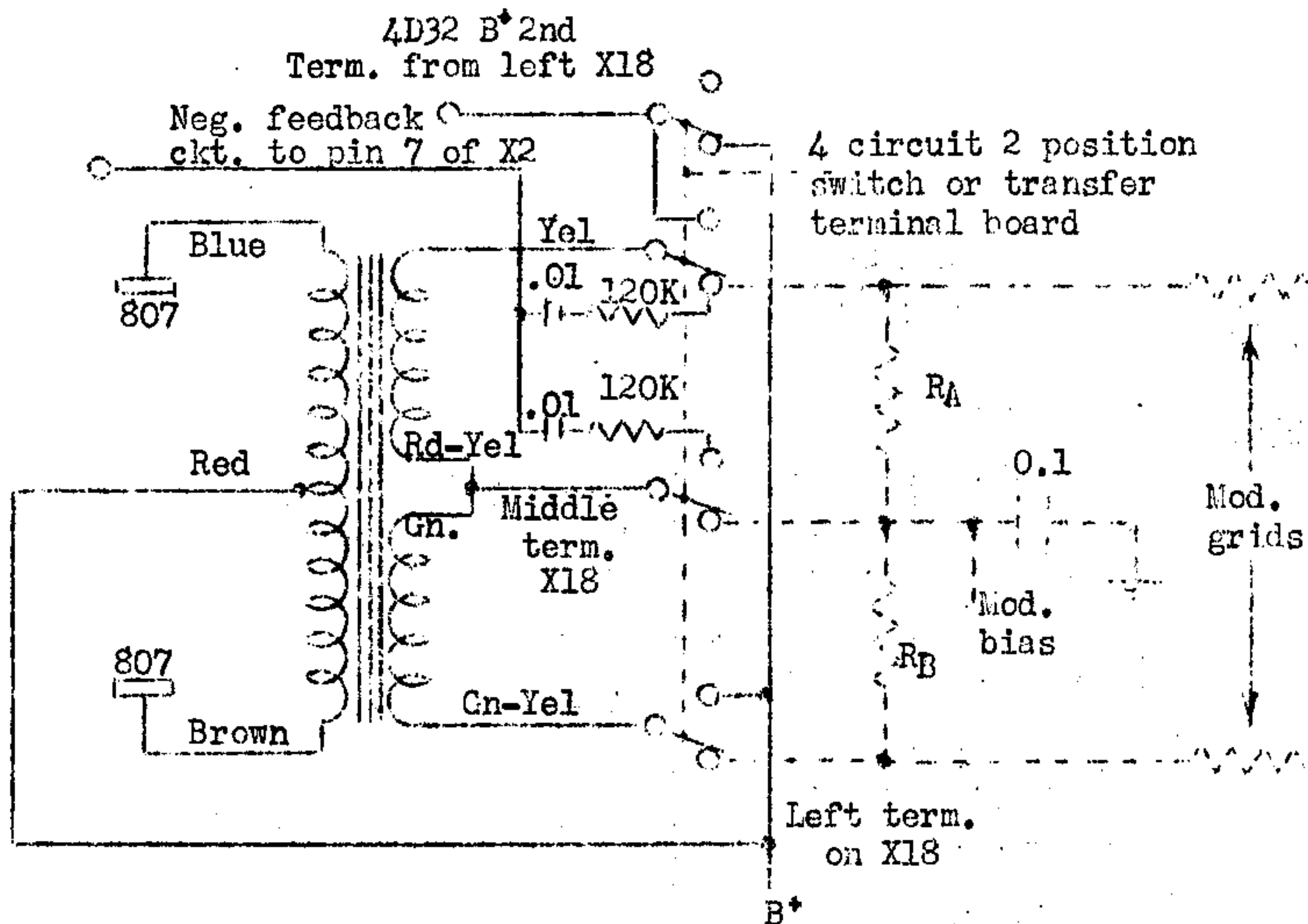
When the Viking I is fed with a VFO, it is well to remember that the specified voltage is that at the Viking I 6AU6 grid and that a transmission line must be loaded in a manner to provide the required voltage at the grid of the 6AU6. An example of this problem is a four foot length of RG59U. It will appear as approximately 84 mmfd of shunting capacity at the VFO output and should be treated as such at frequencies below 10 mc unless excessive VFO output is available and the attenuation of the transmission line is desired.

The VFO must be shielded enough so that feedback does not exist between the transmitter and the VFO. Monitoring a VFO driven transmitter should be done more carefully than usually necessary with crystal operation. Keep the VFO and transmitter decoupled from the monitoring receiver to avoid overloading the receiver. Receiver blocking or local oscillator shift due to overloading often causes an unreliable indication of transmitter keying or frequency.

12 The VIKING I as an EXCITER for a LARGER TRANSMITTER:

a When the Viking I is used as an RF exciter only, tuning and loading procedure will be essentially the same as used with normal transmitter operation. The output of the Viking I can be link coupled to the grid stage of the power amplifier. Enough power should be required at the power amplifier grid circuits to load the Viking to at least 30 watts. Shunt dissipating resistors can be added if the grid requirement is too small to load the Viking I sufficiently.

b Conversion of the Viking I Modulator to serve as an audio driver is shown on the following sheet. Figure A suggests how a switch or transfer



The 500 ohm Modulator driver connections are shown in FIGURE B on the other side of this sheet.

VIKING I MODULATION TRANSFORMER CONNECTED TO DRIVE A
LARGER MODULATOR WITH SWITCHING OR TRANSFER FOR NORMAL OPERATION

- 1 Refer to Figure 2 at the rear of the book for terminal locations. The yellow and gn-yel modulation transformer leads in Fig. A and the yellow and rd-yel leads of Fig. B must be disconnected from present terminations.
- 2 A 4 circuit 2 position switch may be mounted on the side of the chassis above X1, or a transfer terminal block may be mounted on the outside rear of the chassis. No attempt will be made to provide mounting details as available switches or terminal boards will differ markedly. Steatite switches or terminal boards should be insulated for 1200V between terminals.
- 3 RA, RB, or RC may be chosen to load Viking I Modulator if quality is impaired by light loading.
- 4 Negative feedback components, R9 and C5, shown in the Viking I schematic, must be replaced by those shown in sketches.
- 5 Permanent connections for exciter operation can be made as indicated by the closed circuits in the switch positions shown above, eliminating the switch or transfer board.

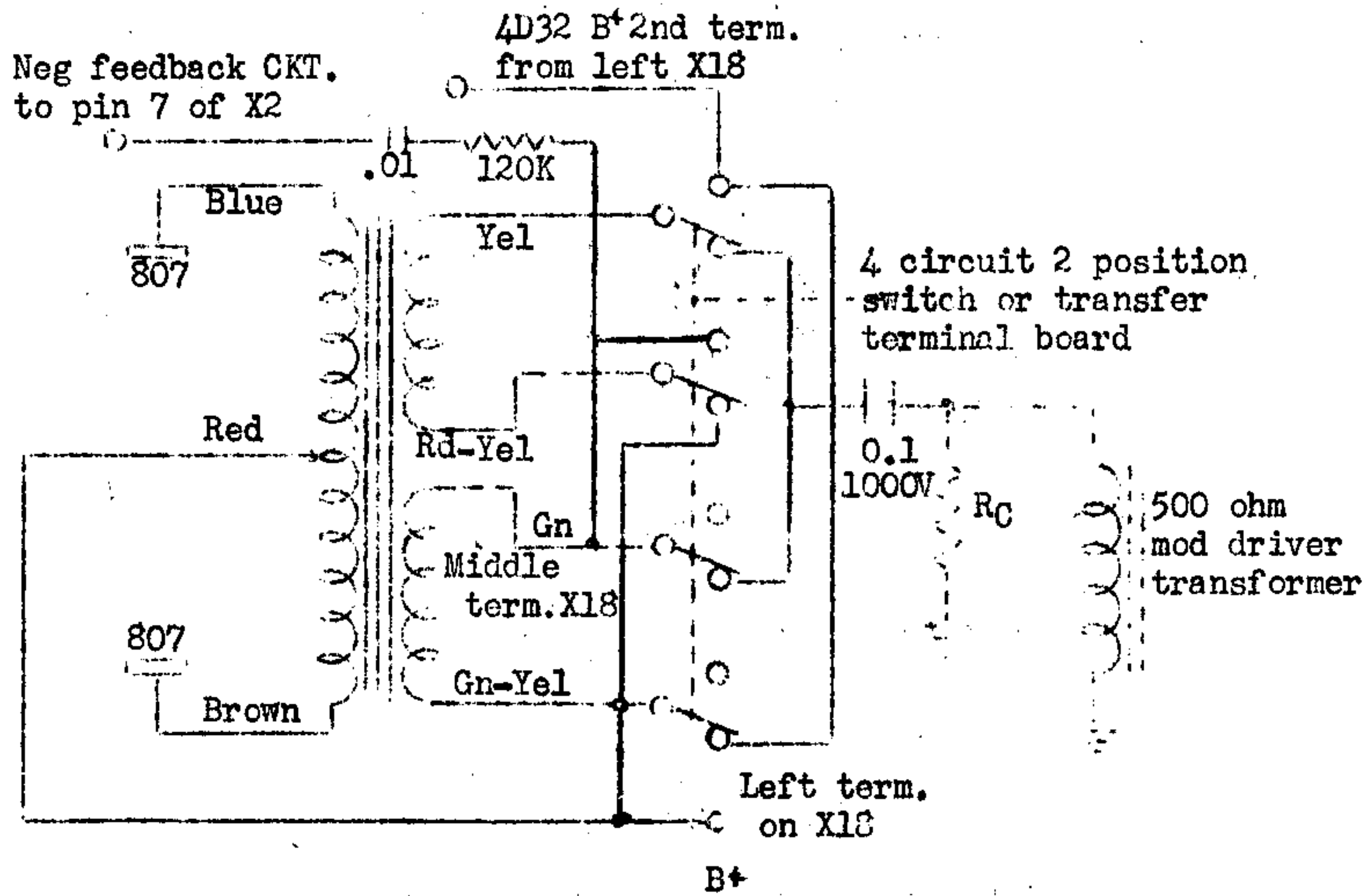
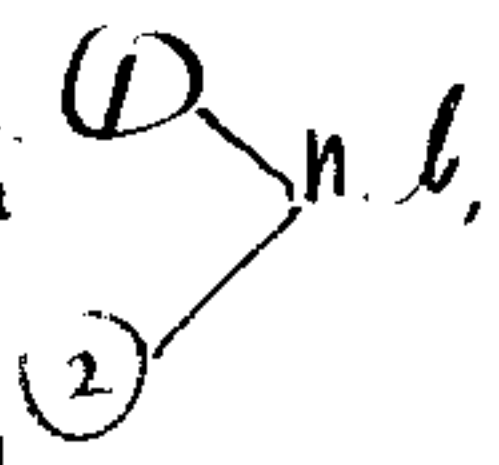


FIGURE B
CONNECTION THROUGH 500 OHM PRIMARY
OF MODULATOR DRIVER TRANSFORMER

terminal board may be used to connect the Viking I modulator to drive the grids of a larger Modulator directly and allow normal Viking I operation upon switching or moving the transfer jumpers to the alternate position shown. Figure B shows the connections for feeding the larger modulator grids through a 500 ohm line and audio driver transformer. A hole may be punched in the rear of the Viking Chassis to bring out the audio leads conveniently either directly or through an appropriate connector.

- c Connection of the Viking I as an audio driver in a permanent installation suggests itself in Figures A and B. The switches are shown in the driver exciter position; permanent connections can be made ignoring the alternate normal Viking I operating position. The secondary winding of Figure B may be isolated from B+ and grounded which will eliminate the need of the 0.1 mfd D.C. isolating condenser.
- d Relay connections to the Low Voltage and Filament transformer primary may be brought out from the lug nearest the chassis bottom on X17 (with a blue-orange harness lead) and the second terminal from the rear on X22 (brown-black harness lead). Relay connections to the High Voltage Supply may be taken from the two rear terminals of X22 (brown-black and gray-red harness leads).



C Viking I Tuning Details

- 1 TYPICAL TUNING: 40 METER tuneup procedure will serve to acquaint the operator with the usual steps involved. Deviations of procedure for other bands will follow. Before turning on power make the adjustments a through j, then proceed as indicated:
 - a Connect a good ground wire or counterpoise to the ground terminal at the rear of the chassis. If there is some question of ground effectiveness read the section "How to obtain a Good Ground" under the Pi Network tuning and Harmonic Suppression topic of page 15. Connect an antenna or dummy load to the output receptacle at the rear middle of the chassis.
 - b Plug in a 7.00 to 7.30 mc crystal in position 1 of the crystal selector socket. 3.5 to 3.65 mc crystals are usually very satisfactory, 1.750 to 1.825 mc crystals may be used but with caution as it is possible to obtain output at 5.250 to 5.475 mc.
 - c Set the "crystal" dial on "0".
 - d "Band" on "40".
 - e "Drive" on "0".
 - f "Final" on "0" (full tank in).

- g "Cw-phone" on "cw".
- h High voltage "plt" bat handle down.
- i "Coupling" on "1".
- j "Final Coupling" on "0"
- k "160" switch on "out".
- l Approximate settings of the oscillator and buffer may be obtained from tuning curves on the sheet following page 14.
- m Throw "fil" Switch SW1 on. This applies all voltages except plate and screen voltages for the 4D32 final and 807 modulators.
- n Turn "crystal" to position 1. The "osc" current should drop perceptibly.
- o Turn "meter" to "bfr" and advance "driver" to about position 4 in the clockwise direction.
- p Tune "oscillator" slowly for a rise in buffer current. Adjust tuning for buffer current. In some cases a slight dip of buffer current may occur between two maximum current points. This is true with very active crystals or a strong 6AU6 oscillator tube. Correct tuning, when this occurs, is usually on the dip between the maximum points.
- q Turn meter to "grid" and note 4D32 grid current. If it should be over 15 ma, reduce it at once by turning "drive" counterclockwise. Usually there would be no grid current at this point but the buffer tuning could happen to be nearly correct.
- r Tune "buffer" for maximum grid current keeping the grid reading below 15 ma by means of the "driver" control. After "buffer" has been properly adjusted, turn "driver" to its 0 position.
- s Turn meter to "plt" position and "plate" on. Turn "drive" clockwise until plate current rises to 150 ma.
- t Tune final toward 100 until plate current dips sharply. Be certain that the final is tuned to the first dip in plate current thus assuring that the amplifier is tuned to the fundamental and not to a harmonic.
- u Turn meter to "grid", and touch up buffer tuning for maximum grid current. Advance "drive" until 9 to 12 ma of grid current is noted. Turn meter to "plt".
- v Proceed to load the antenna by advancing the "coupling" control toward higher numbers until the "plt" current is around 200 ma. Retune "final" for a dip and again advance "coupling" and retune the "final" for dip

Turned less capacitance (mean - heavier loading) - see p. 14 for information.

- 10 - Also see p. 14 for info on Dargy - hammer reduction depends on the capacitance of output coupling condenser, so never reduce it to zero!!

Impedance too high

until around 200 ma or slightly less is again read under resonant conditions.

w A minimum coupling capacity equivalent to that of step 6 of "coupling" should be maintained in any case on 40 meters. The antenna is usually out of the range of the Viking I if less than a total of 150 mmfd of output capacity is required on 40 meters. If "coupling" is turned to 7, "fine coupling" should be advanced no further than 60 on 40 meters in step x. *Page 4 states to use less capacity*

x Turn "fine coupling" toward high numbers until the "plt" reading rises to about 250. Dip the plate current with "final" adjustment again and follow this procedure until a desired plate current between 250 and 275 ma has been reached. A slight broad dip of 15 to 30 ma should be maintained when tuning is complete. Complete lack of a dip indicates over-coupling with accompanying inefficiency and poor harmonic rejection. If the desired coupling cannot be obtained with the "coupling" setting of step w, turn the "fine coupling" to 0 and advance "coupling" another step (normally not beyond 6 on 40 meters) and readjust "final" and "fine coupling".

C. W. OPERATION may now be carried on by simply plugging in the key. Check to be sure the 4D32 plate current is zero with the key up before operating. If keying is slightly erratic, retune the "oscillator" slightly until keying is crisp and clean.

*Keying
See also
other manual
p 21, P14,
and P 8
this
manual*

2 160 METER TUNING: Proceed as on 40 meters with the following exceptions:

- a "160" switch on "in" (do not turn until "plate" is off).
- b Use 1.8 to 2.0 mc crystals in crystal socket position corresponding to "crystal" setting.
- c Final tuning will be very broad. With high impedance antennas the "final" may be against the stop on the "0" end when resonance is indicated. In this case leave the main dial at "0" and advance "coupling" toward higher numbers. Do not advance "coupling" beyond 6 with the "fine coupling" beyond 50 in any case. A further reduction in output capacity indicates that the antenna terminal impedance is out of the range of the transmitter. Although you may feel the tank is out of resonance, the circuit is so broad that good resonance conditions still exist and its efficiency is not impaired.

1.2 to 1.5 high

3 80 METER TUNING:

- a "160" switch on "out" ("plate" off while changing).
- b Use 1.75 to 2.0 mc or 3.5 to 4.0 mc crystals.

- c Do not attempt to reduce "coupling" beyond step 6 with "fine coupling" beyond 50 in cases of high antenna impedance again as in the case of 160 meter tuning.

4 20 METER TUNING:

- a 7.0 to 7.2 mc, or 4.666 to 4.8 mc (14.0 to 14.4 mc harmonic) crystals may be used. 3.5 to 3.6 mc and 1.750 to 1.8 mc crystals may be used but caution must be exercised as it is possible to obtain output at 10.5 to 12 mc. Reduced drive will be noted with the latter crystals.
- b In nearly all cases of 20 meter operation the "coupling" switch can be set at 7 and loading accomplished by "fine coupling" alone. The "fine coupling" should never be advanced beyond a setting of 70 to 20 meters with "coupling" at 7.

5 15 METER TUNING:

- a 7.0 to 7.15 mc crystals are preferred. 3.5 to 3.575 mc crystals may be used with limited 4D32 grid drive.
- b Set "coupling" at 7. The "fine coupling" control should never be advanced beyond 80 in any case on 15 meters.

6 10 and 11 METER TUNING

- a 7.0 to 7.425 mc or 6.74 to 6.8075 mc crystals are recommended. 14.0 to 14.85 mc or 13.48 to 13.615 mc crystals (usually harmonic cut but oscillate at 1/3 of their indicated frequency in the Viking I) may be used with somewhat lower final drive. 3.5 to 3.7125 mc crystals will drive the final weakly (5 to 8 ma grid current) but caution is necessary as 24.5 to 25.987 mc output is possible.
- b Set "coupling" at 7. Do not advance "fine coupling" beyond 90.
- c Touch up tuning. Final will have setting near 100. Under conditions of low line voltage, weak RF tubes, or low crystal activity, it may be difficult to obtain 15 ma grid drive. This is not serious as 8 to 10 ma is adequate for full 10 meter output.

If difficulty is experienced in obtaining a "grid" indication on the 10, 11, and 15 meter bands due to weak crystal activity or double peaks on buffer current tuning, the "plt" current may be used to determine the initial settings as follows (this procedure is rarely needed as the Viking is normally very easy to tune on these bands):

- a Tune oscillator stage as usual.
- b Turn "drive" to 0.
- c Turn "meter" to "plt".

- d Turn "plate" switch on.
- e Turn "driver" up to about 4 while watching the plate current.
- f Tune buffer and oscillator to maximum plate current, limiting the "plt" reading to 100 ma by means of the "drive" control during tuning. Do not leave "plate" on while final is untuned for periods of more than 1 minute.
- g Turn "plate" switch off and check "grid" current. Log settings if difficulty is anticipated in retuning under the same conditions.

7 PHONE OPERATION:

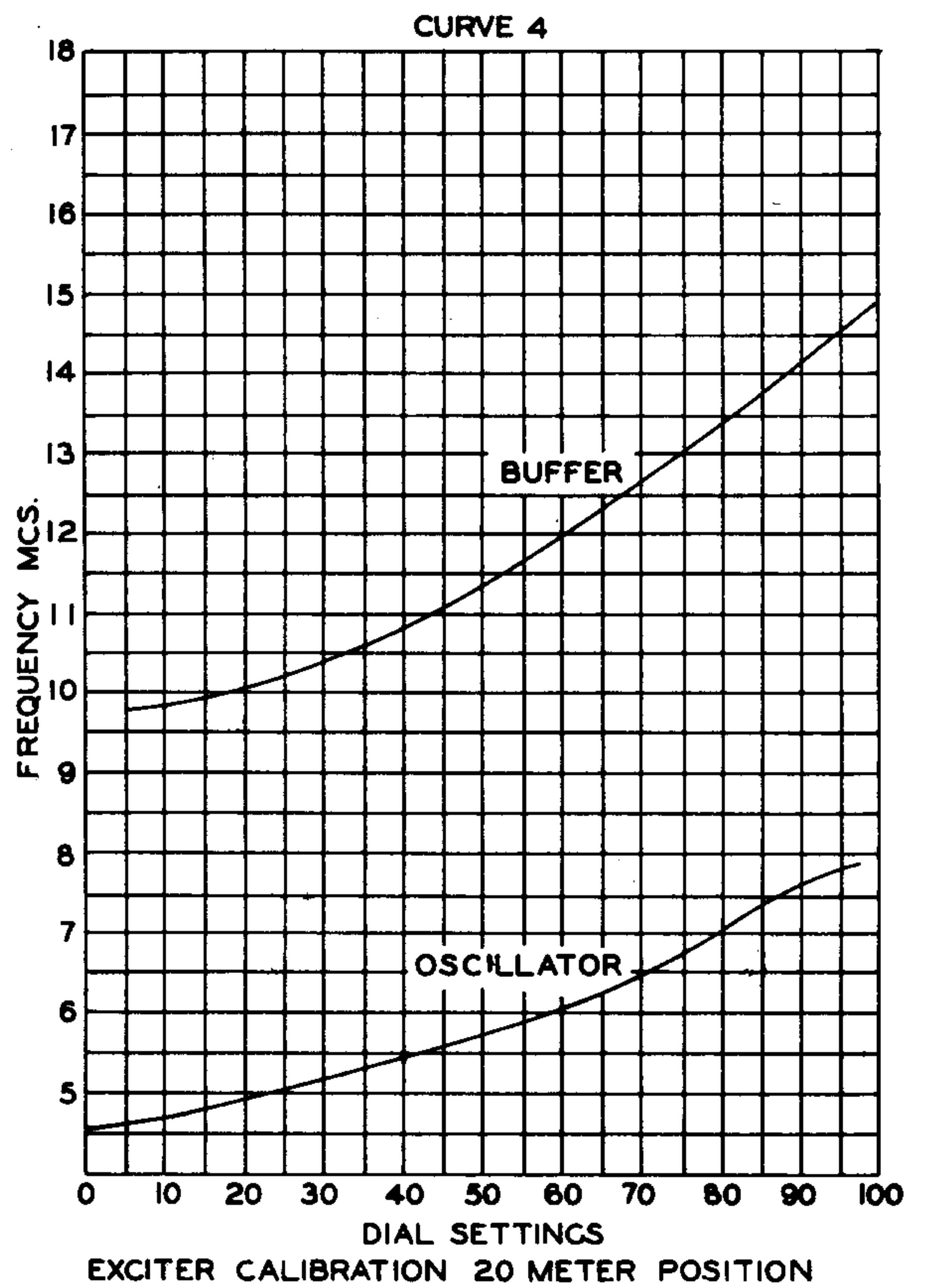
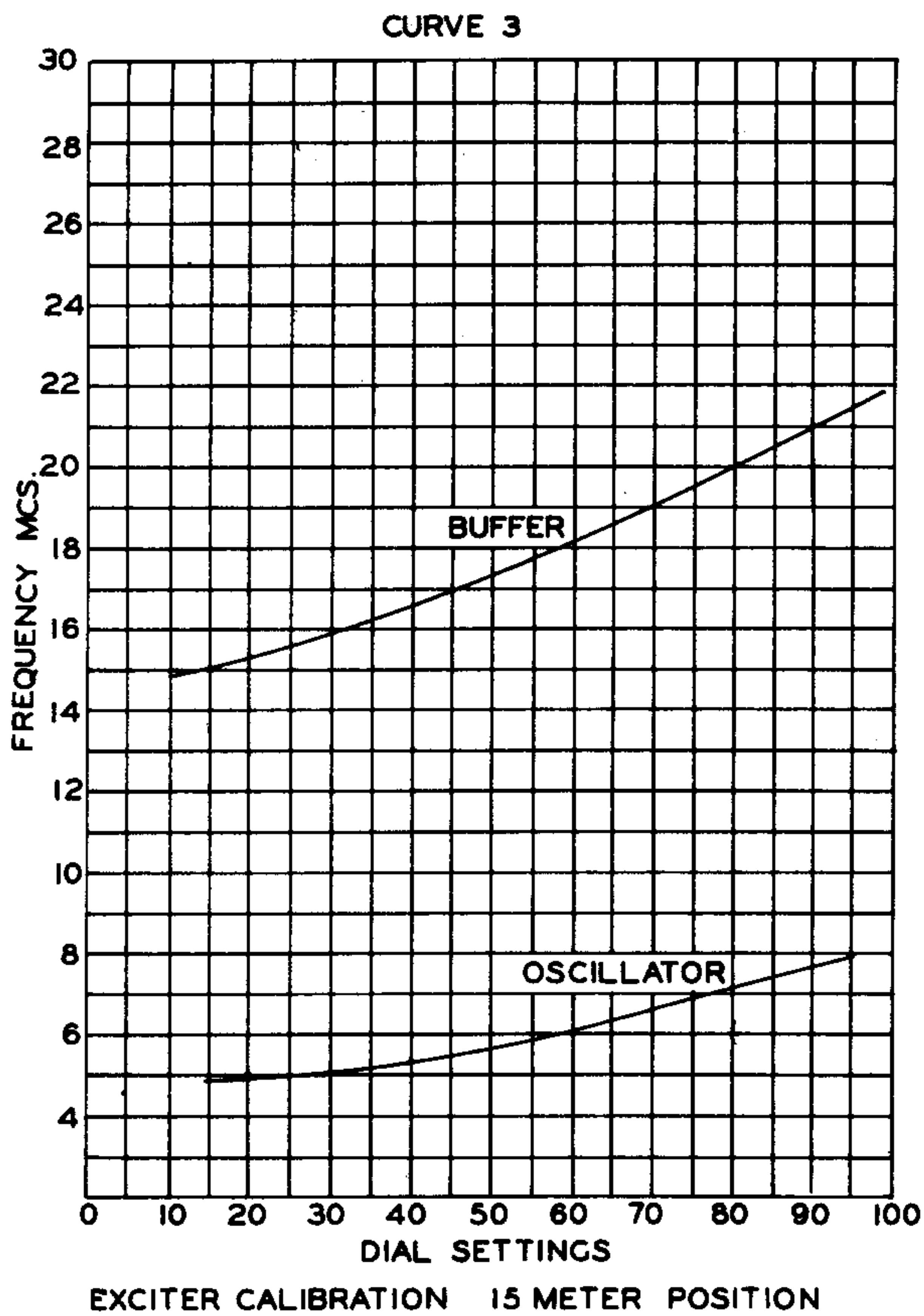
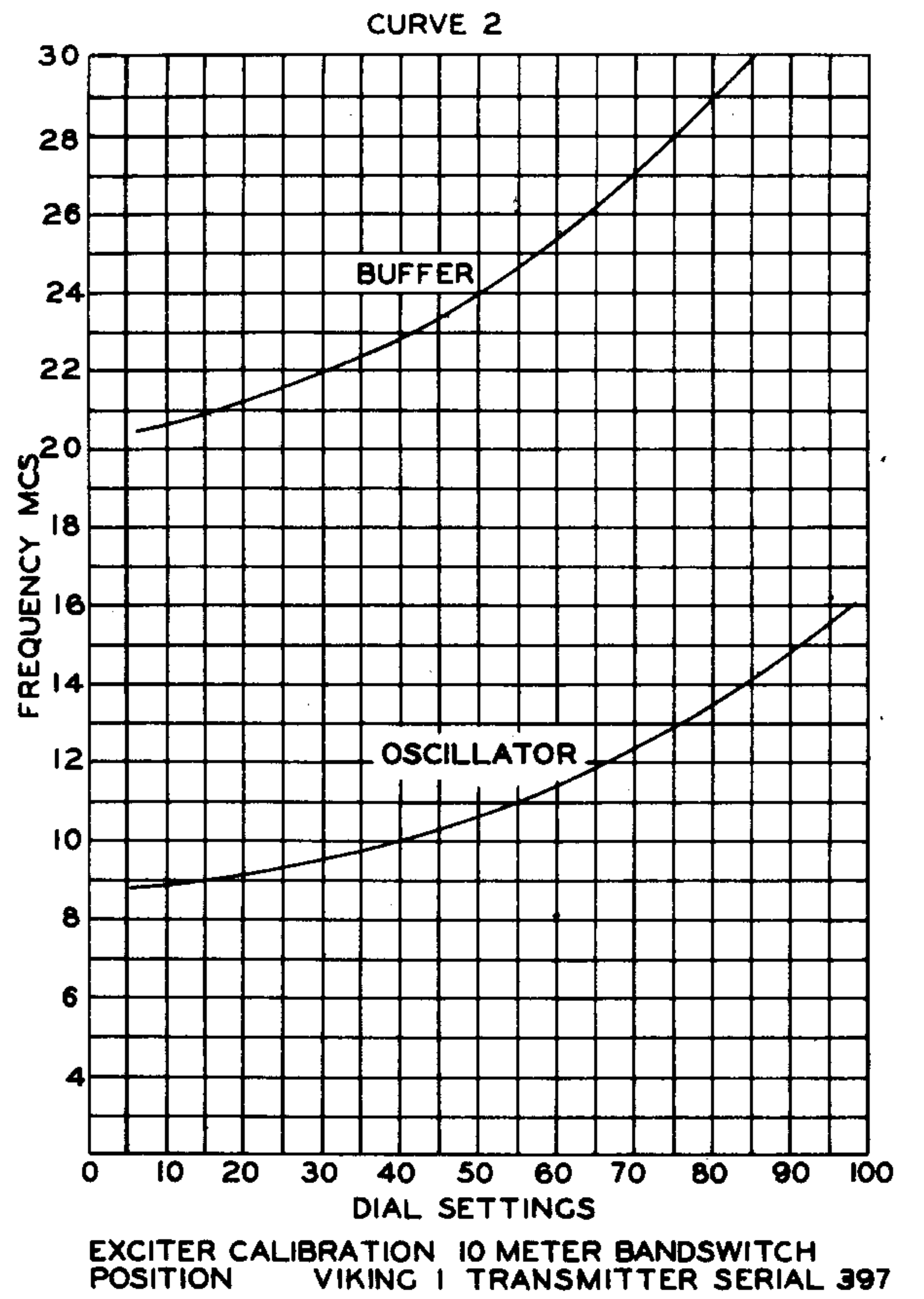
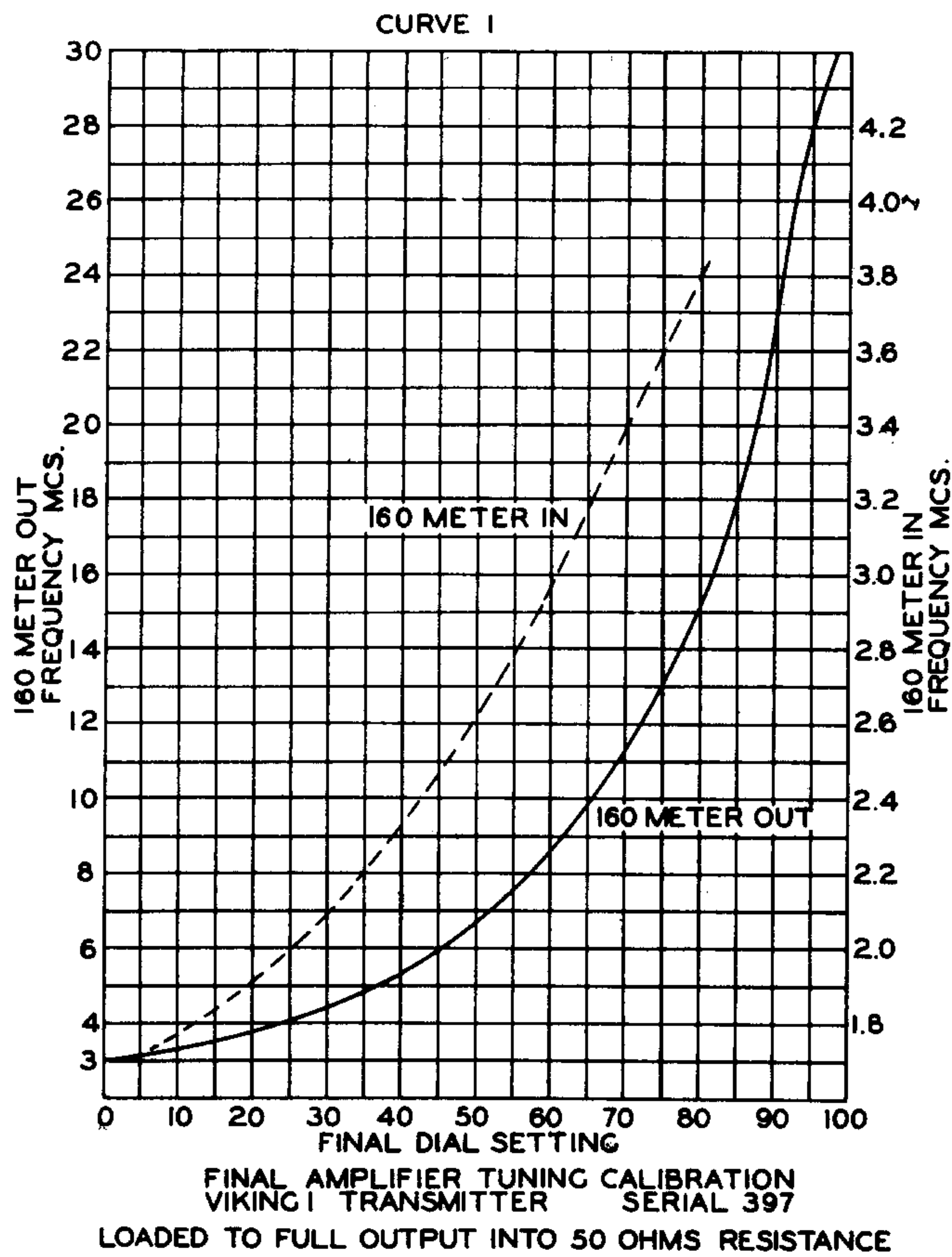
- a Tune up Viking I in "cw" position.
- b Turn the "plate" switch off.
- c Turn "phone-cw" switch to "phone".
- d Turn "audio" to "0".
- e Turn "plate" on. If squeal is heard, turn "plate" off immediately and reverse 807 plate caps. Before doing so, be sure the high voltage is off by shorting plate caps to transformer case with an insulated screw-driver!
- f Connect a high impedance crystal or high output dynamic microphone to the connector marked "mic".
- g Turn meter switch to "mod". The modulator no signal current should be between 60 to 80 ma. **OK**
- h ~~Talking into the microphone, advance audio until the "mod" current rises to 150 to 175 ma on audio peaks. 150 to 175 ma of modulator current corresponds to 100% modulation. Antenna current will advance 15 to 20% with 100% sustained modulation. Do not tone modulate the transmitter near full modulation for periods of more than two minutes as the power supply loading will be excessive. A small downward reading of "plt" is normal during modulation.~~
Other manual pg 175

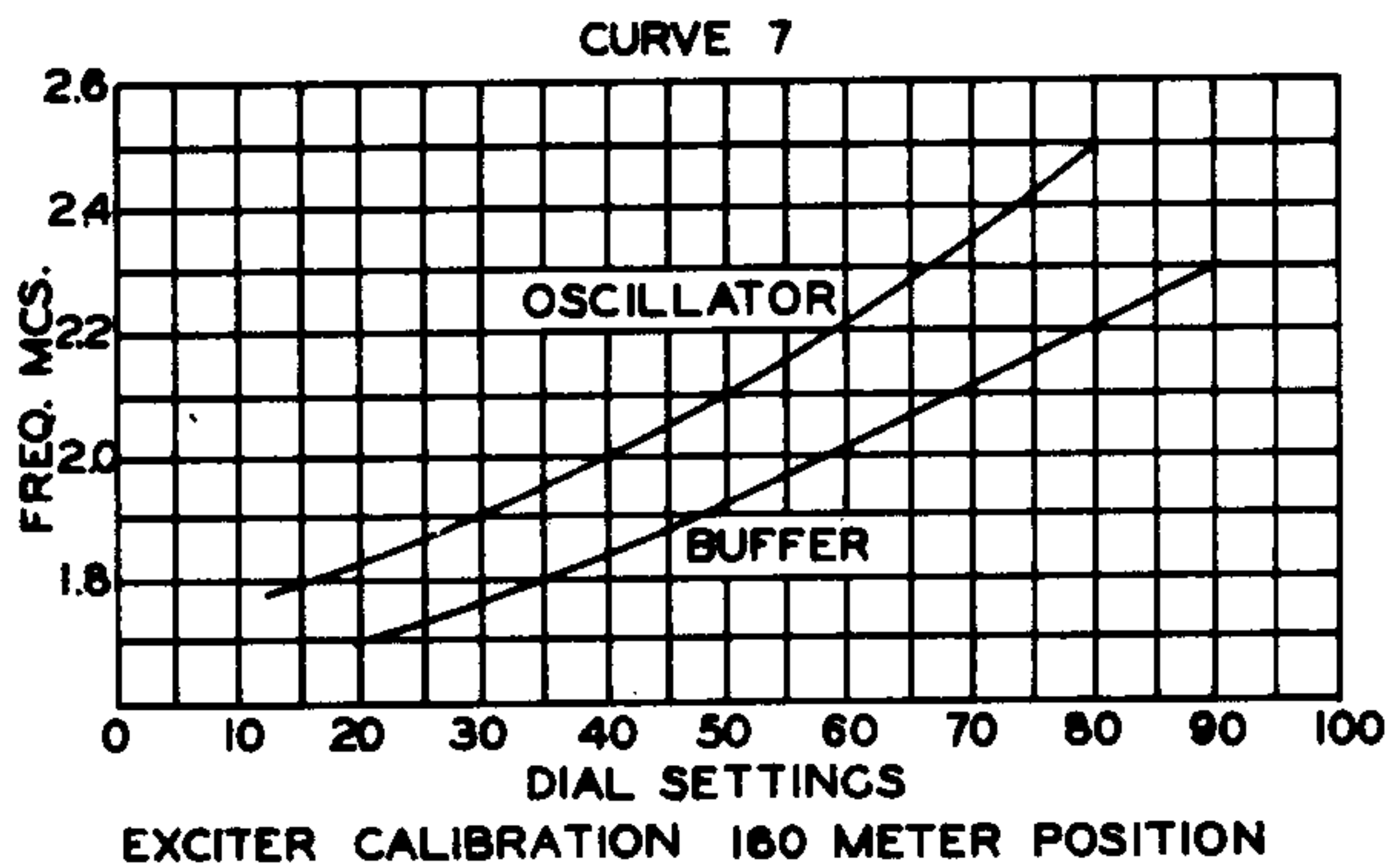
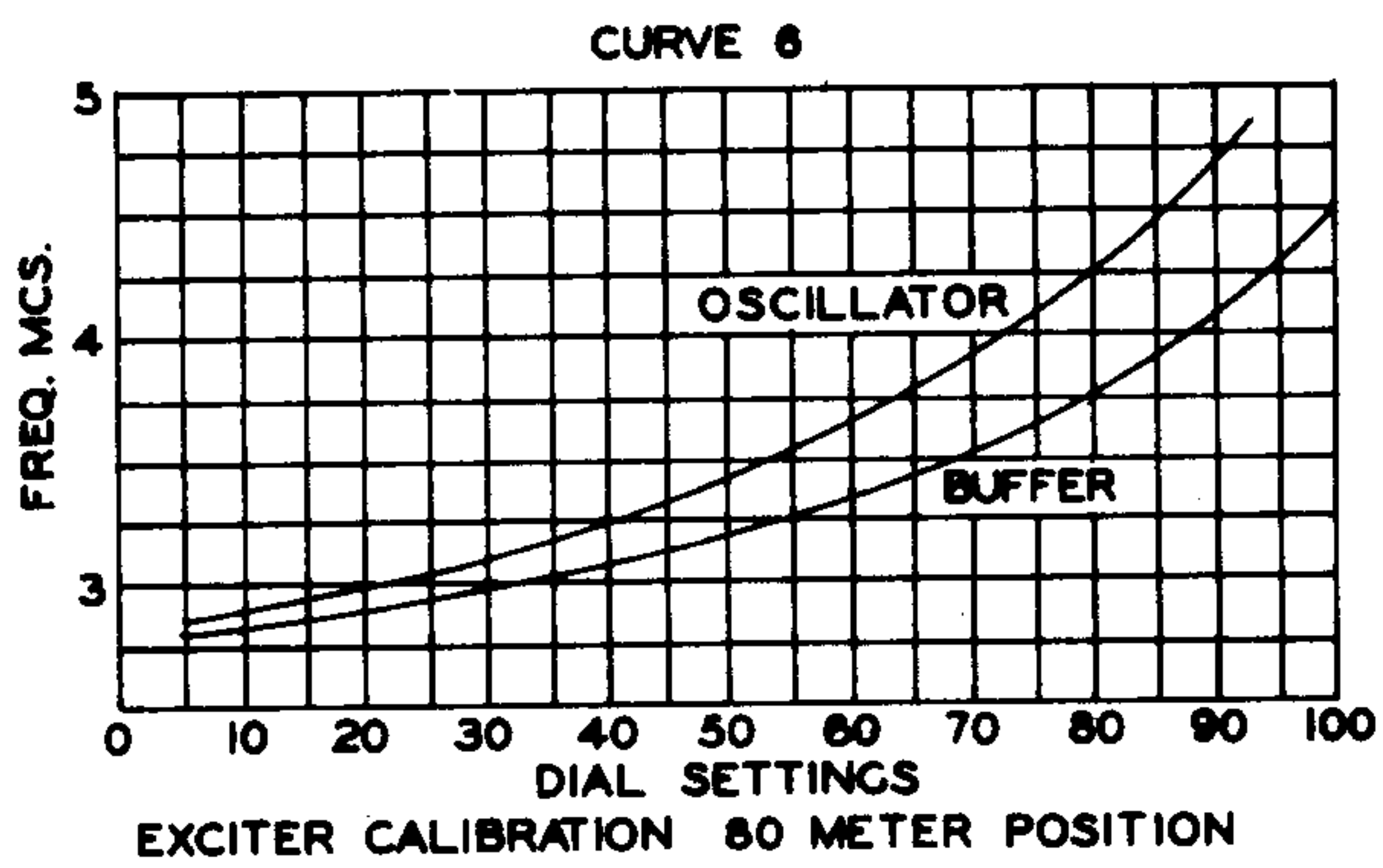
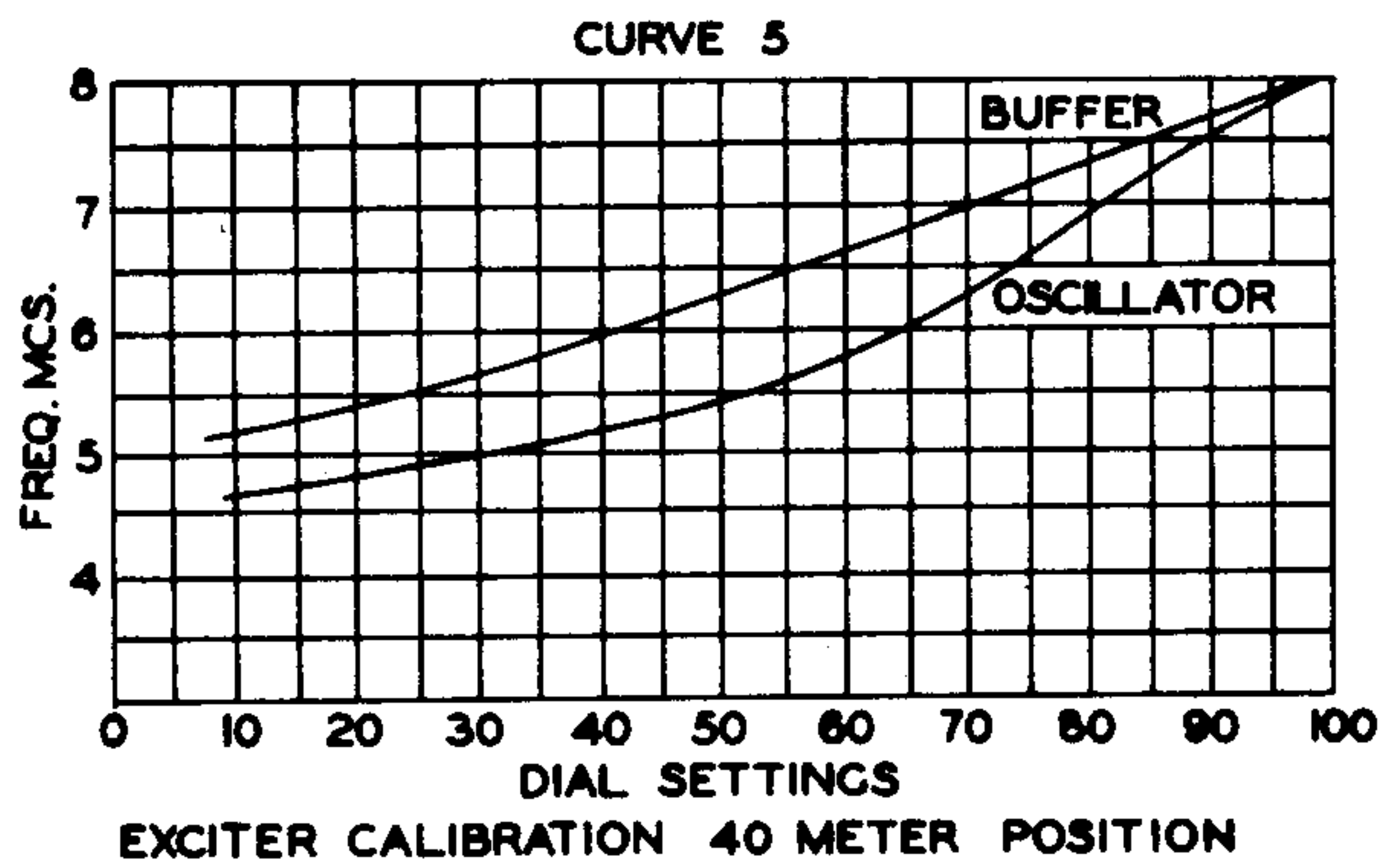
also see P33 of other manual.

8 VFO OPERATION:

- a Review the discussion of VFO excitation under "Theory of Operation".
- b Plug the VFO output cable to the VFO coax receptacle at the left rear of the Viking I chassis. A 50 to 150 mmfd isolating condenser may be needed in the center conductor of the connecting cable to prevent the 6AU6 grid from being short circuited if the VFO output has a continuous D.C. path to ground.

- C.W.
- c Use the VFO in the same manner as crystals are used for output on the band selected. Only two volts of 160 meter signal at the Viking I 6AU6 grid will drive the transmitter to full output on 160 to 80 meters. The 160 meter VFO signal will also drive 40 meters satisfactorily. Six volts of 40 meter VFO excitation at the 6AU6 grid will be sufficient to drive the Viking I to full output on all bands, 40 meters through 10 meters. The R. F. Voltage at the 6AU6 grid should be limited to a value of less than 15 or 20 volts to prevent the stage from blocking.
 - d It should be borne in mind that any tendency of a VFO to chirp or drift is multiplied when the transmitter's output frequency is two, three, or four times the V.F.O. output.
 - e Zero beating a received signal in cw operation is accomplished by simply closing the key (with "plate" off) and adjusting the VFO for a zero beat with the received signal in the receiver. If the coupling of the Viking I exciter stages to the receiver is so close that the receiver tends to block, the exciter stage can be disconnected from the VFO by tuning the "crystal" switch to the #5 or #6 vacant crystal positions while adjusting the VFO. (enough VFO coupling takes place in the #1 and #2 position to excite the 6AU6 somewhat)
 - f Zero beating signals in phone operation is done by turning the "phone-cw" switch to "cw" and proceeding as described previously. In cases of very weak signals the receiver BFO may aid in making the VFO zero beat setting.





TABULATED DATA
Typical conditions, amplifier fully loaded into 50 ohm resistance
Curve #1

Freq.	Final Tuning Setting	Coarse Coupling	Fine Coupling	Remarks
30 MC	98.5	7	55	160 Meter Out
28	95	7	55	"
21	88	7	48	"
14	77	6	45	"
7	51.5	4	98	"
3.839	20	2	74	"
3.610	15	2	70	"
3.610	79	7	100	160 Meter In*
1.994	25	4	38	"
1.805	11	3	50	"

*Not fully loaded

Curve #2

MO or XTAL Freq. MC.	Oscillator Setting	Buffer Setting	Buffer Output Freq. MC.	P.A. Grid M.A.	Minimum M.O. Voltage Required For P.A. Grid M.A.
15 MO	92	86	30	15 Plate Off	0.8 V
14	85	75	28	15 Plate Off	0.95
				10 Plate On	0.95
				15 Plate On	1.95
12.8	77	82	25.6	15 Plate Off	6.4
10.8	51	20	21.2	15 Plate Off	1.4
9.34	23				
9.07	17				
7.00 XTAL	86	75	28	16.5 Plate Off	
				13.5 Plate On	
7.00 MO	86	75	28	15 Plate Off	5.6

Curve #3

7.6 MC	88	100	22.8		
7.0	79	85	21.0	15	XTAL
7.0	79	85	21.0	15	2.2 V
6.0	58	58	18.0	15	7.0
5.0	25	25	15.0	15	XTAL

Curve #4

7.3	83	93	14.6	15	1.4 V
7.0	80	86	14.0	15	1.1 V
7.0	80	86	14.0	15	XTAL
6.0	80	81	12.0	15	1.4 V
5.0	26	16	10.0	15	XTAL
4.95	23	98	14.85		XTAL
4.80	16	4	9.80	15	XTAL

Curve #5

8.0	100	98	8	15	1.0 V
7.6	90	85	7.6	15	.92 V
6.0	67	42	6.0	15	.45 V
5.0	34	0	5.0	15	XTAL

NOTE: The use of 80 meter crystals and doubling in the oscillator stage is satisfactory for 40 meter operation.

Curve #6

4.53	85	100	4.53	15	XTAL
4.00	72	87	4.00	15	XTAL
3.5	52	66	3.50	15	.2 V
3.0	22	34	3.00	15	.25 V
2.8	5	11	2.80	15	.7 V

Curve #7

2.4	73	97	2.4	15	.3 V
2.3	65	87	2.3	15	.3 V
2.0	38	57	2.0	15	.35 V
1.9	30	50	1.9	15	.35 V
1.8	15	34	1.8	15	.45 V

D Viking I Pi-Network Tuning and Harmonic Suppression

The pi tuning/coupling network in the Viking I is designed to load the final amplifier into antenna resistances of nominally 50 to 600 ohm throughout its frequency range. In addition, it is capable of "tuning out" series antenna reactances up to several hundred ohms to complete a good match to most unbalanced antenna systems. The range of antenna impedances which may be matched by the pi network at frequencies higher than 7.0 mcs. extends from roughly 25 to 2000 ohms.

When the transmitter is well grounded and properly tuned, the harmonic suppression is excellent, generally much better than other conventional methods of antenna coupling. This should be of interest to amateurs afflicted with TVI or other high frequency interference problems.

1 Importance of grounding:

To obtain proper tuning, coupling and harmonic suppression with any transmitter antenna coupling system, the part of the circuit designed to operate at RF ground potential must be at RF ground potential. A "room full of RF" is evidence that a high RF potential exists on something in or near the room. In many cases the source of RF is the transmitter's chassis and power cord. The power cord is very closely coupled to the chassis by the electrostatic shields of the power transformers. This condition is very undesirable for several reasons. Three objectional factors which obviously affect the loading of the transmitter when poor grounds are involved are:

- a The impedance that the output terminal of the transmitter looks into includes not only the true antenna to ground impedance as presented by the antenna feedline but also the transmitter chassis to ground impedance. This additional impedance in some cases will raise the apparent antenna impedance to such a high value that it cannot be loaded by the pi network.
- b Part of the transmitter's power is lost in the ground system due to radiation of the ground lead, power cord or cabinet. This power is quickly dissipated in surrounding objects and contributes nothing to effective radiated power except to distort the antenna's normal field pattern.
- c It is conventional, in designing a transmitter, to bypass harmonics or any possible sources of stray high frequency currents to the chassis on the assumption the chassis will be kept as near ground potential as possible. When a high impedance is presented to these currents at the chassis they are able to radiate to some extent rather than be passed harmlessly to ground.

2 How to obtain a good ground:

What may appear to be a good ground at one frequency may prove to be a poor ground at another. A single ground lead may have "standing waves" on it

due to its length. While it may seem difficult to obtain a good ground over a wide range of frequencies, it can be done and will be well-worth the trouble when increased radiation efficiency, ease of antenna loading and reduced TVI and BCI are considered. There is also reduced danger of damaging microphones, receivers and other associated equipment with excessive RF fields.

Avoid using the "cold" side of the power line, power line conduit or gas lines for RF grounding. Your good relationship with neighbors and the safety of your family may be jeopardized by RF in the wrong places. Some suggestions which may help to obtain a good ground are:

- a Water pipes or metal building structural members are usually good sources of earth grounds.
- b Use heavy conductors (#14 or larger) between the connection at the ground point and the transmitter. Copper ribbon is excellent for this purpose.
- c The use of several ground leads, each of a different length and selected at random may be helpful in keeping grounding impedance low at the transmitter, even though the transmitter is some distance from a true earth ground. The possibility of obtaining an effective ground at any frequency throughout the transmitter's range is quite good. If at any one frequency, one of the ground leads presents a low impedance at the chassis, the chassis is effectively grounded. By changing the length of one of the ground leads experimentally, a good ground can often be obtained at a frequency which has been troublesome. In bringing several leads to the transmitter, small closed loops near the transmitter or antenna feed line should be avoided. Induction fields will tend to raise the impedance of the ground leads.
- d In cases where it is impossible to obtain a good earth ground, connecting the transmitter chassis to some system of conductors having a very low effective impedance to ground compared to the antenna impedance may be helpful. Usually this artificial "ground" takes the form of a system of radial wires spread horizontally on the floor, a gridwork of wires, or a large metal sheet on the floor below the transmitter. To be effective, the minimum area covered by the metal conductors should be roughly equivalent to a square, the length of one side of which approaches a quarter wavelength. This system of "grounding" should be experimented with before committing the location to any permanent installation.
- e A simple counterpoise made up of a single wire attached to the chassis may be helpful. On 10 meters a length of 6 to 8 feet may be attached and the open end cut off 4 inches at a time until the chassis becomes "colder". The open wire may be allowed to drop along the floor although its open end will be somewhat "hot".

f A rough check on the effectiveness of the transmitter ground may be made by touching the chassis while watching the PA cathode current and grid current with the transmitter operating into its antenna. A change in current upon touching the chassis is indicative of an ineffective ground. If a neon bulb, held between the fingers, can be ignited by touching a contact to the chassis, the RF present is excessive and is another indication of an ineffective ground. In cases where the transmitter is feeding a low impedance antenna, the test by touching the chassis is more reliable since 50 to 60 volts is required to ignite the neon lamp.

3 Loading Random Antennas with the Pi Network:

With the transmitter chassis well grounded, correctly designed antenna systems having relatively "flat" unbalanced feeder systems, can easily be loaded by following the instructions already given, provided the antennas' terminal impedances fall within the range of the pi network. Feeding a balanced system with a feedline over a quarter of one wavelength long, may prove to be surprisingly successful if the transmitter chassis is held at ground potential. The transmission line between the transmitter and antenna will tend to assume a partial balance at the antenna. Some standing waves will result but may not be excessive. Methods of changing from an unbalanced to balanced transmission system are discussed in the ARRL Radio Amateurs Handbook and devices for accomplishing this change over the amateur bands are beginning to be available commercially.

Antennas having random lengths, random feed points and various types of feed lines will exhibit widely different resistance and reactance characteristics. It is well to remember that the feedline is a very important part of the system. A common example of the random antenna is a horizontal wire fed by a single wire feed line. The feedline in this case actually becomes part of the radiating system. An antenna of this type can, in most instances, be fed by the pi network directly but there are critical dimensions where the antenna series reactance (inductive or capacitive) becomes too high and the antenna resistance can become either too high or too low to be matched by the pi network.

Warning! Antennas with high terminal resistance or reactance can usually be recognized while loading the final stage of the Viking I. The final amplifier is normally loaded by reducing the output coupling capacitor (C30) in small steps, retuning the amplifier to resonance each time. This results in an increase in PA cathode current and is continued until full loading is achieved. If however, a point is reached where decreasing the output coupling capacitor (C30) does not result in a marked increase in PA cathode current and the PA is not fully loaded, the antenna can be assumed to have a high resistance or reactance at this frequency. *PI network is much better without coupling capacitance as is practical at all times.*

Antennas with low terminal impedance (resistance and reactance both low) can usually be recognized by a noticeable lack of coupling condenser effect in the range of settings normally used at the operating frequency. There will be little or no detuning evidenced as the coupling control is changed.

But 0.2 pF indicates harmonic suppression depends on some capacity loss at the coupling capacitor. AT never use zero output capacitance!! "Use a small coupling capacitor as is practical at all times" (Page 18)

N.B. See P10 + "for more on loading ground."

Several things can be tried in an effort to bring the antenna system into the tuning range of the pi network:

- a Change the length of the feeder line between the antenna and transmitter experimentally $1/8$ to $1/4$ wavelength.
- b Change the point of connection of the feedline to the antenna $1/8$ to $1/4$ wavelength.
- c Change the antenna length $1/8$ to $1/4$ wavelength. Antennas shorter than $1/8$ wavelength (antenna and feeder) may be difficult to load. They present a high capacitive reactance to the transmitter output terminals. Effective antenna lengths in the vicinity of $1/2$ wavelength will in general exhibit characteristics of high resistance, high reactance (inductive or capacitive), or both.
- d "Load" the antenna feeder by placing an inductor or capacitor in series to cancel out the reactance of the antenna feeder. This may require considerable cut and try and will affect only the reactive component of the antenna impedance. However, it can prove useful in some cases.
- e L type matching networks of inductance and capacitance may be used to aid impedance matching. Much discussion of this more elaborate method of bringing the antenna impedance within the range of the pi network could be included, however, the few cases where it is necessary do not justify inclusion herein. Textbook and handbook discussions will be helpful if work along this line is pursued. There is danger of resonating the coupling condenser of the pi network when using an external coil. This should be watched as excessive voltage built up across the coupling condensers can cause damage. Improper coupling or loading will take place under these conditions.

4 Dangers to be avoided and hints which may further aid in harmonic and TVI reduction

- h.s.*
- Danger.*
- Danger*
- a When loading high impedance antennas there is a temptation to "squeeze" the last watt into the antenna by opening the coupling condensers as much as possible. Harmonic suppression is dependent, to a great extent, on the amount of coupling capacity in the circuit. It is wise to use as much coupling capacity as practical at all times. The proper amount of coupling when the antenna impedance is high, can be conveniently determined by holding a neon lamp against the antenna feeder. The coupling condenser can then be opened until little increase in glow is noticed when the coupling condenser and tuning controls are adjusted for maximum output. A decrease in coupling capacitance beyond this point may cause a higher plate current reading due to reduced plate circuit efficiency. Higher harmonic output will also result as the coupling capacity is reduced beyond the point where the output has leveled off. The random antenna system may present a more favorable impedance to harmonic output than the output on the fundamental frequency; hence it is well to

✓ use as much coupling capacity as is practical. It is well to remember that the amount of coupling capacitance needed is dependent on the operating frequency. For example, 2,000 micro microfarads at 3.5 mcs. corresponds to 160 micro microfarads at 28.0 mcs. These are the values necessary to couple resistive loads of less than 50 ohms, at the frequencies stated.

- b The low frequency bands (80 to 160 meters) may present the danger of doubling in the final stage when the antenna impedance is high. If the coupling condensers are reduced to values comparable to the capacity of the tuning condenser (C29) the net plate tuning capacity is reduced, as these condensers are effectively in series, and it becomes very possible to inadvertently tune to the second harmonic instead of the fundamental of the intended output frequency. To avoid doubling in the final, the initial tuning should be done with all the output coupling capacity in the circuit and the final tuning control starting from its zero setting. The first dip of the amplifier cathode current, as the tuning control is advanced from zero setting, is the resonant point for the fundamental output frequency. As the coupling condensers are reduced the tuning control should be reset, toward zero, for minimum cathode current so that the original plate circuit resonant frequency is maintained. Avoid reducing the coupling condenser values below the point where the output levels off as discussed previously. No danger of doubling in the final will occur if the proper tuning method is followed. For some high impedance coupling conditions on the low frequency end of the 160 meter band, much of the output coupling capacity may be out of the circuit as the antenna is loaded and the tuning control may approach the maximum tank capacity setting (dial zero) and tend to go beyond. The amplifier is quite broad on 160 meters and if, under these conditions, the tuning control is left at zero, the output coupling capacity can be reduced slightly more as more output is indicated by a neon lamp or plate current increase. Even though the amplifier seems to be out of resonance, it will still be resonant, unless the output coupling capacity has been reduced excessively, and the efficiency will be quite good. n. l.
- c If the power line voltage is low or the high voltage rectifiers have low emission, the loaded plate current may not reach the normal value. This condition should not be confused with the inability of the pi network to load an antenna system.

E Trouble Shooting

- 1 SCHEMATICS, PHOTOGRAPHS, AND CHARTS aid greatly in trouble shooting; use them. Part 2 and 3 list typical voltage, current and winding resistance values; individual transmitters may vary somewhat from the values shown but generally no more than 10 to 20%. Parts 4 through 13 list symptoms of trouble and suggestions for their location and cure.

Figures 9, 10, 11, 12, and 13 on the last sheets of this book will facilitate component and wire location in the Viking I.

BE CAREFUL when making HIGH VOLTAGE measurements. **DO NOT TAKE CHANCES.** Do not depend on the bleeder resistor to drain the high voltage condenser but use a well insulated screwdriver to short any high voltage point to chassis by first grounding the screwdriver to the chassis and bringing the shank to the terminal to be discharged.

All power supplies must be off and discharged before making ohmmeter measurements.

- 2 Typical Viking I voltages and currents with the 4D32 Final loaded into a 50 ohm load:

a CW operation 116V 60 cycle ac input voltage measurements made with 220,000 ohm/volt voltmeter.

Frequency 28.868 mc

Screen current = 28

P.A. screen and plate current 260 ma

P.A. grid current

9.5 ma *with 10 ohms*

P.A. plate voltage

+660 V

P.A. screen voltage

+285 V

P.A. grid bias (total)

-97 V (-77V no sig)

Power output

116 watts

Buffer current

34 ma

Oscillator current

5.5 ma

Low Voltage B +

+265 V

Bias Supply Voltage

-80 V (with 9.5 ma 4D32 grid current)

6A05 fixed bias

-25 V "

807 fixed bias

-37 V "

To reduce to 50 watts input for 100 watts output we

calculate 620V

*.080amps
49.600 watts*

- 20 -

But since a .02 amp is screen current we can add it to that as

answer is .100 p.a. screen and plate current as shown on meter for screen

6AU6 speech amplifier (socket X1) screen voltage +88 V (no sig)
 6AU6 speech amplifier plate voltage +92 V "
 6AU6 audio driver (socket X2) screen voltage +150 V "
 6AU6 audio driver (socket X2) plate voltage +263 V "

b Phone operation with the above input conditions. Only readings which vary significantly from cw operation or apply only to phone operation are recorded. Approximately 30% modulation was applied during measurements.

Screen current = 28
 P.A. screen and plate current 230 ma ← **NB**
 P.A. plate voltage **+620 V**
 P.A. screen voltage +280 V
 Power output 110 watts (carrier and side bands)
 102 watts (no signal)
 Modulator 807 screen voltage +260 V
 Modulator cathode current 90 ma (75 ma no signal)
 (The no signal "Mod" current should be between 60 to 80 ma. This may be adjusted by moving the tap of the high voltage divider R13. (WITH POWER OFF)) *Nb.*

3 Transformer and choke winding resistances and open circuit voltages.

	<u>Winding</u>	<u>Color of Leads</u>	<u>Resistance</u>	<u>Open ckt ac voltage</u> (112 V 60 cy input)
T1 P1781	115 V pri.	black to black	1.0 ohms	---
	secondary	red to yel-rd	105	865 volts
		yel-rd to other red	96	865
T2 P1893	115 V pri.	black to black	2.5	---
	L.V. sec.	red to yel-rd	97	298
		yel-rd to other rd	95	298
	Bias sec.	blue to blue	46	140
	Fil	green to green	less than .1	6.4
L.V. rect.	brown to brown	.2	5.1	
H.V. rect.	yel to yel	.1	5.2	

cont.

	<u>Winding</u>	<u>Color of Leads</u>	<u>Resistance</u>	<u>Open ckt ac voltage</u> (112 V 60 cy input)
L1 P1783	H.V. choke		95	
L2 P1501	L.V. choke		280	
L3 P1784	Bias choke		440	Open circuit <u>1000 cycle inductance</u>
T3 P1503	Audio pri.	red to blue	210	approx 2.6 H
	Sec.	black to yel	110	
		black to green	105	
T4 P1992	Mod. pri.	red to brown	100	1.5 to 1.75 H
		red to blue	95	1.5 to 1.75 H
	Mod. sec.	Gn yel to green	36	(.01 bypass condenser C32 must be disconnect.. ed before measuring in- ductance)
		rd yel to yel	36	

No attempt has been made to anticipate all troubles, operating errors, or component failures in parts 4 through 13, but a few symptoms with a discussion of probable causes may suggest means of analyzing other symptoms related to those mentioned.

get more!

NEVER REPLACE FUSE WITH A VALUE HIGHER THAN 5 AMPERES.

- 4 Fuse blows when "Fil" is turned on:
 - a Check 6AL5, 5Z4, 6AU6's and 6AQ5 tubes for shorts between plate and other elements.
 - b Look at tube socket terminals and T2 primary ac wiring for shorts.
 - c The low voltage B+ may be shorted. An ohmmeter test of the exciter coils to chassis should show approximately 25,000 ohms.
 - d If no short is found on the B+ line, check the transformer windings for shorts to ground or shorted turns. Open circuit voltage data may be useful in finding turn to turn shorts.

- 5 FUSE BLOWS when "plate" is turned on:
 - a Check for condensed moisture on 5R4 sockets X8 and X9.
 - b Check 5R4, 4D32, and 807 tubes for shorts.
 - c Check High Voltage B+ line for shorts (violet leads 42, 43 and 43 may be conveniently isolated at the H.V. bleeder-divider resistor R13).

- d Check H.V. primary wiring and "plate" indicator pilot light.
 - e If no ground is found on H.V. B+ line, test H.V. transformer for shorts to ground or winding to winding.
- 6 R. F. EXCITER:
- a No "osc." current may be due to "cw-phone" switch on phone, key open, 6AU6 filament being open, or no L.V. B+.
 - b "Grid current low and "bfr" current low - may be due to a weak buffer or oscillator tube. A few 6AQ5's or 6AU6 may show good emission in a tube tester but will prove to be poor R.F. amplifiers. Check tuning curves to be certain tuning is near the expected setting. A 9 ma 10 meter grid current is sufficient to drive the 4D32 to full output.
 - c Key up "bfr" current being excessive (over 20 ma with "drive" on 5) may be caused by failure of the bias supply.
 - d Erratic keying usually can be corrected by adjusting the "oscillator" tuning. If this does not correct the condition the crystal may be suspected as normally the Viking keys cleanly with most crystals.
 - e Failure to oscillate is usually due to the crystal but it may be well to check to position of the "crystal" dial to be certain it corresponds to the socket number.
- 7 Inability to tune Final:
- a Check position of 160 meter switch.
 - b Check for loose connections in the tank and loading circuits.
- 8 Inability to load Final:
- a Check ground connections.
 - b Check antenna connections.
 - c Read discussion on pi network loading.
- 9 Report of excessive harmonics:
- a Check tuning to make certain doubling is not taking place in the final.
 - b Examine antenna to make certain that its efficiency at the harmonic is not many times greater than at the fundamental.
 - c Read discussion on Pi Network Tuning and Harmonic Suppression.

- d In checking harmonics, the test receiver must be far from the transmitter as the exciter stages are harmonic generators. Also remember that an excessive fundamental signal to the receiver may cause harmonic generation in a receiver stage - hence a false indication may be noted.
- 10 Report of signals 20 to 60 KC away from either side of carrier:
- a These spurious signals originate in the crystal. A few crystals will show some excitation near the fundamental mode of oscillation. Oscillator tuning may clear this condition in a few cases but usually the crystal must be replaced.
- 11 R.F. on Chassis or Mike:
- a Ineffective grounds or a very low impedance at the antenna termination to the transmitter may cause this - usually the former.
 - b Read discussion on grounds in the pi network tuning discussion. Page 15.
 - c R.F. pickup can result if an unshielded antenna lead-in is used with a high standing wave existing in the vicinity of the operator.
- 12 High 4D32 "plt" current with Key up:
- a A fixed bias failure is indicated. Check 6AL5 tube.
 - b Check bias voltage on second terminal from the rear of X21 (white wire).
 - c Check the resistance of the bias supply terminal to ground. This should be in the neighborhood of 5000 ohms.
- 13 A Squeal is heard on "phone":
- a If squeal takes place with audio turned down, it is probable the 807 plate caps have been reversed.
 - b If a squeal or howl takes place when the audio is turned up, acoustical feedback between the mike and receiver may be the cause.
 - c A microphonic 6AU6 in the speech amplifier can originate a ringing or squealish noise.
 - d A poorly shielded mike connection or lead can cause feedback conditions.

**PHOTOGRAPHS, CHARTS AND
SCHEMATIC DIAGRAMS**

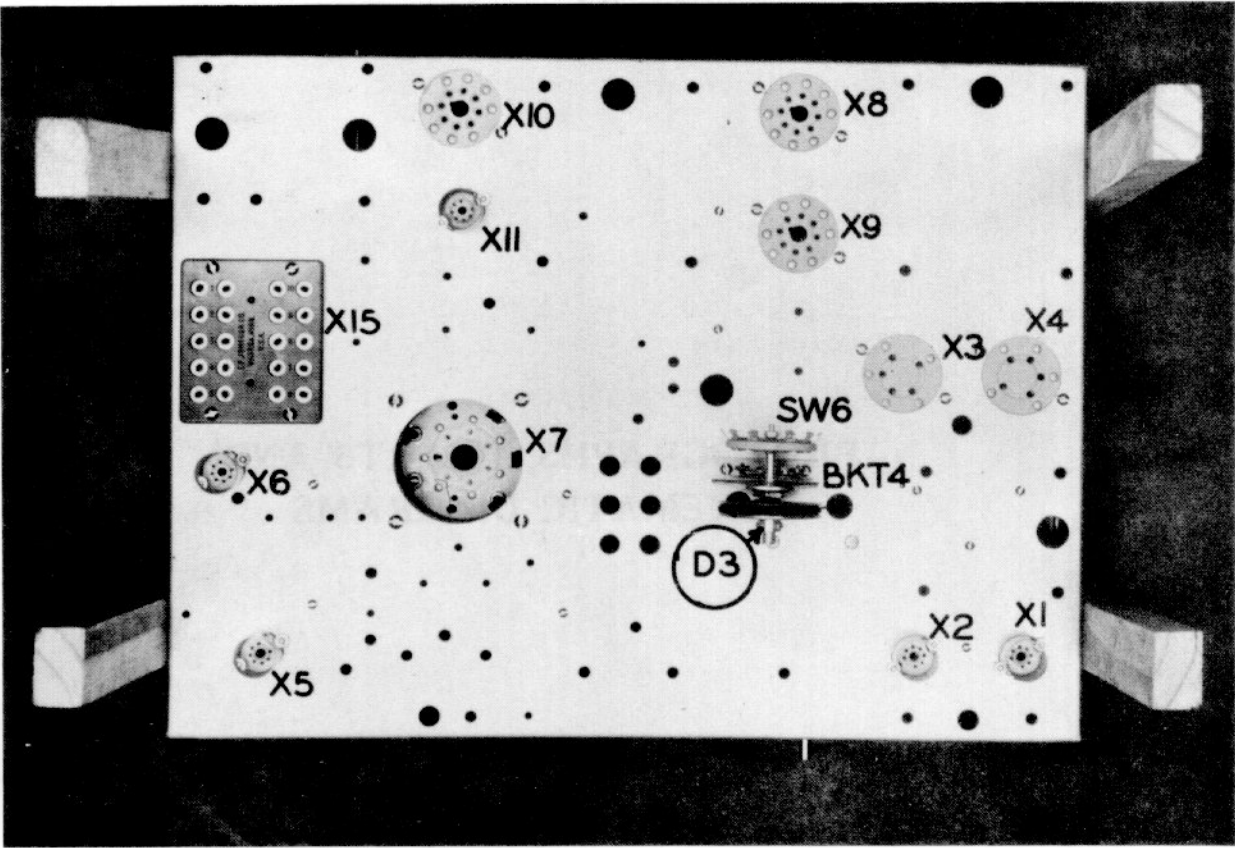


Figure 1

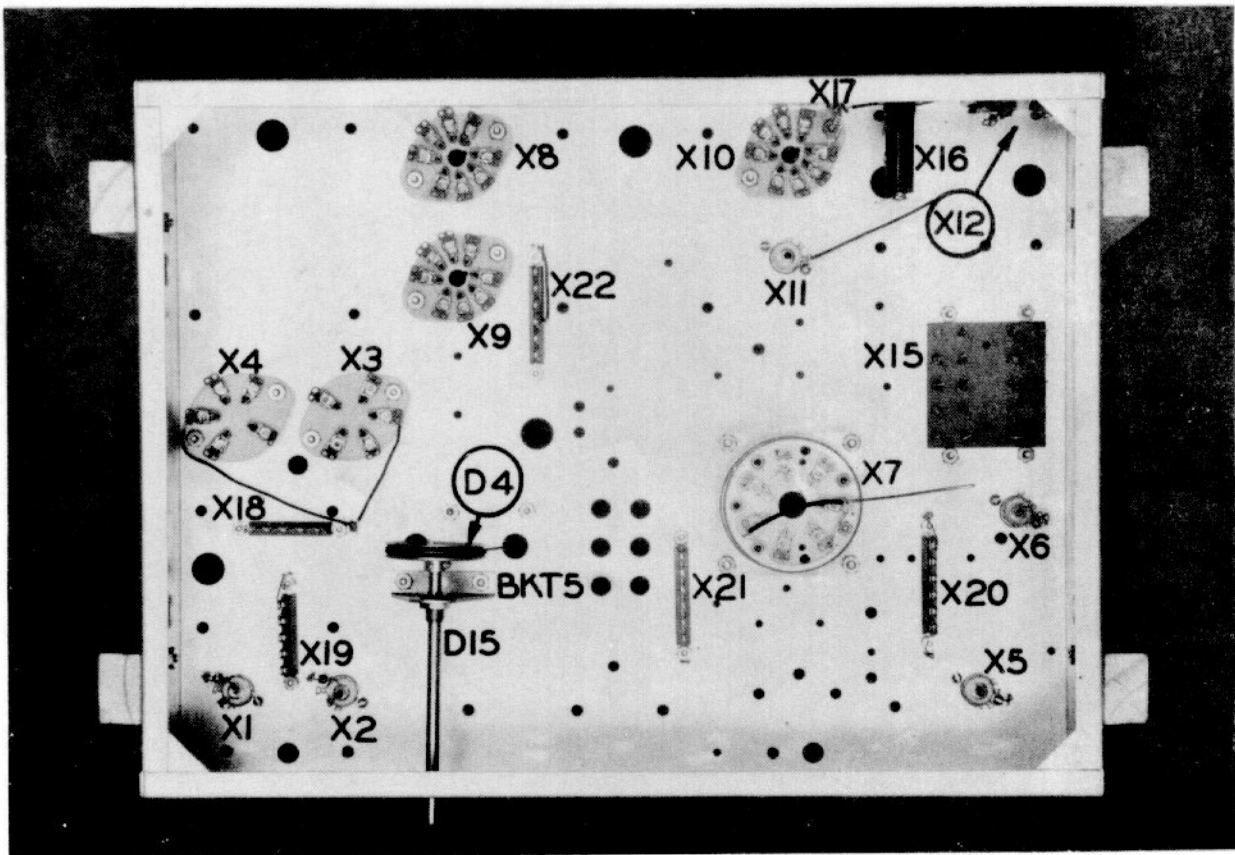


Figure 2

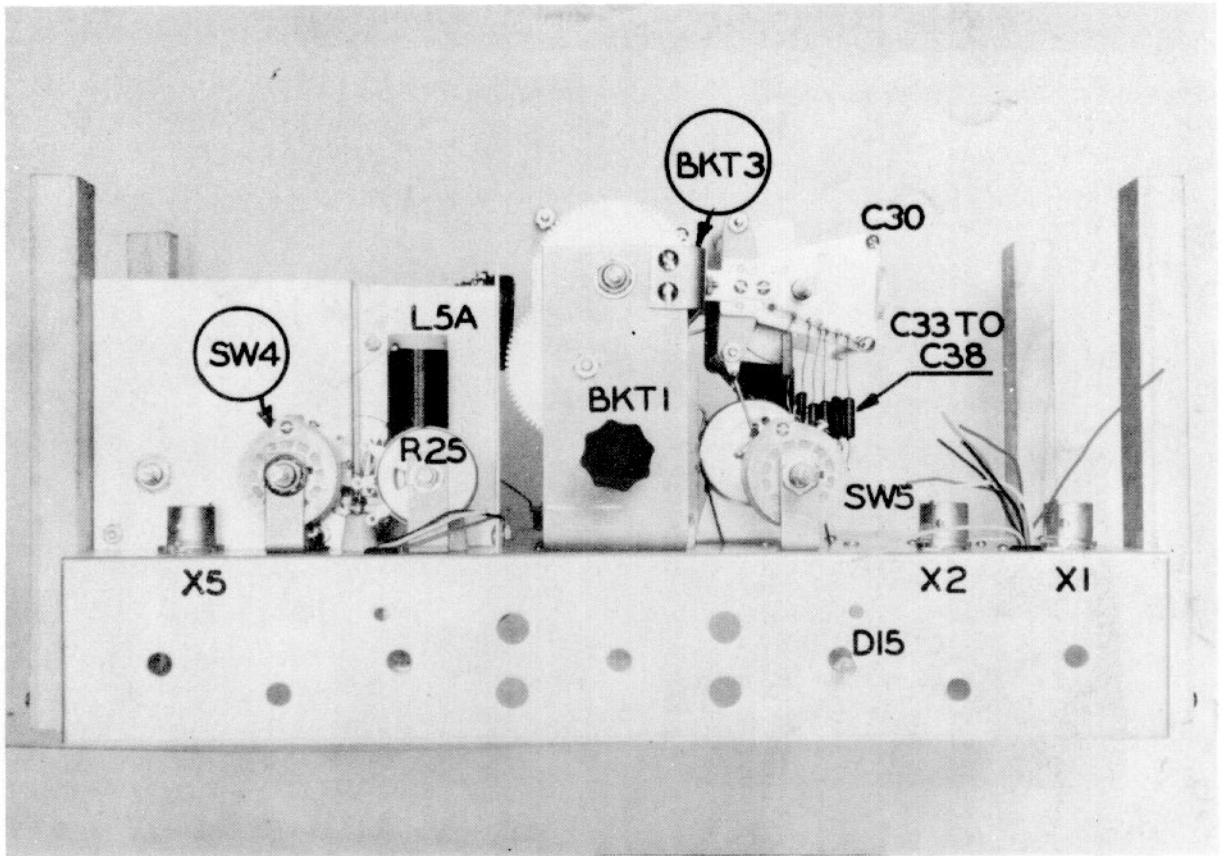


Figure 3

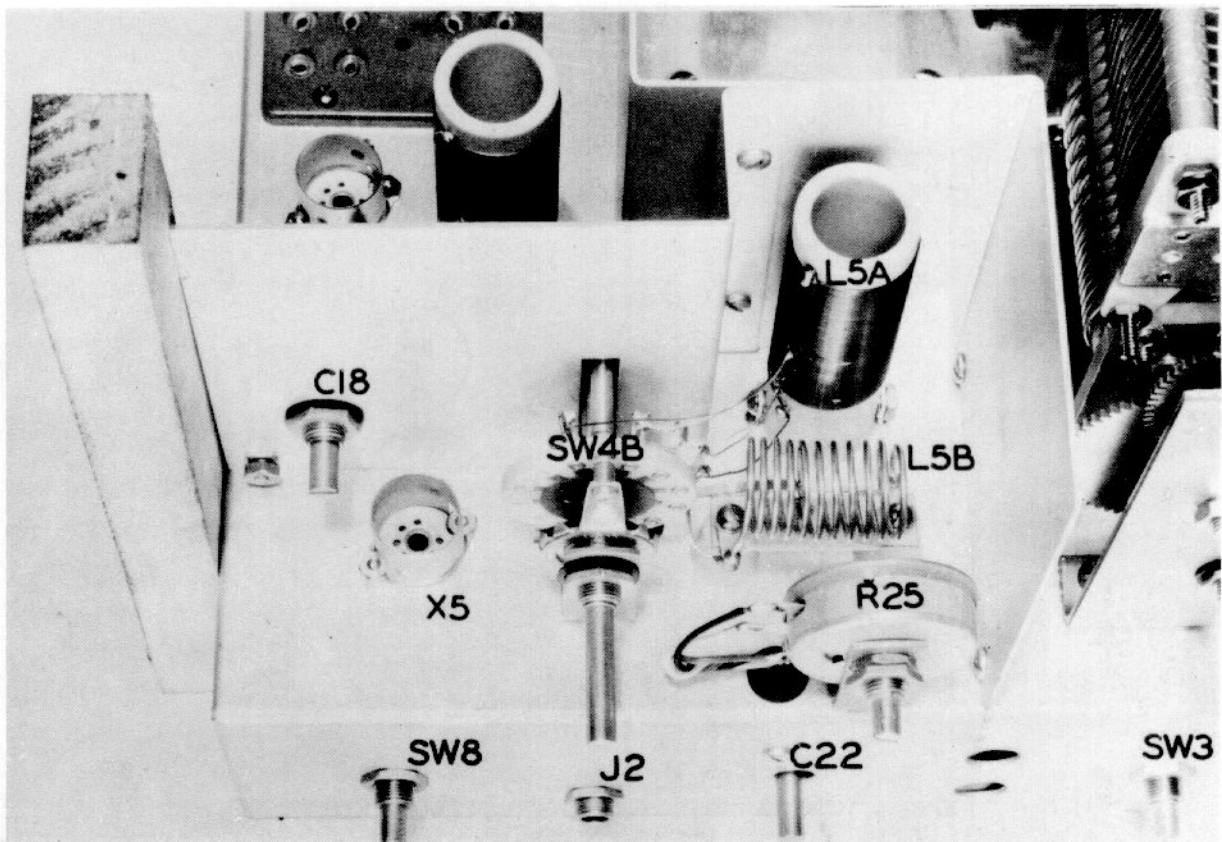


Figure 4

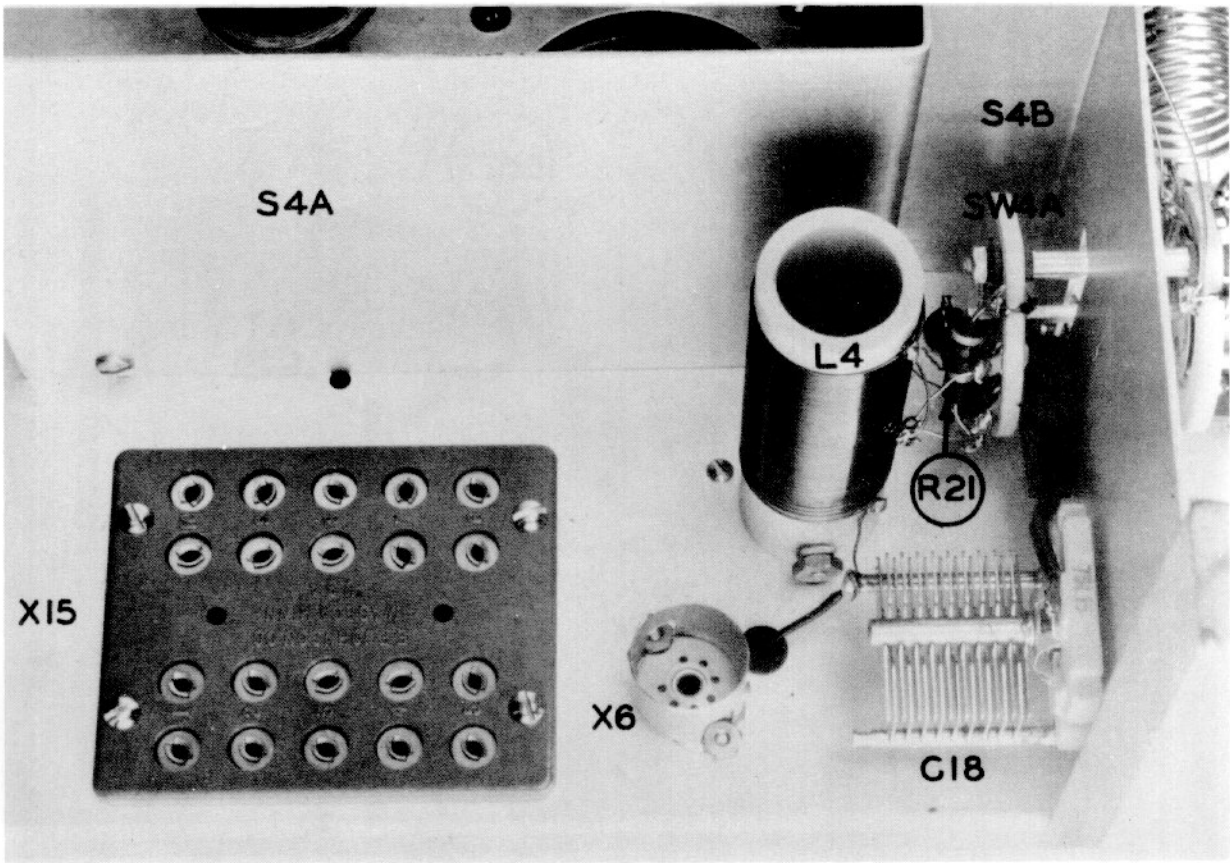


Figure 5

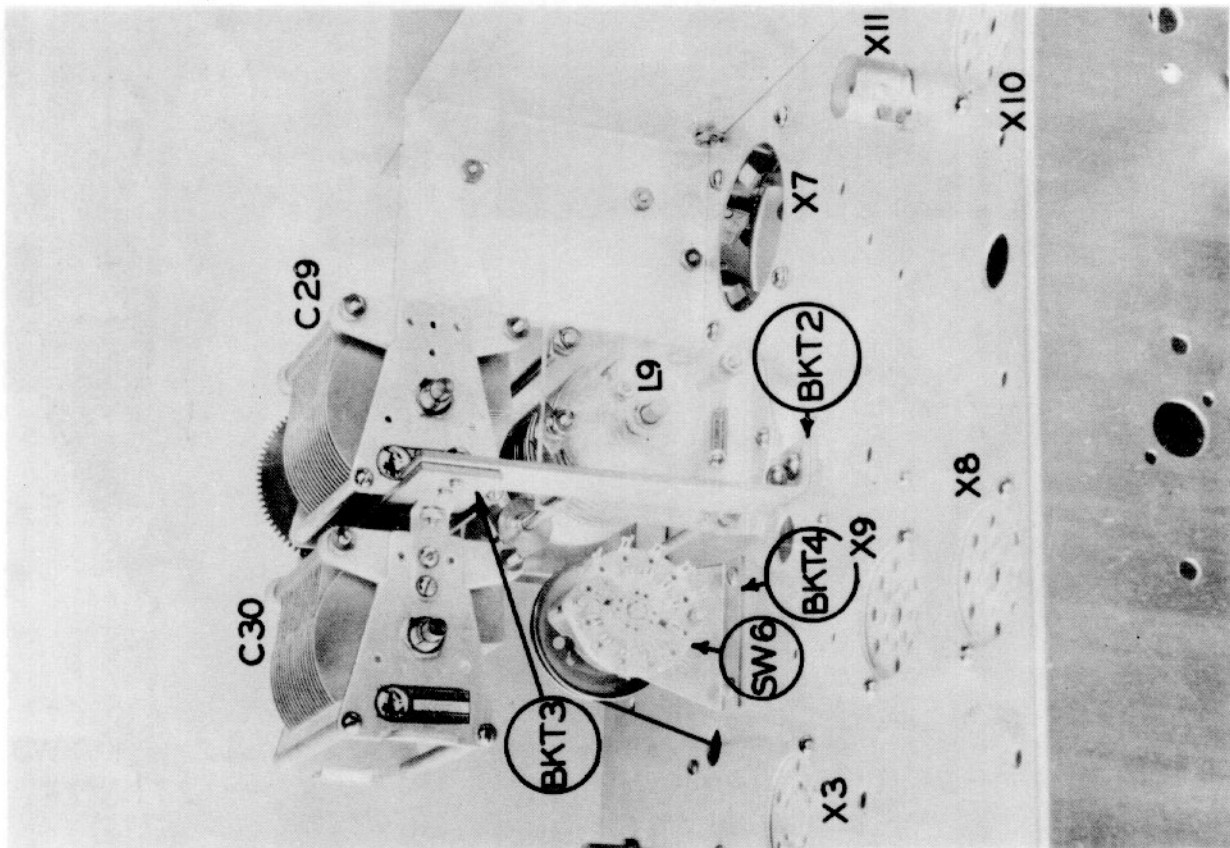


Figure 6

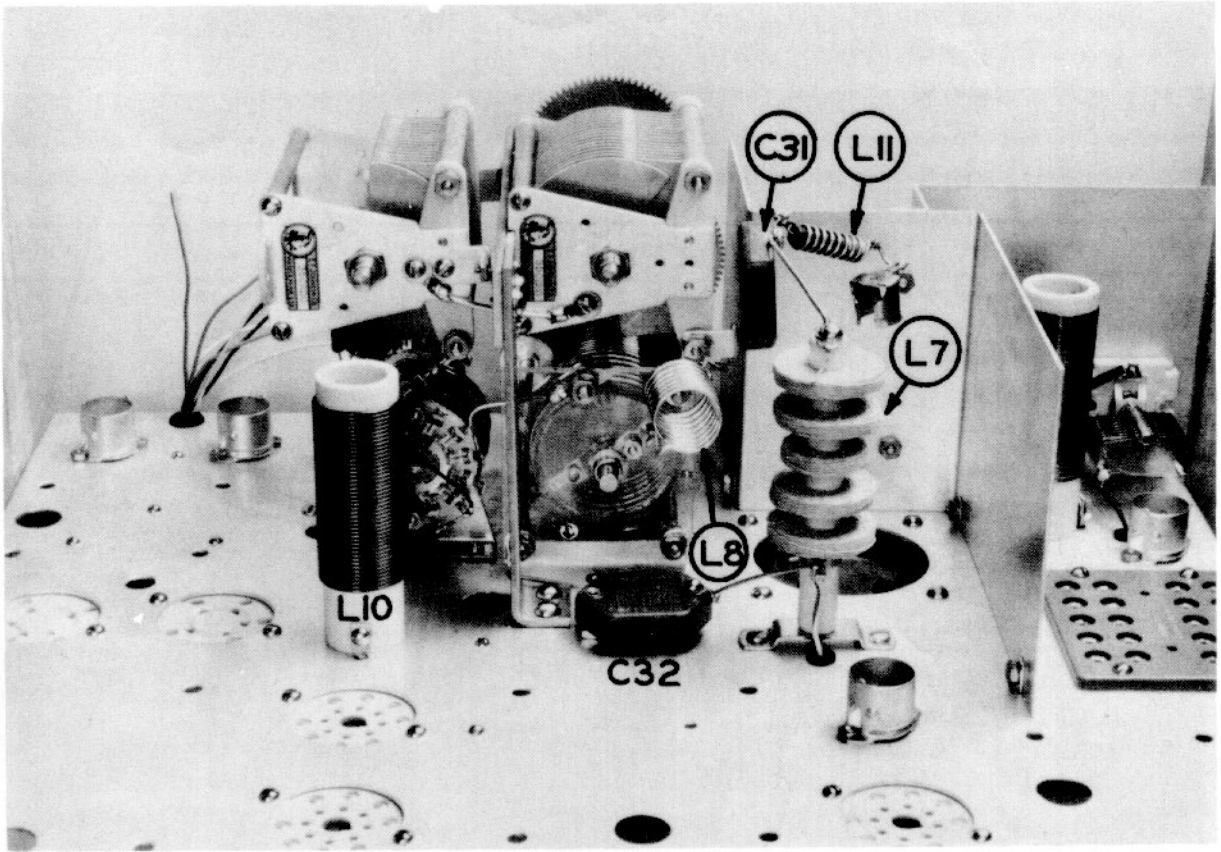


Figure 7

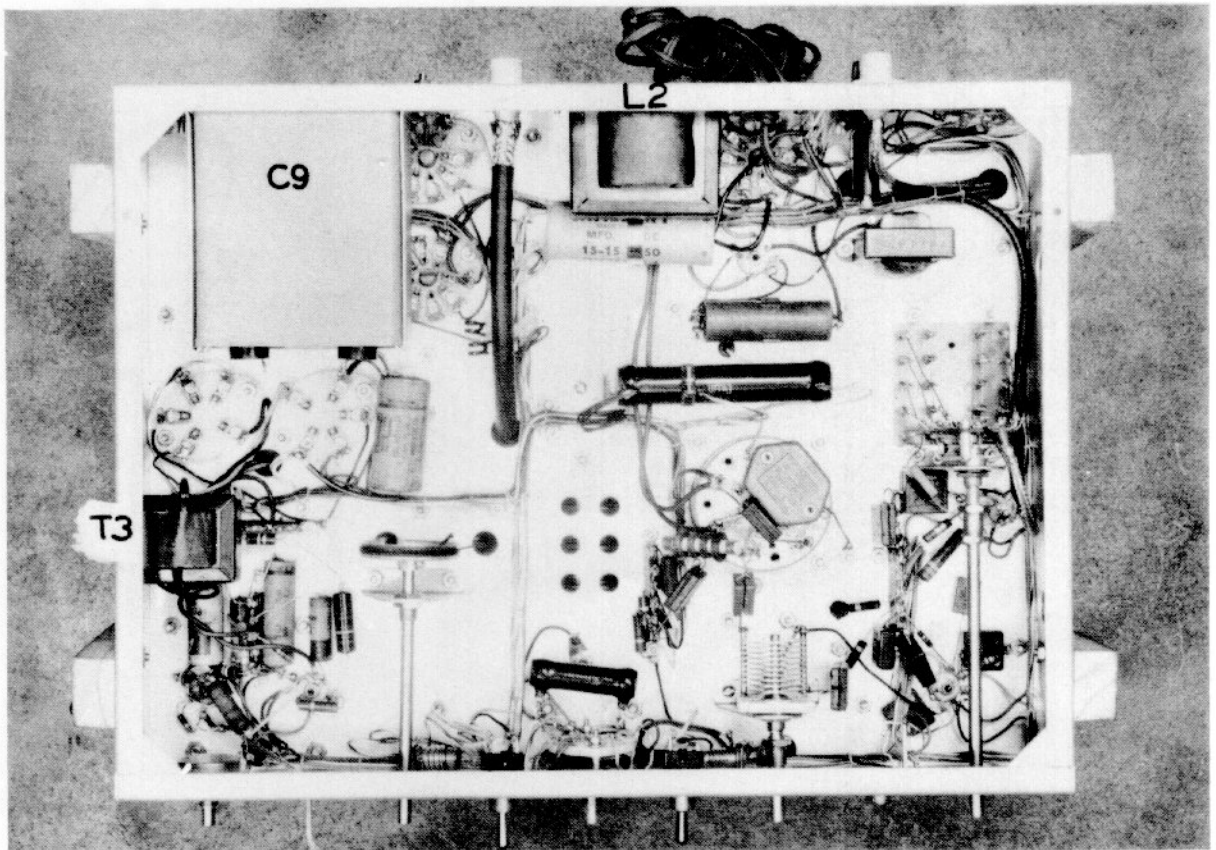


Figure 8

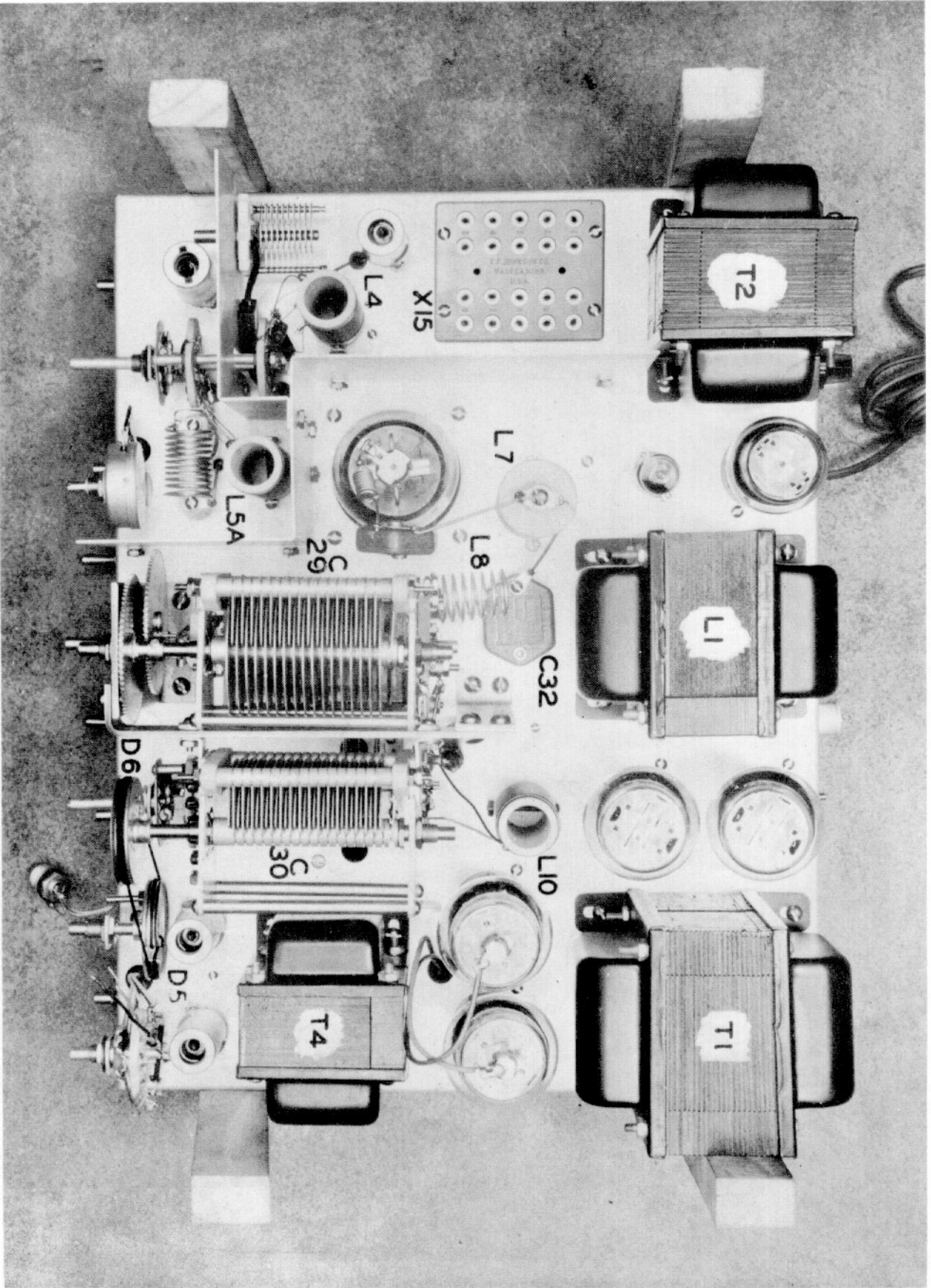


Figure 9

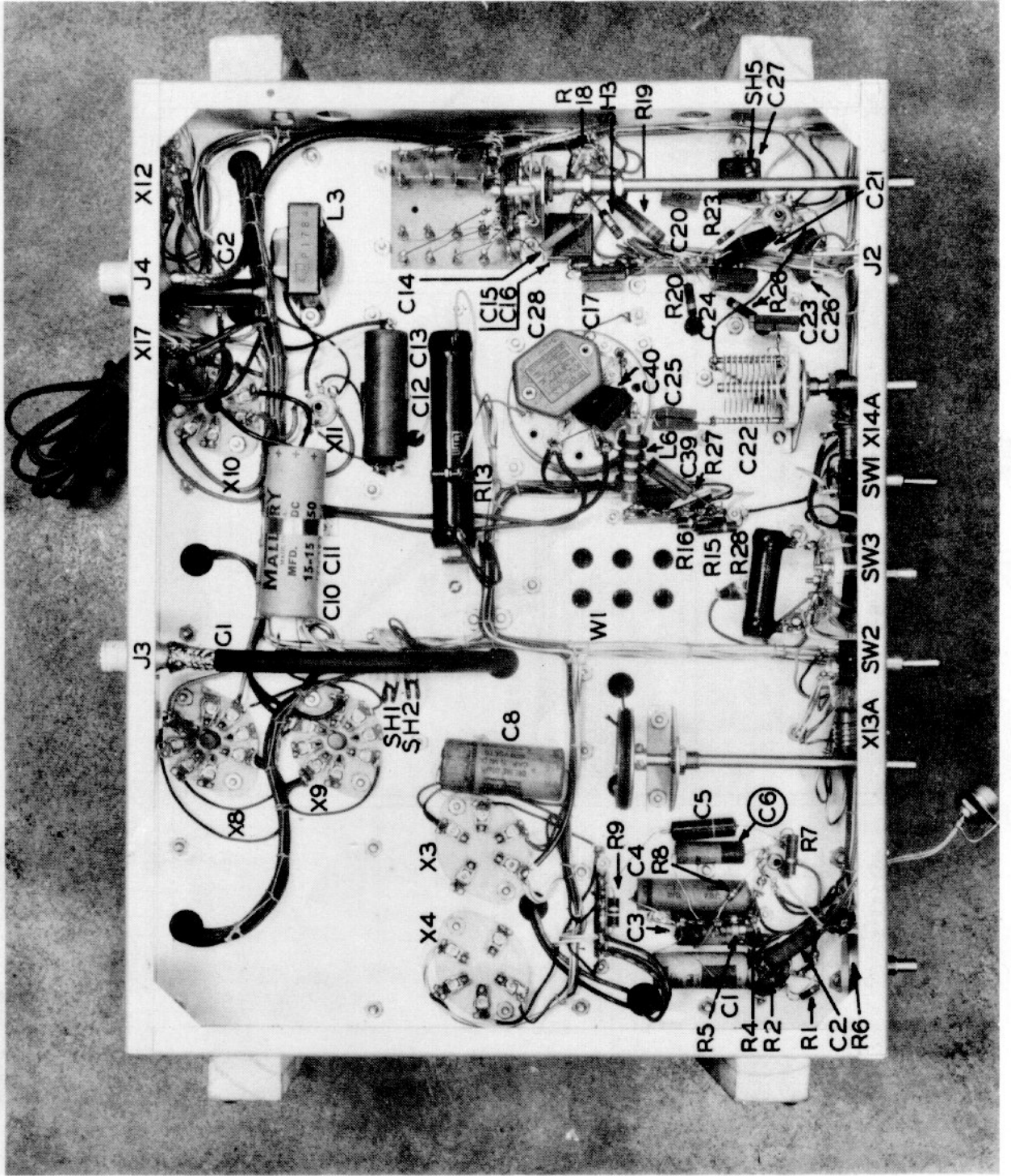
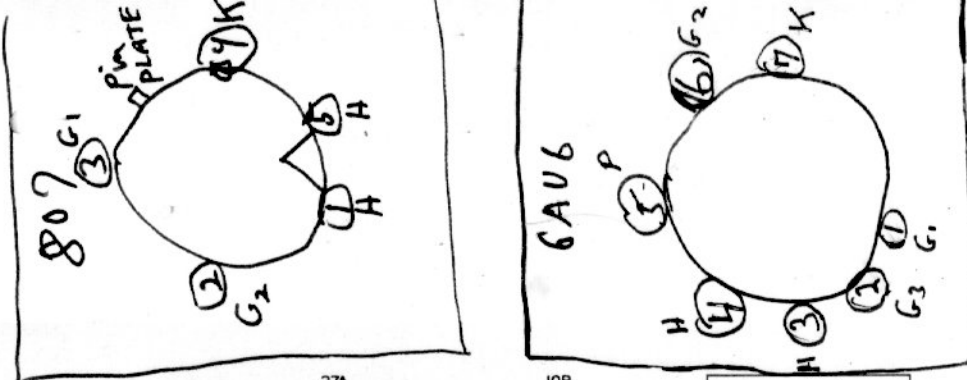
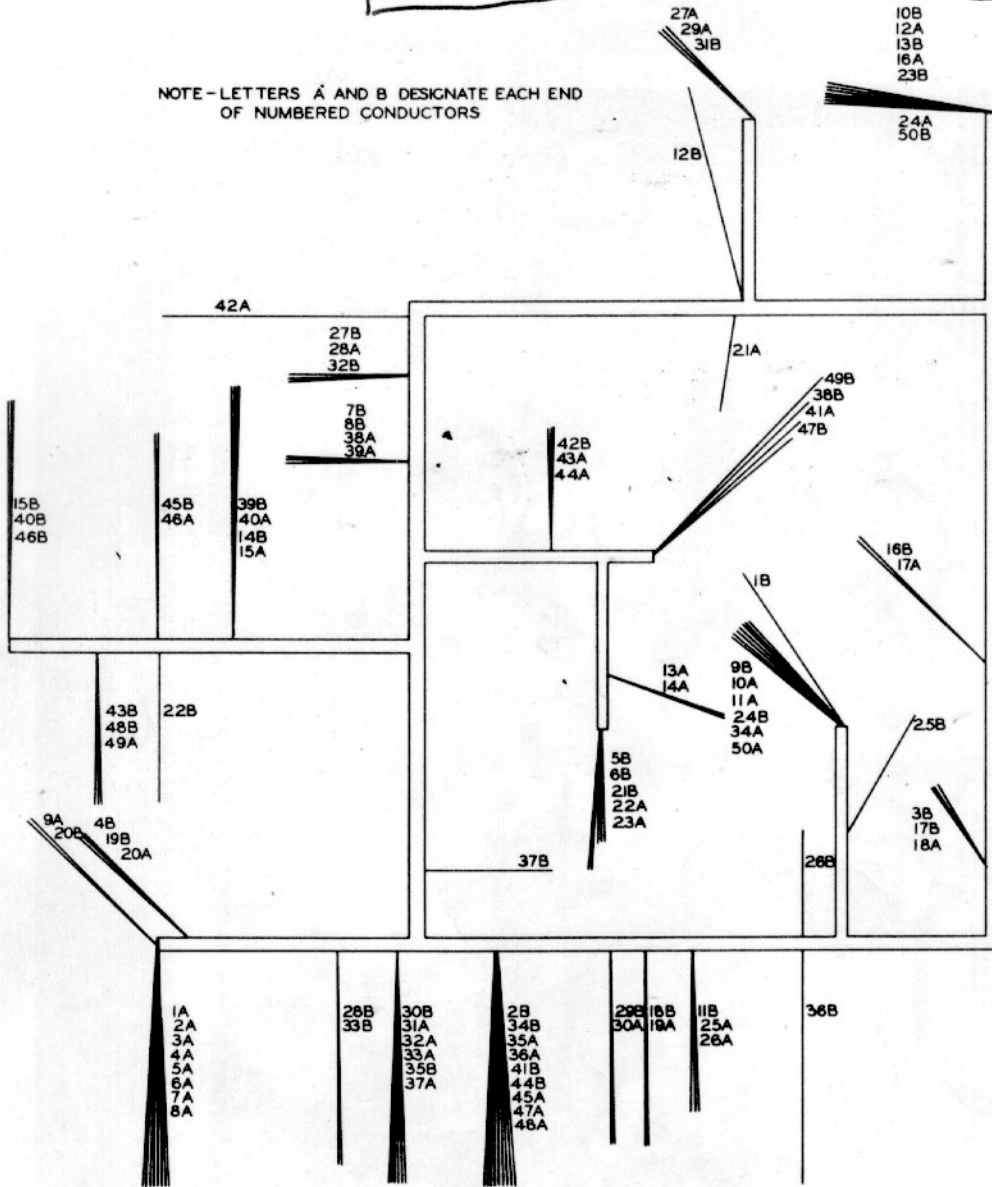


Figure 10



NOTE - LETTERS A AND B DESIGNATE EACH END OF NUMBERED CONDUCTORS



LEAD COLORS	
1	BLUE
2	BROWN
3	GREY
4	BLACK
5	ORANGE
6	WHITE
7	YELLOW
8	VIOLET
9	RED
10	RED
11	RED
12	RED
13	GREEN
14	GREEN
15	GREEN
16	GREEN
17	GREEN
18	GREEN
19	GREEN
20	GREEN
21	WHITE
22	BLACK
23	BLACK-BROWN
24	BLACK-BROWN
25	WHITE
26	BLACK
27	BLACK-BROWN
28	BLACK-BROWN
29	WHITE
30	BLUE-ORANGE
31	BLUE-ORANGE
32	GREY-RED
33	GREY-RED
34	BROWN
35	ORANGE
36	BLUE
37	BLACK
38	YELLOW
39	VIOLET
40	VIOLET
41	GRAY-RED
42	VIOLET
43	VIOLET
44	VIOLET
45	YELLOW-BLUE
46	YELLOW-BLUE
47	GREY
48	GREEN-WHITE
49	GREEN-WHITE
50	BROWN

Figure 11, Wiring Harness

TUBE SOCKET CONNECTIONS BOTTOM VIEW

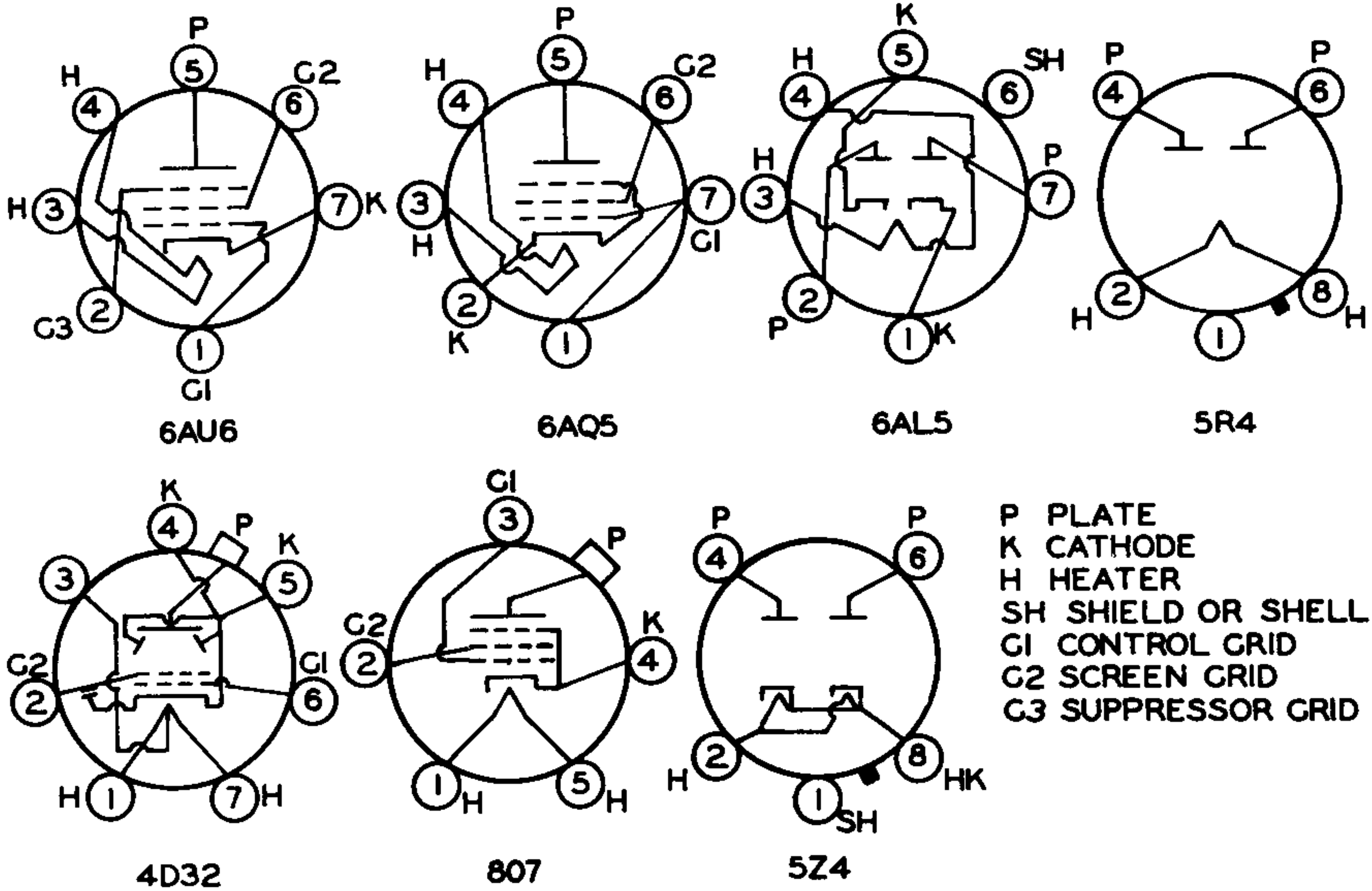


Figure 13, Socket Connections

CONDENSER-RESISTOR COLOR CODE

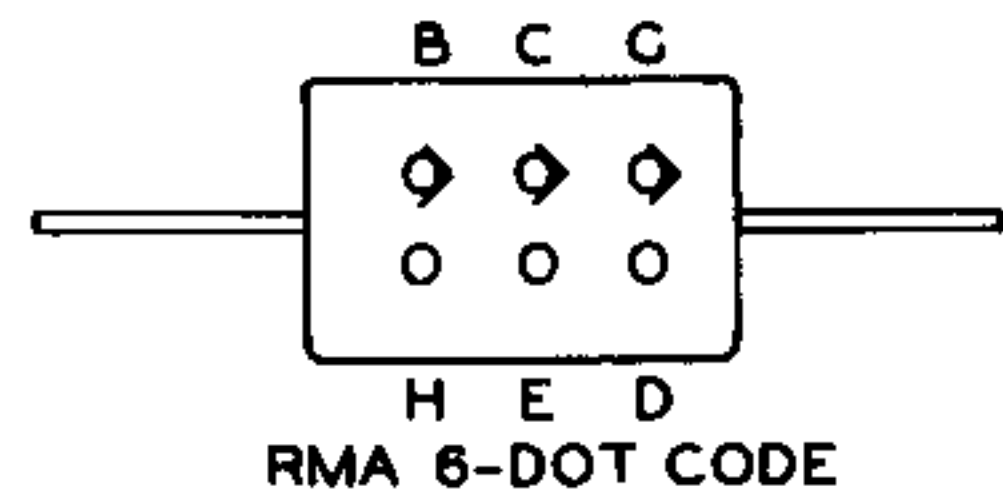
COLOR	SIGNIFICANT FIGURE	DECIMAL MULTIPLIER	TOLERANCE (%)	VOLTAGE RATING*
BLACK	0	1	-	-
BROWN	1	10	1	100
RED	2	100	2	200
ORANGE	3	1,000	3	300
YELLOW	4	10,000	4	400
GREEN	5	100,000	5	500
BLUE	6	1,000,000	6	600
VIOLET	7	10,000,000	7	700
GRAY	8	100,000,000	8	800
WHITE	9	1,000,000,000	9	900
GOLD	-	0.1	5	1,000
SILVER	-	0.01	10	2,000
NO COLOR	-	-	20	500

* APPLIES TO CONDENSERS ONLY

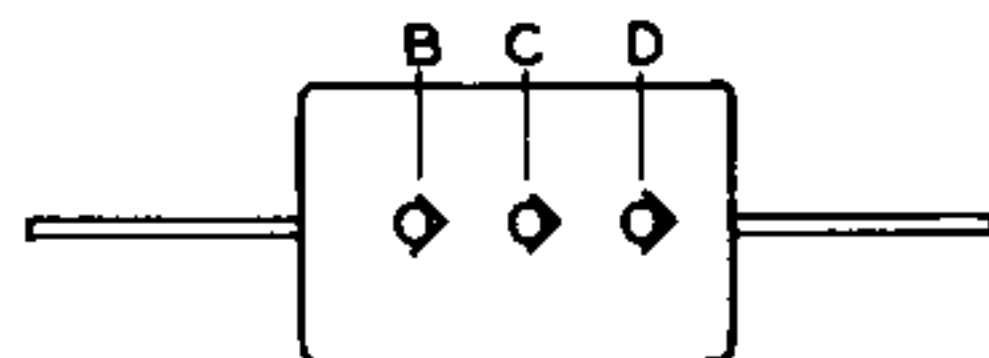


COLOR CODING OF FIXED RESISTORS

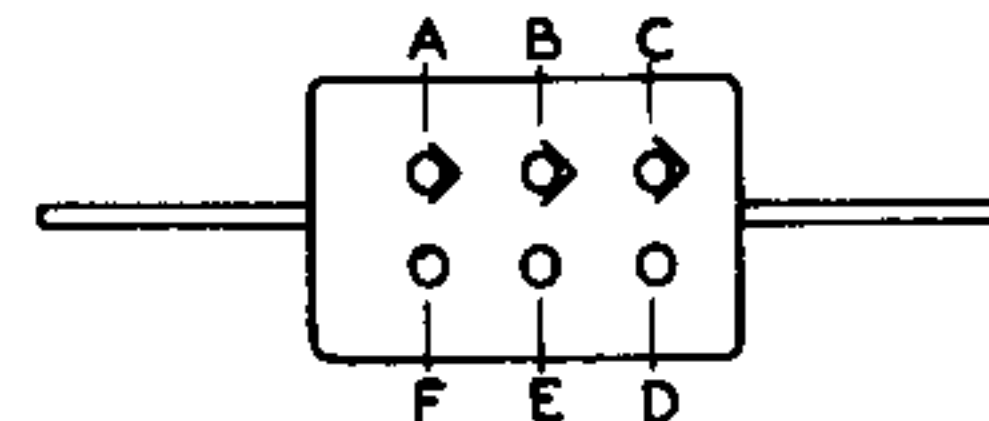
- A-FIRST SIGNIFICANT FIGURE OF RESISTANCE IN OHMS
- B-SECOND SIGNIFICANT FIGURE
- C-DECIMAL MULTIPLIER
- D-RESISTANCE TOLERANCE IN PERCENT. IF NO COLOR SHOWN TOLERANCE IS $\pm 20\%$.



RMA 6-DOT CODE



RMA 3-DOT CODE 500VOLT $\pm 20\%$



JAN FIXED CAPACITORS

- COLOR CODING OF FIXED CONDENSERS
- A-TYPE: MICA BLACK, PAPER SILVER
- B-FIRST SIGNIFICANT FIGURE OF CAPACITY
- C-SECOND SIGNIFICANT FIGURE
- D-DECIMAL MULTIPLIER
- E-TOLERANCE
- F-CHARACTERISTIC
- G-THIRD SIGNIFICANT FIGURE
- H-VOLTAGE RATING

Figure 14, Resistor-Condenser Color Codes

Viking I Transmitter

Typical operation using 829B final
within ICAS tube ratings

CW operation with 115 V 60 cycle ac input:

FREQUENCY	28 mc.
P. A. CATHODE CURRENT	230 ma.
SCREEN GRID VOLTAGE	225 volts (loaded)
P. A. PLATE VOLTAGE	660 volts (loaded)
P. A. GRID CURRENT	12 ma.
P. A. GRID BIAS	-97 volts
POWER OUTPUT	95 watts

Phone operation with 115 V 60 cycle ac input:

FREQUENCY	28 mc.
P. A. CATHODE CURRENT	230 ma.
SCREEN GRID VOLTAGE *	225 volts (loaded)
P. A. PLATE VOLTAGE	620 volts (loaded)
P. A. GRID CURRENT	12 ma.
P. A. BIAS VOLTAGE	-97 volts
POWER OUTPUT	87 watts
MODULATOR CATHODE CURRENT	80 ma. (no signal)

* - 13,000 ohm screen dropping resistor used.

VIKING I TRANSMITTER

Changes required for use of 829B final amplifier.

- 1 Turn coupling capacitor C31 down toward chassis to keep plate leads short.
- 2 Connect another parasitic choke (L11) to C31 by means of a solder terminal.
- 3 Connect a plate terminal (Johnson 119-848) to each of the parasitic chokes L11.
- 4 Leave pins 4 and 5 of socket X7 grounded to the chassis, but remove the ground lead from pin 7.
- 5 Remove filament wire from pin 7 and connect filament lead to chassis by means of a solder terminal under a convenient screw.
- 6 Connect pins 1 and 7 together with #20 wire.
- 7 Remove the ground lead of the filament bypass condenser C40 and re-connect to ground on the socket mounting screw near pin 1.
- 8 Remove C28 lead together with the gray screen grid lead from pin 2 and connect to pin 3.
- 9 Either change screen dropping resistor R28 to 12,500 ohms 20 watts, or connect a 3,000 ohm 10 watt resistor in series with R28.
- 10 Remove condenser C25 and choke L6 from pin 6.
- 11 Connect a jumper of #14 wire between pins 2 and 6 allowing it to bow upwards 1/2".
- 12 Re-connect C25 and L6 to the center of the jumper to provide balanced drive to the grids.

Adjustment: With the final amplifier loaded to approximately 230 ma. the voltage divider tap should be adjusted so that screen voltage is approximately 225 volts. This screen voltage setting should provide about 80 ma. no audio signal cathode current in the 807 modulators on the "phone" position.

Viking I Transmitter

Parts List

<u>Part No. or Drawing No.</u>	<u>Item No.</u>	<u>Qty.</u>	<u>Description</u>
197-111-5	CH 1	1	Cabinet
17.750	CH 2	1	Chassis
17.751-3	CH 3	1	Panel
23.900-1	BKT 1	1	Final Tuning Drive Assembly
17.754-1	BKT 3	1	Bracket - Final Cond. Mounting
17.752-1	BKT 2	1	Bracket - Final Tank Support
16.857-2	BKT 4-7	4	Bracket - Crystal Sel. and Mounting
16.1001-1	BKT 8-12	5	Bracket - Component Mounting
16.29-1	BKT 13	1	Bracket - Plate Coup. Cond. Mounting
23.906-1	D 1	1	0-100 Final Tuning Dial and Hub
23.908-1	D 2	1	Final Index and Escutcheon Plate Assembly
23.909	D 3-6	4	Drive Pulley Hub Assembly
42.49-150	D 7-8	8-1/2 ft.	Dial Cord for Coupling Cond. and 160 M Sw.
16.1027-1	D 9-10	2	Dial Cord Springs 9/16 x 3/16 x .033 Wire
14.145-7	D 11	1	1/4" D. NFB Shaft Extension 5-1/2" long
14.145-6	D 13	1	1/4" D. NFB Shaft Extension 2-1/4" long
115-256-15	D 14	1	Shaft and Bearing Assembly 1-5/8" length
115-256-16	D 15	1	Shaft and Bearing Assembly 5-1/16" length
104-250-51	D 16	1	Insulated Coupling
13.123-7	D 17	2	Panel Bearing
104-258	D 18-19	2	Split Sleeve Coupling
23.910-2	K 1	1	Knob - Final Tuning
23.907-12	K 2-4	3	Knob Dial (100-0)
23.907-13	K 5-7	3	Knob Dial (10-0)
23.907-14	K 8-9	2	Knob Dial (Single Marker)
23.907-17	K 10	1	Knob Dial (Meter)
23.907-15	K 11	1	Knob Dial (7-1)
23.907-16	K 12	1	Knob Dial (Bandswitch)
		1	#4 Hardware Envelope
		1	#6 Hardware Envelope
		1	#8 Hardware Envelope
		1	#10 Hardware Envelope
		1	3/8" Hardware Envelope
		1	Terminal and Lug Hardware Envelope
23.08-1	Hw. 438	1	Envelope for C30 154-2 Condenser Hdw.
133-278-7	S1 S2 S5	3	1-3/4" Miniature Tube Shield
133-278-8	S6	1	2-1/4" Miniature Tube Shield
17.755	S4B	1	Oscillator Buffer Shield
17.756	S4A	1	Oscillator Buffer Shield
120-277-1	X1 X2	5	Shielded 7 Pin Miniature Socket
	X5 X6 X11		
122-225	X3 X4	2	5 Pin Wafer Socket
122-101-8	X7	1	7 Pin Large Shielded Wafer Socket
122-228	X8 X9 X10 X12	4	Octal Wafer Socket
147-620	X13A	1	115 V Candelabra Socket

✓ 22.760	SW6	1	2 Pole 2 Pos. (160M) Switch
22.761	SW7	1	2 Pole 6 Pos. (Meter) Switch
✓ 22.628	SW8	1	1 Pole 11 Pos. (Crystal) Switch
167-104-2	C18	1	75LJ5 Variable Condenser
167-104-3	C22	1	75 mmf. variable condenser with long shaft
154-2-3	C29	1	350E20 Variable Condenser
154-2-1	C30	1	350E20 Variable Condenser
22.763	C1	1	✓ 10mfd 25 V. W. <u>Electrolytic Cond.</u> ①
22.764	C10 C11	1	✓ Dual 15-15 mfd 450 V. W. <u>Electrolytic Cond.</u> ②
22.765	C12 C13	1	✓ Dual 15-15 mfd 150 V. W. <u>Electrolytic Cond.</u> ③
22.766	C2	1	✓ .003 mfd 400 V. W. Paper Condenser
22.767	C3 C6	2	✓ .02 mfd 400 V. W. Paper Condenser
22.768	C4	1	✓ .1 mfd 400 V. W. Paper Condenser
22.770	C5	1	✓ .01 mfd 1000 V. W. Molded Tubular Cond.
22.771	C9	1	8 or 10 mfd 1000 V. W. Oil Filled Condenser
22.773	C14	1	✓ 50 mmfd 450 V. W. Molded Mica Condenser
22.774	C33 C34 C35	3	✓ 300 mmfd 450 V Molded Mica Condenser
22.772	C36 C37	2	✓ 300 mmfd 600 V Mica Condenser
22.775	C24 C26 C27 C15 C17 C19 C21 C23 C39 C40 C16	11	✓ .005 or .0047 mfd 450 V. W. Mica Condenser = 10 mmfd 25 V <u>Electrolytic</u> (see chart on modification sheet for code)
22.776	C20 (C54)	1	✓ 50 mmfd 450 V. W. Silver Mica Condenser
22.777	C25	2	✓ 25 mmfd 450 V. W. Silver Mica Condenser
22.778	C38	1	✓ 150 mmfd 1200 V. W. Mica Condenser
22.779	C28 C31	2	✓ .002 or .0022 mfd 1200 V. W. Mica Condenser
22.545	C32	1	✓ .01 mfd 1200 V. W. Mica Condenser
22.719	R1	1	✓ 1 megohm - 1/2 Watt Resistor
22.715	R2	1	✓ 1800 or 2000 ohm - 1/2 Watt Resistor
22.718	R3 R18	2	✓ .47 Megohm - 1/2 Watt Resistor
22.716	R5	1	✓ 24,000 or 22,000 ohm - 1/2 Watt Resistor
22.714	R7	1	✓ 220 ohm - 1/2 Watt Resistor
22.717	R23	1	✓ 47,000 or 51,000 ohm - 1/2 Watt Resistor
22.728	R4 R9	2	✓ .24 or .22 Megohm - 1 Watt Resistor
22.726	R8	1	✓ 51,000 or 47,000 ohm - 1 Watt Resistor
22.722	R15	1	✓ 1500 ohm - 1 Watt Resistor
22.721	R16	1	✓ 820 ohm - 1 Watt Resistor
22.724	R17 R24	2	✓ 2700 ohm - 1 Watt Resistor
22.727	R19	1	✓ 62,000 or 68,000 ohm - 1 Watt Resistor
22.720	R20 R26	2	✓ 100 ohm - 1 Watt Resistor
22.723	R27	1	✓ 2200 or 2000 ohm - 1 Watt Resistor
22.725	R21	1	✓ 4700 ohm - 1 Watt Resistor
22.713	R22	1	✓ 22 ohm - 1/2 Watt Resistor
22.731	R6	1	✓ .5 Megohm Linear Volume Control
22.732	R25	1	✓ 25,000 ohm W. W. Potentiometer
22.729	R13	1	✓ 20,000 ohm W. W. Adjustable Resistor
22.730	R28	1	✓ 10,000 ohm W. W. Fixed Resistor
22.762	M1	1	5 ma Meter 20 ohm
22.21	I1	1	#6S6 120 Volt Candelabra bulb
22.743	I2	1	#40 608 Volt min. screw bulb

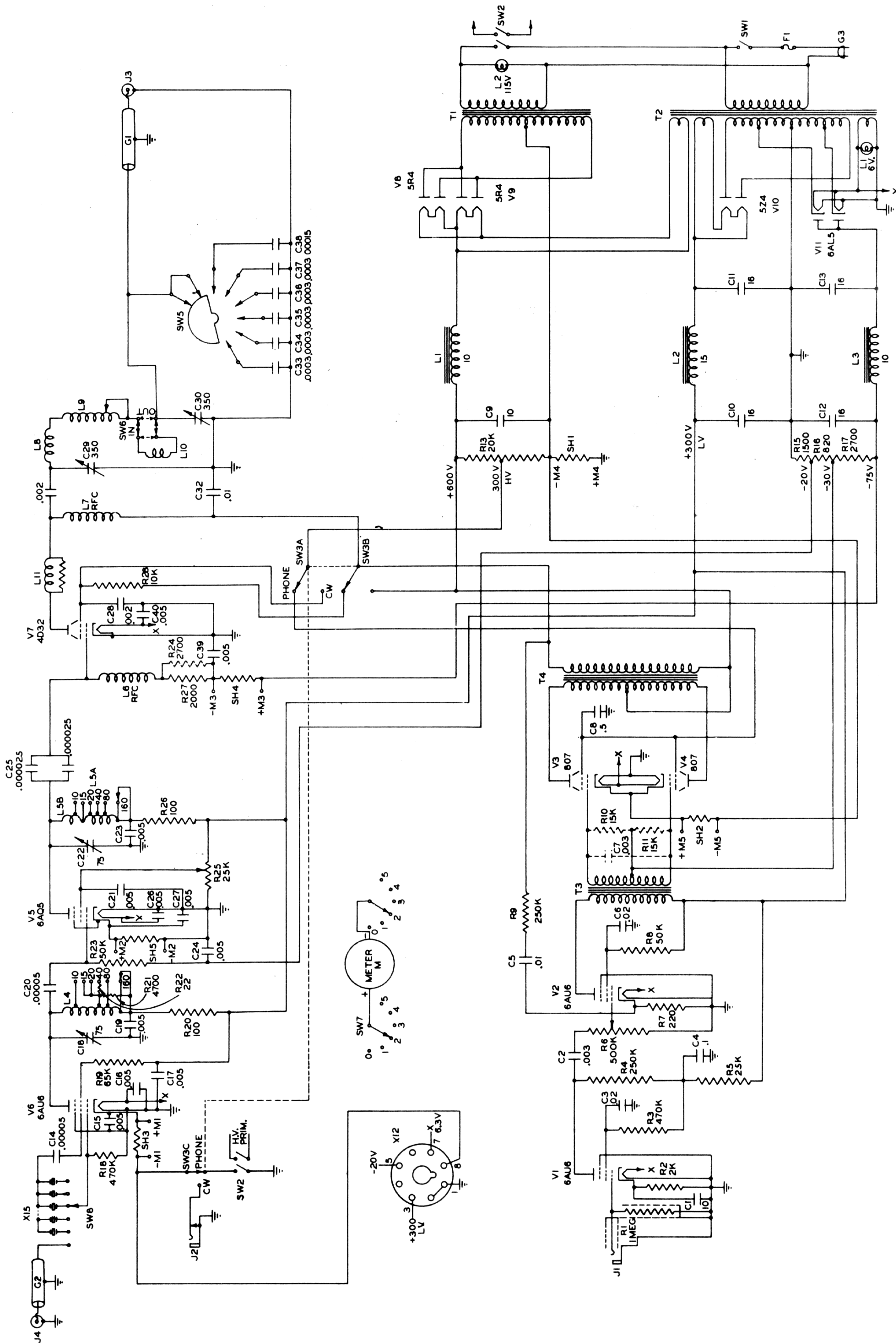


Figure 12, Circuit Diagram

