INSTRUCTION MANUAL

MODEL LPE-10

FM EXCITER

MODEL LPT-10

TEN WATT TRANSMITTER

MOSELEY ASSOCIATES, INC.

SANTA BARBARA CALIFORNIA

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MODEL LPE-10 FM EXCITER
and
MODEL LPT-10 TEN WATT TRANSMITTER

TABLE OF CONTENTS

(revised 2/64)

TABLE OF CONTENTS (continued)

INSTRUCTION MANUAL

FOR

MODEL LPE-10 FM EXCITER

AND

MODEL LPT-10 TEN WATT TRANSMITTER

SECTION 1. GENERAL

1.0 INTRODUCTION

The Model LPE-10 FM Exciter and the Model LPT-10 Ten Watt Transmitter for non-commercial FM educational use are described in this manual. As these units are essentially the same, the contents of this manual apply equally to each unit except where noted otherwise. The primary differences are found in the method of mounting. The Model LPE-10 FM Exciter is supplied on standard 19 inch rack panels and requires 14 inches of vertical panel mounting space. The Model LPT-10 Ten Watt Transmitter is furnished in an enclosed 42 inch high cabinet in which the FM Exciter has been mounted. In addition, an electric-wave, low-pass filter is included in the RF output of the Exciter to reduce all harmonic content 70 db below the carrier level. Other than these basic differences, the units are identical, and in the following text reference will be made only to the Model LPE-10 FM Exciter to avoid repetition. Both the Models LPE-10 and LPT-10 have been FCC type accepted as an FM exciter and as a low power non-commercial educational transmitter, respectively, for monophonic, FM stereophonic, and SCA service.

1.1 DESCRIPTION

The Model LPE-10 FM Exciter employs direct frequency modulation and will deliver 10 watts of output power to a

51 ohm load on any preselected channel in the commercial FM band (88-108 mc/s). The Exciter consists of two basic components. These are the Type H-6242 FM Generator and the Type H-6240 Ten Watt RF Amplifier. The first unit requires 8-3/4 inches of 19 inch panel space and is mechanically fabricated in two sections. The lower section contains the regulated power supplies and metering circuits. The second section, consisting of a smaller shock mounted assembly, is the upper portion of the Type H-6242 FM Generator and contains the oscillator, reactance modulator, frequency conversion circuits, and the automatic frequency control (AFC) circuitry. The output frequency of the FM Generator is on the selected FM channel and at a power level of approximately 5 milliwatts.

The Ten Watt RF Amplifier, Type H-6240, is a three stage neutralized RF amplifier which elevates the input signal to a power level of 10 watts at the output termination. It is constructed on a 5-1/4 inch by 19 inch rack panel.

The Model LPT-10 Ten Watt Transmitter, consisting of the above items, also includes a Type S-6310 three section 51 ohm M-derived low-pass filter. The derived sections of the filter are designed to attenuate, in particular, the second harmonic content of the Exciter. The third and higher order harmonics, however, are attenuated by more than 100 db when the filter is employed.

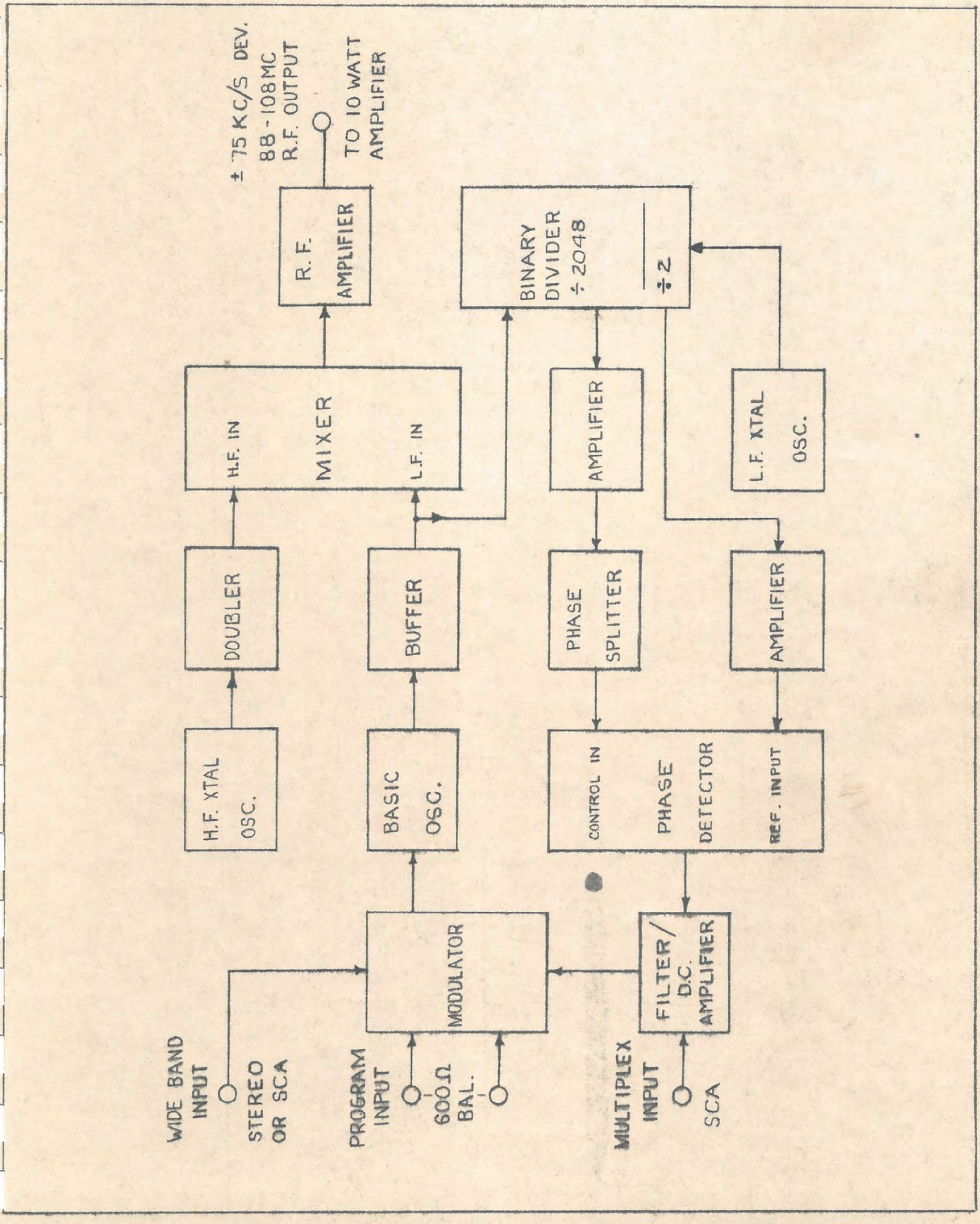
The panels of the Model LPE-10 FM Exciter are photo etched, and the markings cannot be destroyed by normal cleaning solvents. Therefore, solvents or warm soapy water may be used to remove smudges and fingerprints from the panel.

The Model LPE-10 FM Exciter is designed for monaural or stereophonic FM broadcast service. Provisions are made for the addition of two SCA multiplex subcarrier inputs, such as delivered by the Moseley Associates, Inc. Model SCG-4 Subcarrier Generators. For FM stereophonic operation, the Moseley Model SCG-3 FM Stereo Generator is connected to the wideband input connector. In this mode of operation a single SCA subcarrier channel may be connected to the multiplex input. For the monaural mode of transmission, a standard 75 microsecond pre-emphasis network is included in the Exciter.

1.2 PRINCIPLE OF OPERATION

A block diagram of the FM Generator is shown in Figure 1. It is to be noted that this diagram covers only the Type H-6242 FM Generator and does not include the Ten Watt RF Amplifier. To describe the operation of the unit (refer to Figure 1.), the heart of the Exciter centers around the basic oscillator. This is essentially a modified Hartley oscillator operating on a frequency of approximately 14 mc/s. (The exact frequency is dependent upon the output frequency of the Exciter as will be explained in greater detail in SECTION 3 of this manual.) The basic oscillator output is coupled into a buffer amplifier and then to a frequency mixer and binary divider unit. The purpose of the high frequency mixer is to convert the approximate 14 mc/s oscillator signal to the assigned output frequency by heterodyning it with a stabilized signal generated by a high frequency crystal controlled oscillator/multiplier chain. A suitable tuned amplifier stage amplifies the sum of the two frequency inputs to the mixer to derive the output signal of the Type H-6242 FM Generator.

The binary divider, deriving its input signal from the buffer amplifier following the basic oscillator, divides the approximate 14 mc/s signal by a factor of 2048 times through eleven stages of bistable flip-flops. The output of the binary divider is then amplified, passed through a phase splitter, and applied to one input of a standard phase comparitor. The second input to the phase comparitor is obtained from a low frequency crystal oscillator with suitable amplifiers and frequency divider. The frequency of the low frequency reference crystal is directly related to the desired frequency of the basic oscillator by the factor of frequency division afforded by the binary divider. Thus, under normal operation the frequency of the input signals to the phase comparitor will be the same (or very nearly so). Under these conditions the output voltage from the phase comparitor will depend upon the phase difference between the input signals. Consequently, a corrective phase comparitor will depend upon the phase difference between the input signals. Consequently, a corrective error voltage is obtained which, after suitable filtering and amplification, is applied to the reactance modulator for automatic frequency control. Modulation is applied to the modulator tube to obtain the desired amount of frequency deviation of the basic oscillator. As can be seen from Figure 1., provisions are made in the FM Generator for one monaural and two multiplex inputs. One of the multiplex inputs has a wide-band frequency response and is used for FM stereophonic operation. However, under monaural conditions this wide-band input may be used for an SCA subcarrier input. Care must be exercised with this input since any low frequency spurious signals appearing at the output of the SCA generator will modulate the main channel of the FM carrier.



BLOCK DIAGRAM *TYPE H6242* DIRECT FM GENERATOR

FIGURE 1

1.3 SPECIFICATIONS

Frequency Range	88 mc/s to 108 mc/s (available for channels other than U.S. on request)
Power Output	10 watts into 51 ohms
Type of Emission	F3 (direct frequency modulation)
Frequency Deviation	±75 kc/s for 100% modulation. Capable of 133% (±100 kc/s) without degradation of performance.
Center Frequency Stability	±1000 cycles
Harmonic Distortion	Less than 0.4%, 40 cp.s to 15 kc/s
FM Noise	Greater than 68 db below 100% modulation
Carrier AM Noise	Greater than 68 db below carrier reference
Frequency Response	
Monaural input	±1/2 db, 40 cycle to 15 kc/s, 600 ohms balanced. Approximately +6 dbm for 100% modulation.
Wide-band input	30 cycle to 300 kc/s (bandwidth required for proper transmission of composite FM stereophonic program).
SCA input	20 kc/s to 75 kc/s.
Power Requirements	117V a.c. 60 cp/s 140 watts
Over-all Dimensions	19" wide, 14" high, extends 5" in front and 6" behind mounting surface

SECTION 2. INSTALLATION

2.0 UNPACKING

The individual panels of the Model LPE-10 FM Exciter are separately packed prior to shipment. All plug-in components, such as electrolytic capacitors and crystal ovens, are wrapped separately. Before applying power to the system, it is important to make certain that all plug-in components are in place. It is recommended that a double check be made to assure that the external meter shunt and all packing spacers that might have been inserted between components have been removed. This equipment has been fully checked at the factory prior to shipment, and it is intended that the Model LPE-10 be ready to operate when it is installed by the user. The only adjustments necessary will be the center frequency, output tuning, and output loading.

2.1 RACK MOUNTING REQUIREMENTS

The Model LPE-10 is constructed on three separate 19 inch standard rack panels and requires a total of 14 inches of vertical panel space. In most installations it is recommended that the Exciter be mounted in a standard rack situated near the FM transmitter with which it is to be used. In some cases it may be possible to physically locate the exciter panels within the confines of the FM transmitter cabinet, but due caution should be exercised if high energy RF fields are present.

The exciter panels are slotted for standard Western Electric spacings, and each panel should be thoroughly secured to the rack by mounting screws for the best possible common grounding. The Exciter is designed in such a way that the FM Generator is mounted below the Ten Watt RF Amplifier. The portion of the FM Generator containing the regulated power supplies and meter should be located at the bottom. All interconnecting cables for the power, metering, and RF are furnished with the Exciter.

2.2 POWER REQUIREMENTS

The Model LPE-10 FM Exciter requires 120/240 volts AC, 50-60 cps single-phase power. The power consumption for the complete unit will not exceed 140 watts. In order that the crystal oven be continuously maintained at the operating temperature, the Exciter should be connected to the power line source at all times. It should be noted that when the front panel power switch of the FM Generator (Type H-6242) is turned off, the oven heater remains energized as well as the regulated filament supply for the oscillator and modulator tubes. This process assures minimum warm-up time at the beginning of regular broadcast operation.

2.3 ENVIRONMENTAL CONDITIONS

The Model LPE-10 FM Exciter will meet specifications over a temperature range of 20°F to 125°F. If these temperature extremes are to be exceeded, facilities should be provided to assure that the ambient temperature within the area of the Exciter does not exceed these limits.

2.4 CONNECTOR REQUIREMENTS

The 600 ohm input terminals for monaural service appear on a standard barrier strip mounted on the rear of the power supply subpanel of the FM Generator. Two Type BNC coaxial connectors are mounted in the upper left-hand corner of the front panel of the shock mounted subassembly and permit either two SCA subcarriers or one SCA subcarrier and a composite stereophonic signal to be applied to the FM Generator. A UG-88A/U plug will mate with the panel mounted multiplex connectors.

The output signal from the Type H-6240 Ten Watt RF Amplifier is available from a rear mounted Type N coaxial connector. The mating plug for RG-8A/U cable is a Type UG-21A/U fitting. Unless the distance between the Exciter and the transmitter is excessive, RG-8A/U coaxial cable is recommended for use between the Exciter and the driver stage of the FM transmitter. Under certain conditions a lower loss transmission line may be desirable.

SECTION 3. THEORY OF OPERATION

3.0 INTRODUCTION

This section describes in detail the theory of operation of the Model LPE-10 FM Exciter. It will be helpful to refer to the block diagram shown in Figure 1. and to the schematic drawings included at the rear of this manual. For convenience, these drawings correspond to the individual chassis: i.e. FM Generator Power Supply, Drawing No. 91B-6089; FM Generator, Drawing No. 91C-6088; Ten Watt RF Amplifier, Drawing No. 91B-6090.

3.1 OPERATION

Although the basic oscillator and high frequency oscillator doubler circuits operate at various frequencies depending upon the FM channel assignment, an example frequency of 92.9 mc/s will be used to simplify this discussion on theory of operation.

When the system is delivering an output frequency of 92.9 mc/s, the basic oscillator, V107, is operating at 13.9 mc/s. The tuned circuits of the basic oscillator are shunted by V105, the reactance modulator. The reactance modulator tube is a very high GM linear pentode. A tap on the basic oscillator coil delivers the 13.9 mc/s RF to the grid circuit of the buffer amplifier, V108. The output of the buffer amplifier drives both the high frequency mixer and the binary divider.

Consider first the signal that is delivered to the binary divider. The binary divider unit, BD-101, is a series of transistorized flip-flops. This series of flip-flops forms an untuned frequency dividing system. The division ratio of this divider system is 2048. The input frequency, F_1, is 13.9 mc/s. The average output frequency, F_2, of the binary divider is 6787.109 c/s. An LC resonate circuit following the last (eleventh) binary divider stage is employed within the enclosure to produce the near sinusoidal output (F_2) waveform. This signal is then coupled to V112, an amplifier and phase splitter circuit. The output of the phase splitter drives the switching legs of a phase bridge circuit. The phase detector compares the phase of the 6,787 c/s signal from the binary divider, which is directly related to the 13.9 mc/s basic oscillator, with the output of the low frequency oscillator amplifier, V111. The frequency of the low frequency oscillator, V111A, is controlled by the low frequency crystal, Y101, contained within the crystal oven. In this case the frequency of Y101 crystal is 13.574 kc/s. The output frequency of the low frequency reference (F_r) oscillator (V111A) is divided by two in a single solid state flip-flop stage which is physically located in the same enclosure as the eleven stage binary divider. Another LC shaping circuit is used to remove the harmonic content of this frequency divider. This signal ($\frac{F_r}{2}$) is amplified by V111B and applied to the second input of the phase detector. The output of the phase detector circuit is a d.c. voltage which is proportional to the phase relationship of the low frequency crystal and the binary divider output. The d.c. error voltage from the phase detector is filtered by C138, L107, and C136. The error voltage is phase compensated by C135, R155, and C137. The filtered and compensated d.c. error is then applied to the control grid of V106, the AFC amplifier. The d.c. plate voltage of V106 provides the screen voltage for V105, the reactance modulator. The GM of the Type 6688 reactance modulator tube can be controlled by either screen voltage or control grid voltage. Therefore, variations in the plate voltage of V106 will cause a variation in the GM of V105 which in turn will control the frequency of the basic oscillator, V107.

The high frequency crystal, Y102, controls the frequency of the high frequency oscillator and doubler circuit, V109. In the case of our example of 92.9 mc/s as an operating frequency, the frequency of Y102 will be 39.5 mc/s. The doubler output frequency would then be 79.0 mc/s. This 79 mc/s signal is added, in the high frequency mixer circuit, with the output of the buffer amplifier. The sum frequency produced by the high frequency mixer is 79.0+ 13.9 or 92.9 mc/s. The output of the high frequency mixer is coupled to V110, the first RF amplifier. A single-turn link couples the output of V110 to the RF output connector, J102. The RF power level at this point is approximately 5 milliwatts.

3.2 FM GENERATOR REGULATED POWER SUPPLY, CIRCUIT DESCRIPTION

The following paragraphs describe the operation of the individual circuit sections of the equipment. (See Drawing No. 91B-6089.)

3.2.1 General

The power supply delivers three different regulated d.c. voltages as well as 6.3V a.c. for operating the FM Generator. The power supply panel also provides mounting space for the metering selector switch as well as the 50 microamp d.c. meter.

3.2.2 Negative 6V d.c. Supply

The -6V d.c. supply source is T103 driving four diodes connected in the full-wave bridge configuration. The -6V d.c. regulator system consists of Zener diode CR116 and transistor Q101. The Zener diode holds the base of the transistor at a constant voltage. This voltage is approximately 6V d.c.. The current gain of the 2N278 transistor allows the power supply to deliver a constant voltage up to 1-1/2 amps d.c. The output of the -6V d.c. regulator provides two operating voltages to the FM Generator. Approximately 1 amp of the -6V d.c. supply is used to operate the heaters of V105, V106, and V107. Approximately .250 amps of this supply is used as the collector supply for the binary divider system.

3.2.3 Deleted 2/64

3.2.4 Positive 110V d.c. Supply

The regulated +110 d.c. is developed across V104, a Type OB2 gas regulator. The current for the +110V d.c. supply is drawn from the regulated +200V d.c. supply. The output of the +110V d.c. supply provides a double regulated screen voltage for the AFC d.c. amplifier, V106.

3.2.5 Positive 200V d.c. Supply

The +200V d.c. regulated supply is a conventional electronic regulated power supply. T102 operating into full-wave rectifiers delivers approximately 300V d.c. to the electronic regulating system. The regulator is composed of V103 as a reference d.c. tube, V102 as a control amplifier tube, and V101 as a series voltage regulator. The output of the +200V regulated d.c. supply provides the plate voltages for all of the circuits in the FM generator.

3.2.6 Metering Circuit

The metering selector switch is a two section, eleven position, wafer switch. This form of switching allows the 50 microamp meter to read either positive or negative voltages. The last position on the metering switch, EXTERNAL, connects the 50 microamp meter directly to the external metering plug located at the rear of the unit. This external metering position is intended for use with future Moseley Associates, Inc. products which will operate in conjunction with the Model LPE-10 FM Exciter. However, the user may, at his discretion, use this external metering position for any other function he desires to meter. As an example, an output power metering device such as a reflectometer could be used to read the power output of the Exciter. It should be kept in mind that these external metering connections are directly connected to the 50 microamp meter. Extreme caution should be used if the external metering position is used since no series resistor is included in the external metering circuit.

3.3 FREQUENCY MODULATION GENERATOR, CIRCUIT DESCRIPTION

The basic oscillator is a modified Hartley circuit. The frequency determining elements are L101, C144, and C105.

L101 is wound on a 3/4 inch by 2-1/4 inch ceramic form for maximum long term stability. C144 is a high stability porcelin capacitor. C105 is the coarse frequency adjust capacitor. Its capacitance range is 1.7 to 11 micromicrofarads. Vernier adjustment of the basic oscillator frequency is accomplished by adjusting the metallic slug inserted into the center of the coil form. This adjustment is accessible from the front of the exciter unit where it protrudes from the oscillator coil cover. Proper adjustment of this control is determined by selecting the AFC position on the meter switch and adjusting the slug for zero indication. A tap on L101 is capacitively coupled to the grid circuit of V108, the buffer amplifier. The buffer amplifier isolates the basic oscillator from the high frequency mixer and the binary divider.

3.3.1 Frequency Divider Unit, Part No. 2-2048S

The frequency divider system used in this Exciter is an untuned series of flip-flops employing silicon transistors and steering diodes. Both frequency and deviation are divided by a factor of 2,048. The reduction in deviation allows the phase detector circuit to maintain phase lock over the broad deviation range of the basic oscillator. The frequency divider package is sealed and is not intended to be serviced in the field. A standby frequency divider unit is available at nominal cost if desired. This should not be necessary, however, since all components within the frequency divider unit are operating well below their ratings. As silicon semiconductors are used in this assembly, it can tolerate environmental temperatures in excess of 150°F, or well above the ratings of normal broadcast electronic equipment. The output signal of the frequency divider unit is a square wave and is applied to a series resistance and inductance to ground. A capacitor is placed across this internal inductor to resonate it to the output frequency of 6,787 c/s. (See SECTION 5, Waveform FM-5) Two silicon diodes are included in the binary divider to rectify the output of both the eleven stage binary divider and single flip-flop divider. The rectified voltages are then added together to derive the voltage metered when the meter selector switch is in the BINARY position. Should the meter reading indicated in SECTION 4 of this manual fall to zero, then both frequency count down systems have failed; and if the meter should fail to approximately one half the normal reading, then one frequency divider is not functioning. If the meter reading does not change when the crystal oven is removed, then either the single one-stage frequency divider or the low frequency crystal oscillator is not functioning.

3.3.2 Low Frequency Reference Oscillator and Amplifier

The low frequency reference oscillator (V111A) is a standard grid-plate crystal oscillator. Diagrams FM-1 and FM-2, SECTION 5, illustrate the waveforms at the grid and plate elements of this pentode oscillator. The sawtooth waveform at the plate circuit is coupled through C162 to the Binary Divider BD-101 and divided in half by a single flip-flop circuit. The divided reference frequency is then applied to the grid of the triode amplifier, V111B. This waveform is shown in drawings FM-3, SECTION 5. The output of V111B (Waveform FM-4) is then coupled to the phase detector. The crystal, Y101, which establishes the frequency of the reference oscillator, is contained in a temperature controlled oven stabilized at 65°C. Power is applied to the crystal oven heater as long as the Model LPE-10 Exciter is connected to the 117 VAC power line.

3.3.3 Automatic Frequency Control Phase Detector

The switching legs of the phase detecting bridge are driven by V112, the divided output amplifier and phase splitter circuits. V112B splits the amplified binary divider output into equal but out-of-phase components. (See SECTION 5, Waveform FM-7.) The other input into the phase detecting bridge is the amplified low frequency reference signal delivered from the plate of V111B. (See SECTION 5, Waveform FM-4.) If the AFC system is not locked, the two inputs (the divided output and the low frequency reference) will be of different frequencies. Under these conditions the phase detector would perform as a difference detector. That is, the output of the phase detector would be equal to the frequency difference between the two input signals.

When the divided output frequency is close enough to the low frequency reference frequency, the error signal from the phase detector will be an a.c. error voltage sufficiently low in frequency to allow it to pass through the low-pass filter comprised of C138, L107, and C136. After AFC lock has occurred, the phase detecting system operates as a standard phase detector comparing the phase of the reference signal to the divided output signal.

The d.c. error voltage that exists in the AFC loop can be metered by turning the metering selector switch on the regulated power supply panel to either +AFC or -AFC as required. The trimmer adjustment on the top of the basic oscillator coil cover (L101) should be adjusted to maintain an AFC reading of zero.

3.3.4 AFC Filter, Phase Corrector, and Amplifier

The low-pass π-section filter consisting of C138, L107, and C136 will remove the reference frequency component and almost all normal program content from the d.c. error. The RC combination of R155 and C137 limits the upper frequency response of the filtering system. C135 shunting R155 adds the required phase lead component to stabilize the AFC loop. The AFC error voltage is coupled through R156, R157, and R158 to the control grid of the AFC d.c. amplifier, V106. R156 isolates the multiplex input line from the AFC filter system; R157 and R158 serve as RF isolating resistors. The screen grid of V106 is double regulated to +110V d.c.. With the AFC set at zero the plate voltage of V106 will be approximately 150V d.c.. This plate potential provides the screen grid voltage for the reactance modulator.

3.3.5 Reactance Modulator

The reactance modulator, V105, is a very high GM pentode. A variation in either control grid or screen grid voltage will cause a linear variation of the GM of this tube. The quadrature RF component required for reactance modulation is coupled through C150 and R108 to the control grid. The input capacity of the tube produces the required 90° phase shift. As stated earlier, a variation in screen potential on this tube will control the transconductance. Therefore, the amplified AFC voltage that exists on the screen grid of the reactance modulator will in turn correct the frequency of the basic oscillator to keep it in phase lock with the low frequency reference oscillator. By applying AFC in this manner the operating point of the modulator tube, so far as the control grid circuitry is concerned, is not appreciably affected.

3.3.6 Monaural, Wide-band, and Multiplex Inputs

The monaural input is 600 ohms balanced, and the terminals are mounted on the rear of the power supply panel. The balanced input transformer, T101, is a broad-band one-to-one ratio transformer. The unbalanced output of T101 is connected to the monaural input jack, J103, on the rear of the FM Generator silvered chassis. J103 connects directly to the RC pre-emphasis network, R105, C149, and R106. The output of the pre-emphasis network is coupled to the control grid of the reactance modulator through R107. The normal frequency response of the monaural channel is 40 cp/s to 15,000 cp/s, ±1/2 db. A monaural input signal of approximately +7 dbm at 400 cp/s will produce 100% modulation.

The wide-band input located on the front panel is divided approximately five to one by R101 and R102. The junction of the resistive divider is coupled through R103 directly to the control grid of the reactance modulator. When operating with a Moseley Associates, Inc. Stereo Generator, Model SCG-3, the composite output from the stereo generator is connected directly to the wide-band input. The frequency response of the wide-band input is d.c. to approximately 300 kc/s. Modulating signal components below 15 cp/s are not recommended as they would tend to influence the stability of the automatic frequency control circuitry. If stereophonic operation is not being used, the wide-band input may be used as a second SCA multiplex input. A signal level of approximately 1.7V rms will provide 100% modulation.

The multiplex (SCA) input is divided by approximately 23 to 1 by R133 and R134. The output of this resistive divider is added to the AFC at the grid of V106. The AFC voltage applied to the screen grid of the reactance modulator will now also contain the signal applied at the multiplex input jack. This method of common electron stream modulation minimizes cross frequency distortion in the modulation process. This in turn produces minimum cross talk from main channel to subchannel and from subchannel to main channel. The multiplex input will operate with any subcarrier frequency from 20 kc/s to 75 kc/s. Signal levels at the multiplex input of approximately .6V rms, 1.3V rms, and 2.0V rms will produce 10%, 20%, and 30% injections respectively.

3.3.7 High Frequency Oscillator and Doubler

The high frequency oscillator doubler, V109, is a conventional double tuned, cathode coupled, Butler oscillator. The cathodes of V109 are coupled by the crystal Y102. This crystal determines the frequency of oscillation of the high frequency oscillator. The high frequency crystal, Y102, is mounted in the same crystal oven asthe low frequency reference crystal, Y101. Therefore, both crystals are operating within the same 65°C temperature environment for maximum stability. The plate circuit of the high frequency oscillator, V109A, is tuned to the frequency of the crystal. The output of V109A is capacitively coupled to the grid of V109B. The cathode of V109B is coupled through crystal Y102 to the cathode of V109A to complete the regenerative oscillator loop. The plate circuit of V109B is tuned to the second harmonic of the high frequency oscillator thus forming a combination cathode follower and doubler amplifier. Frequency trim of the high frequency oscillator is accomplished by slightly detuning the plate circuit of V109A. L104 is adjusted and then locked in a position that places the high frequency oscillator very near the desired frequency. Vernier control of the high frequency oscillator is then accomplished by C152. The output of the doubler is link coupled to the switching leg of the high frequency mixer.

3.3.8 Crystal Selection For A Specified FM Channel

To avoid the possibility of beats produced by harmonics of the basic oscillator, the standard 88 mc/s to 108 mc/s FM band is divided into three sections. These sections correspond to the lower one third, the middle one third, and the upper one third of the FM band.

For FM channels 201 (88.1 mc/s) through 235 (94.9 mc/s) the internal frequencies will be:

basic oscillator	13.9 mc/s
reference oscillator crystal	13.574 kc/s

high frequency crystal = $\frac{F-13.9}{2}$

where F = desired carrier frequency in mc/s.

For FM channels 236(95.1 mc/s) through 265(100.9 mc/s) the internal frequencies will be:

basic oscillator	12.9 mc/s
reference oscillator crystal	12.598 kc/s

high frequency crystal = $\frac{F-12.9}{2}$

where F = desired carrier frequency in mc/s.

For channels 266(101.1 mc/s) through 300(107.9 mc/s) the internal frequencies will be:

basic oscillator 13.9 mc/s
reference oscillator 13.574 kc/s

$$\text{high frequency crystal} = \frac{F-13.9}{2}$$

where F = desired carrier frequency in mc/s.

3.3.9 High Frequency Mixer and First RF Amplifier

The non-linear elements within the high frequency mixer are two high speed switching diodes, CR101 and CR102. The sum frequency of the high frequency doubler and the buffer amplifier is obtained by applying the high frequency doubler signal to the switching leg of the high frequency mixer and applying a push-pull component of the buffer amplifier directly to the anodes of the switching diodes. The RF current within the high frequency mixer is measured by sampling the d.c. level of the common current line. The RF output of the high frequency mixer is capacitively coupled through C116 to a tap on the tuned circuit L105 and C122. The output of this tuned circuit is applied directly to the control grid of the first RF amplifier, V110. The plate circuit of the first RF amplifier is tuned by L106 and C125. Both the grid circuit and plate circuit of V110 are tuned to the desired carrier frequency. The output of the first RF amplifier is link coupled to the RF output jack on the front panel of the FM Generator panel. The carrier frequency power at this point is approximately 5 milliwatts.

3.4 TEN WATT RF AMPLIFIER - CIRCUIT DESCRIPTION

Both the plate power and the filament power for the Ten Watt Amplifier are supplied by T201. (Ref. Drawing No. 91B-6090.) The plate high voltage d.c. supply is developed by conventional full-wave silicon rectifiers operating into a two section choke input filter. The plate supply voltage for the Ten Watt RF Amplifier is a nominal 350V d.c.

Low level RF at the carrier frequency, from the FM Generator, is applied to the input connector located on the front of the RF amplifier panel. Approximately 5 milliwatts at the input is sufficient to drive the RF amplifier to its 10 watt output rating. The input RF signal is loosely coupled to the resonant circuit formed by L201 and C202. The output of this tuned circuit is applied directly to the control grid of V201. V201 is a tuned plate, tuned grid RF amplifier operating at reduced plate voltage. The plate circuit of V201 is capacitively coupled through C208 to the control grid of the driver amplifier, V202. The plate circuit of the driver amplifier is capacitively coupled by C214 directly to the control grid of the output amplifier, V203. Plate tuning of V203 is accomplished by C222. The plate tuning control is accessible from the front. The power amplifier output is link coupled to a Type N RF connector located on the rear of the Ten Watt Amplifier. Variable output loading is accomplished by C223 placed in series with the return leg of the output link. The output loading control is also accessible from the front. Since the power amplifier is not a frequency multiplier, some form of neutralization is necessary to retain maximum stability. In this case a small sample of the power amplifier output is coupled back to the power amplifier input. A link coupling system from the power amplifier output circuit back to the plate circuit of the driver amplifier provides the necessary feedback. The Type 6146 power amplifier tube, V203, has protective cathode biasing. Loss of drive to the Ten Watt Amplifier will not damage the tubes or reduce tube life by an significant amount. The RF Amplifier, Type H-6240, is capable of delivering from 2 watts to 12 watts of RF over a frequency range of 88 mc/s to 108 mc/s. Adjustments L201, L202, L203, and C222 are tuned to the carrier frequency. If adjustment of the tuned circuits is necessary, turn the metering selector switch on the FM Generator power supply panel to the P.A. GRID position. Adjust L201, L202, and L203 for maximum grid current indication. Turn the metering selector switch to P.A. PLATE position and adjust the plate tuning control for minimum meter reading.

SECTION 4. OPERATION OF EQUIPMENT

4.0 WARM-UP PROCEDURE

Under normal operation it is recommended that the FM Generator be left on at all times and only the Ten Watt Amplifier, Type H-6240, be turned off when the Exciter is not in use. Under these conditions, when the unit is turned on prior to broadcast time, only a five minute warm-up period is required. If the FM Generator has been turned off but not disconnected from the primary power source, the required warm-up time is from fifteen to twenty minutes. When the entire system has been disconnected from the power line for an extended period of time, the crystal oven and d.c. filaments of the oscillator and modulator tubes are completely cold. Under these conditions the system should be allowed thirty minutes to forty-five minutes to completely warm-up and stabilize. If necessary, broadcasting can start in less than half this time, but some frequency drift will be apparent until the system has completely stabilized.

4.1 INITIAL ADJUSTMENTS

Once the Model LPE-10 FM Exciter has been installed in a rack and connected to the primary power source, it should be turned on and allowed to stabilize as described in the above paragraph. The meter selector switch should be rotated through its entire range to observe that all circuits are properly functioning. For convenience and reference purposes, the following table shows the readings for each meter selector switch position taken on the Exciter at the time of manufacture and may be used as a guide in routine maintenance.

Type H-6242 FM Generator, Serial No. 2057

Meter Position	Meter Reading
+200V	20
NEG. 6V	26
BINARY	34
+AFC	-
-AFC	-
HF OSC.	8
MIXER	30
PA GRID	24
PA PLATE	19
+350	33
EXTERNAL	-

It may be necessary to resonate the plate circuit of the power amplifier after the Exciter is connected to its load. This is accomplished by turning the meter selector switch to the PA PLATE position and adjusting the PLATE TUNING control on the Ten Watt RF Amplifier panel to a minimum. Turning the OUTPUT LOADING control clockwise will increase the power output from the Exciter.

4.2 ON-AIR ADJUSTMENTS

During normal operation the Model LPE-10 will require little, if any, adjustment. An occasional retrim of the basic oscillator frequency or the center frequency may be required. The proper basic oscillator frequency is determined by adjusting the front panel vernier, L101, until the AFC error voltage reads zero. Maintaining the AFC error voltage as near to zero as possible assures a quick relock in the event of a momentary power interruption or other unpredictable transients. The center frequency (carrier frequency) control, designated FREQ., is located on the front panel slightly above and to the left of the crystal oven. This adjustment will move the center frequency several kilocycles above or below the assigned carrier frequency and should be adjusted only with the aid of FCC Type Approved Frequency Monitor or other suitably accurate frequency measuring equipment. Minor adjustments of the OUTPUT LOADING and PLATE TUNING can be accomplished while the equipment is on the air.

4.3 TURN OFF PROCEDURE

At the end of the broadcast day it is recommended that the Exciter be shut down by turning off the power switch on the Ten Watt Amplifier only. This allows all of the circuitry in the FM generating system to continue to operate normally. Under these conditions the required warm-up time for the next day is minimized, and the life of the tubes within the FM Generator is extended. By leaving the FM generator on continually, the natural system heat tends to minimize temperature variations within the area of the Exciter and in turn produces a more stable operating system.

4.4 POWER OUTPUT DETERMINATION

In the Model LPT-10 Ten Watt Transmitter it may be necessary to calculate the power output of the transmitter by the indirect method if power monitoring test equipment is not available. The following formula may be used to determine the output power.

$$P.O. = E_b \times I_{p'} \times K$$

where P.O. = power output in watts into resistive 51 ohm load.

E_b = plate voltage measured on panel meter in +350 volt meter selector position

$I_{p'}$ = P.A. current meter reading as indicated

K = .7

The K factor shown above was determined during the final test of the Model LPT-10 and is accurate to within 2% for power variations of 10% from the rated 10 watt output level.

For convenience in determining the output power, Figure 2 (included only for the Model LPT-10) is a graph showing the output power versus the meter reading in the PWR. OUTPUT position. The sampling voltage for this measurement is taken from a diode pickup link mounted inside the Type 6310 Low-Pass Filter and is valid when the transmitter is operating into a 51 ohm termination.

SECTION 5. MAINTENANCE AND TROUBLESHOOTING

5.0 MAINTENANCE

During normal maintenance periods, a check of the meter readings for all meter positions provides a means of reviewing the general condition of the Exciter. (See typical meter reading chart in this section.) Small changes in these meter readings from week to week can be expected and will have no significant effect on the operation of the Exciter. A quick check of AFC lock-in range can be accomplished by turning the vernier slug on L101 two or three turns clockwise then back to normal and two or three turns counterclockwise and then back to normal. While the adjustment is being turned, the AFC meter will indicate an AFC error is present, but the AFC system should remain locked throughout this test. Should the AFC system fail to maintain lock during this quick test, further checks should be made using the voltage and waveform charts included in this section.

The binary meter selector switch position is useful in quickly checking the Exciter by providing an indication of proper operation of the basic oscillator, buffer amplifier, and binary divider (Part No. 2-1024S).

5.1 TROUBLESHOOTING

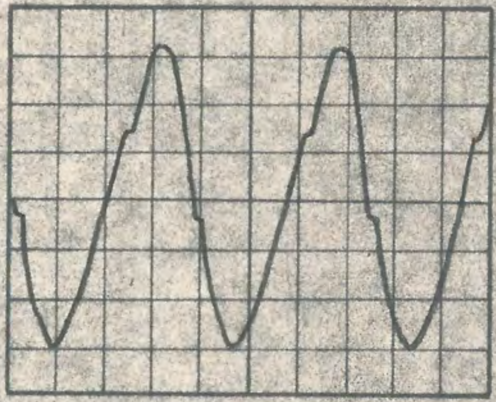
The following voltage-resistance measurements and waveform sketches are provided to aid in troubleshooting. The voltage levels, resistance readings, and waveform shapes given are not to be construed as absolute requirements. For example, the 125V d.c. level measured on pin 1 of V111, the low frequency amplifier, can vary as much as ±10 volts without seriously altering the operation of the amplifier. As long as the measurements taken fall within reasonable tolerances of the information given, they may be considered as normal.

(revised 2/64)

5.1.1 Typical Waveforms

(f_2) BD-101 Output	0.2	20μsec
WAVEFORM LOCATION	VOLTS/DIV.	TIME/DIV.

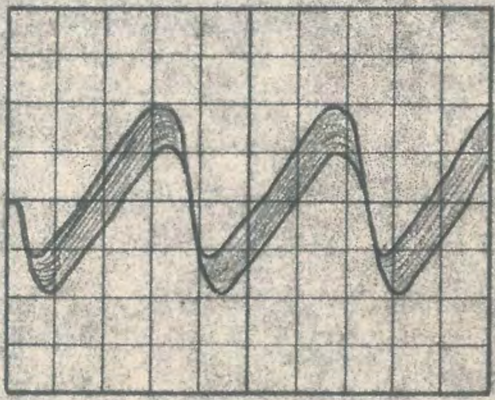
Binary divider output (13.574 kc/s or 12.598 kc/s). D.C. level is 0V d.c.



FM-1

Pin 3 V111	0.2	20μsec
WAVEFORM LOCATION	VOLTS/DIV.	TIME/DIV.

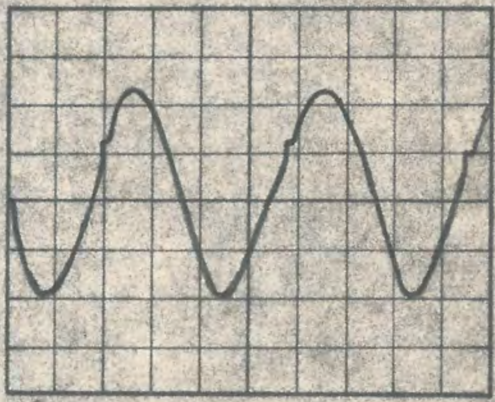
Screen Grid of low frequency oscillator. Voltage level is approximately 115V d.c.



FM-2

Pin 9 V111	0.5	20μsec
WAVEFORM LOCATION	VOLTS/DIV.	TIME/DIV.

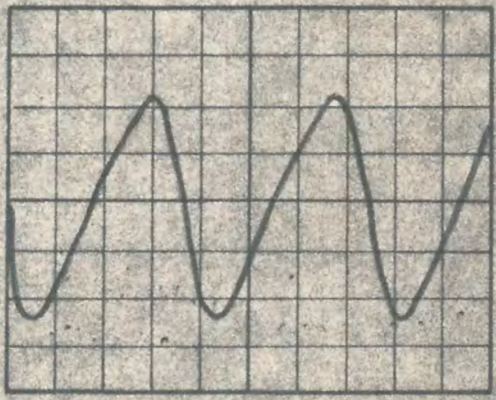
Low frequency oscillator output. This is a high impedance point (1 meg), and care must be taken not to load this point during measurement.
Voltage level is approximately negative 0.1V d.c.



FM-3

Pin 6 V111	5.0	20μsec
WAVEFORM LOCATION	VOLTS/DIV.	TIME/DIV.

Plate of low frequency oscillator. Voltage level is approximately 65V d.c.



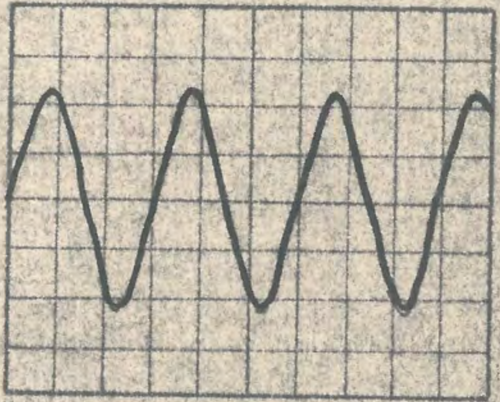
FM-4

TYPICAL WAVEFORMS
(Reference Section 3.3)

Pin 2 V112	1.0	50μsec
WAVEFORM LOCATION	VOLTS/DIV.	TIME/DIV.

F_2 OUTPUT $F_2 = \frac{F_1}{2048}$

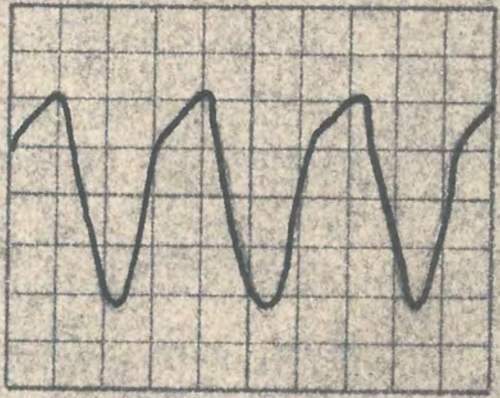
Basic oscillator frequency divided by 2048



FM-5

Pin 1 V112	20	50μsec
WAVEFORM LOCATION	VOLTS/DIV.	TIME/DIV.

AMPLIFIED F_2

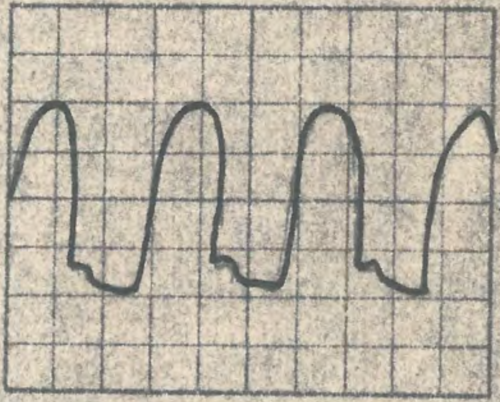


FM-6

Pin 8 V112	10	50μsec
WAVEFORM LOCATION	VOLTS/DIV.	TIME/DIV.

CATHODE OUTPUT OF F_2 PHASE SPLITTER

Pin 6 of V112 will be similar except 180° out of phase.

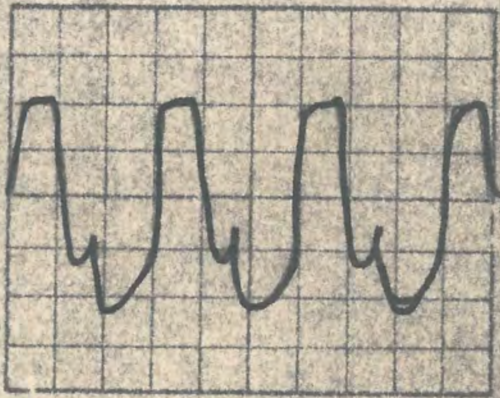


FM-7

JUNCTION CR105,CR106,R145	5.0	50μsec
WAVEFORM LOCATION	VOLTS/DIV.	TIME/DIV.

PHASE COMPARITOR BRIDGE INPUT

Junction CR103, CR104, R145 will be similar except 180° out of phase.



FM-8

5.1.2 VOLTAGE & RESISTANCE MESUREMENTS

MODEL LPE-10 FM EXCITER

NOTE:
1. ALL MEASUREMENTS TAKEN WITH 20K OHM/VOLT VOLT-OHM METER.
2. ALL MEASUREMENTS TAKEN WITH REFERENCE TO GROUND, EXCEPT AS NOTED.
3. ★ DENOTES MEASUREMENT TAKEN WITH AFC LOCKED.

TUBE V №	SCALE	PIN NUMBERS 1	2	3	4	5	6	7	8	9	
		FM GENERATOR - TYPE 6242									
V 101	V	155	290	200	155	290	200	5 VAC FROM PIN 8	5 VAC FROM PIN 7		
	R	1 MEG.	18 K	11 K	1 MEG	18 K	11 K				
V 102	V	155	110	110	5 VAC FROM PIN 9	5 VAC FROM PIN 9	110	80	80	5 VAC FROM PINS 4-5	
	R	1 MEG.	1 MEG.	12 K			1 MEG.	120 K	15 K		
V 103	V	80				80					
	R	72 K				72 K					
V 104	V	105				105					
	R	22 K				22 K					
V 105	V	1.8	0	1.8	-6			195	1.8	150★	
	R	150Ω	2.6 K	150Ω	0			12 K	150Ω	16 K	
V 106	V	0.5	0	0.5	-6			150★	0.5	110	
	R	68Ω	750K	68Ω	0			16 K	68Ω	22 K	
V 107	V	.25		-6		195	100				
	R	47 K		0		12 K	44 K				
V 108	V	-0.1	2		6.3 AC	195	130	2			
	R	100K	220Ω		0	12K	44 K	220Ω			
V 109	V	195	0	3.8			195		2.4	6.3 AC	
	R	12K	22K	600Ω			12K		600Ω	0	
V 110	V		2.5	6.3 AC		195	65	2.5			
	R		100Ω	0		12 K	44 K	100Ω			
V 111	V	80	-4 (50 VOLT SCALE)	115		6.3AC	65			-1.8	
	R	20K	3 MEG	72K		0	50K			100 K	
V 112	V	105	0	1.5			165	25	33	6.3AC	
	R	72K	12Ω	1K			22K	110K	10K	0	
Q 101		EMITTER -6	BASE	COLL.							
		TEN WATT RF AMPLIFIER - TYPE 6242									
		VOLTAGE MEASURED WITH EXCITATION PRESENT. PLATE & CONTROL GRID MEASURMENTS NOT RECOMMENDED. (EXCEPT WITH RF PROBE.)									
V 201	V		2.2	6.3AC			15	2.2			
	R		100Ω	0		390K	410Ω	100Ω			
V 202	V			15	6.3 AC		210	15			
	R	390K		470Ω	0		410K	470Ω	33K	33 K	
V 203	V	27	6.3AC	175	27		27			(CAP)	
	R	430Ω	0	490K	430Ω	52K	430Ω			390K	

ADDENDUM I

The following information is intended to help clarify the tuning instructions of the Model LPE-10 FM Exciter. Reference to the schematic diagrams of the FM Generator and Ten Watt RF Amplifier will be helpful. Reference should also be made to Section 4.1 of the Instruction Manual showing the typical meter readings that can be expected with proper operation of the Exciter.

Tuning Procedure

L-102 — With the meter selector switch in the MIXER position, adjust L-102 for maximum indication. This reading should correspond approximately with the reading shown in Section 4.1. Since the circuit Q of L-102 and C-121 is reasonably high and the full 75 kc/s deviation is present with 100% modulation, the tuning of L-102 should be carefully made in order to minimize the main channel audio distortion and the cross talk from the main channel into the SCA channel. The Exciter will easily meet all FCC requirements with L-102 misadjusted, <u>but for absolute optimum performance the coil should be adjusted to produce minimum audio distortion at 400 cps, 100% modulation.</u> Minimum SCA cross talk will coincide with this minimum audio distortion setting. In no case should it be necessary to detune L-102 from peak by more than one full turn either way.

L-104 — Place the meter selector switch in the HF OSCILLATOR position and adjust L-104 for maximum indication. <u>NOTE:</u> Care must be taken if L-104 is adjusted while the transmitter is on the air as this adjustment will affect the center frequency of the Exciter. <u>Slight</u> detuning of L-104 may be necessary so that the FREQ. adjust capacitor (C-152) is capable of shifting the output frequency above and below the assigned operating frequency.

L-103	With the meter selector switch in the MIXER position, adjust L-103 for peak reading. Again, refer to Section 4.1 of the Instruction Manual for the approximate reading.
L-105 and L-106	Place the meter selector switch in the P.A. GRID position and adjust L-105 and L-106 for maximum reading. The Ten Watt RF Amplifier will have to be turned on for this measurement. It is normal for the tuning of L-105 to be broad and the tuning of L-106 to be rather sharp. <u>NOTE:</u> The meter readings shown in Section 4.1 of the Instruction Manual for the P.A. GRID position will vary depending on the amount of power the Ten Watt RF Amplifier is delivering to its load.
L-201, L-202, and L-203	With the meter selector switch in the P.A. GRID position, adjust L-201, L-202, and L-203 for maximum indication on the meter. It is normal for L-201 to exhibit a broad tuning characteristic while L-202 and L-203 are more critical.
Plate Tuning	With the meter selector switch in the P.A. PLATE position, adjust the PLATE TUNING control on the front panel for a minimum meter indication. This reading will depend upon the setting of the PLATE LOADING control.
Plate Loading	This control should be adjusted to deliver the desired amount of power to the load being driven by the Model LPE-10 Exciter. If the PLATE LOADING is readjusted, the PLATE TUNING control should be rechecked for minimum indication. <u>NOTE:</u> While the PLATE LOADING control will vary the RF output power of the Model LPE-10 Exciter from zero to approximately 12 watts, it is recommended that the output of the Exciter always exceeds 4 watts. If less power is desired for a particular installation, an appropriate attenuation pad should be used. In some

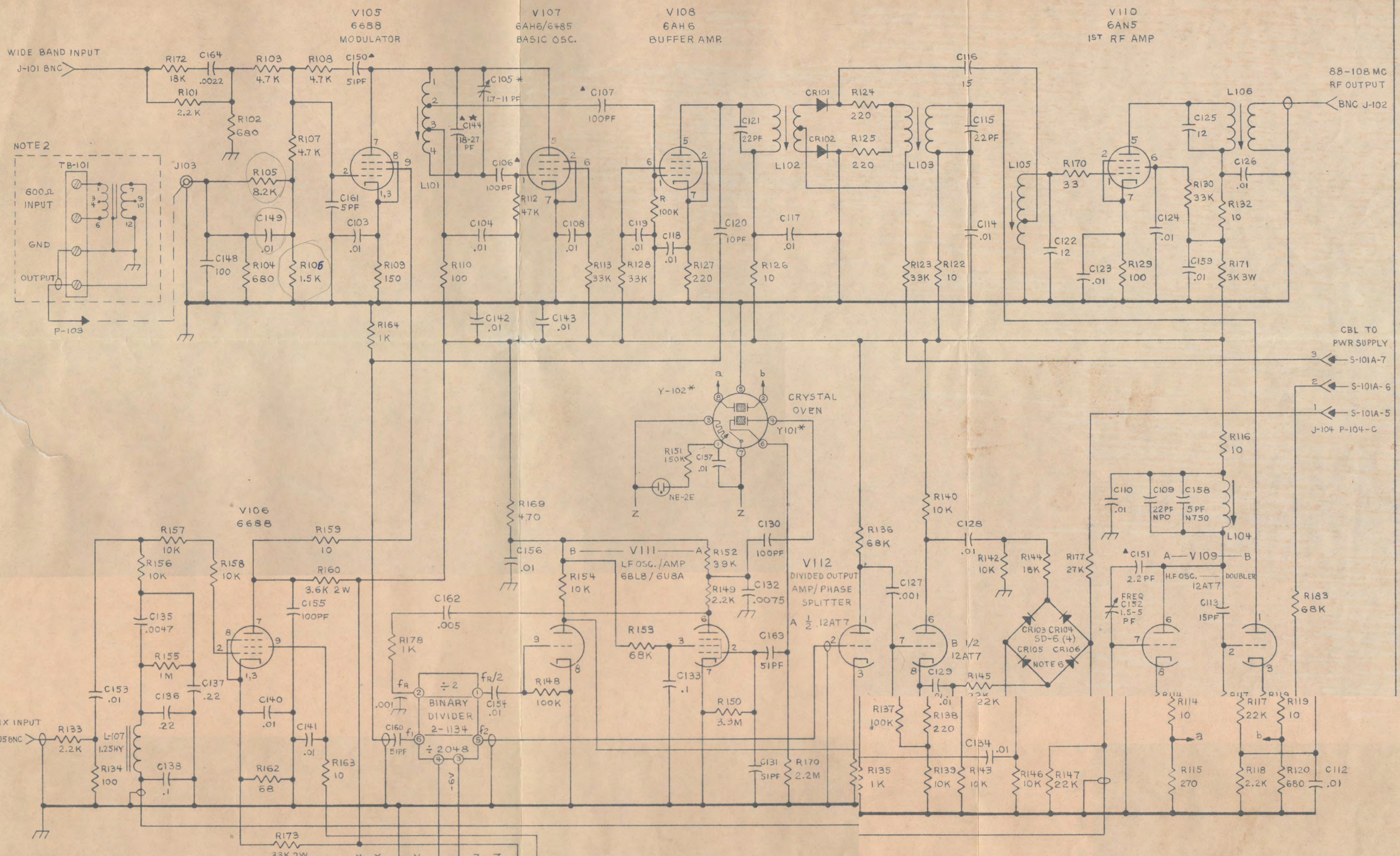
cases RG-58A/U coaxial cable can be used to obtain the desired amount of attenuation. A clockwise rotation of the PLATE LOADING control causes an increase in the power output of the Exciter.

C-105

If replacement of the basic oscillator, modulator, or DC amplifier tubes becomes necessary, normal variations in the tolerances of the tube characteristics may prevent the AFC circuit from phase locking to the low frequency reference crystal. Should this occur, position the tuning knob of L-101 midway in its travel, and adjust C-105 with an insulated screwdriver until the AFC loop is locked. This will be evident by observing the meter with the meter selector switch set in either the AFC(+) or (-) position. Capacitor C-105 is adjusted from the rear of the FM Generator. A small hole plug must be removed to gain access to the screwdriver slot on the capacitor.

NOTES

1. When the AFC circuit is locked, changes in the tuning knob of L-101 will not affect the center frequency of the Model LPE-10 FM Exciter. The AFC error voltage introduced by these changes will be apparent on the meter when the meter selector switch is in the AFC (+) or (-) position. Conversely, when the AFC circuit is not locked, changes in the position of the tuning knob of L-101 will shift the output frequency of the exciter which will be readily apparent on the station's Frequency Monitor. Under these conditions the AFC error voltage will be zero until the basic oscillator comes close to the proper frequency. When this occurs, an AFC error voltage will build up until it is within the capture range of the control system. After lock has been obtained, it will be necessary to readjust L-101 for zero AFC error.



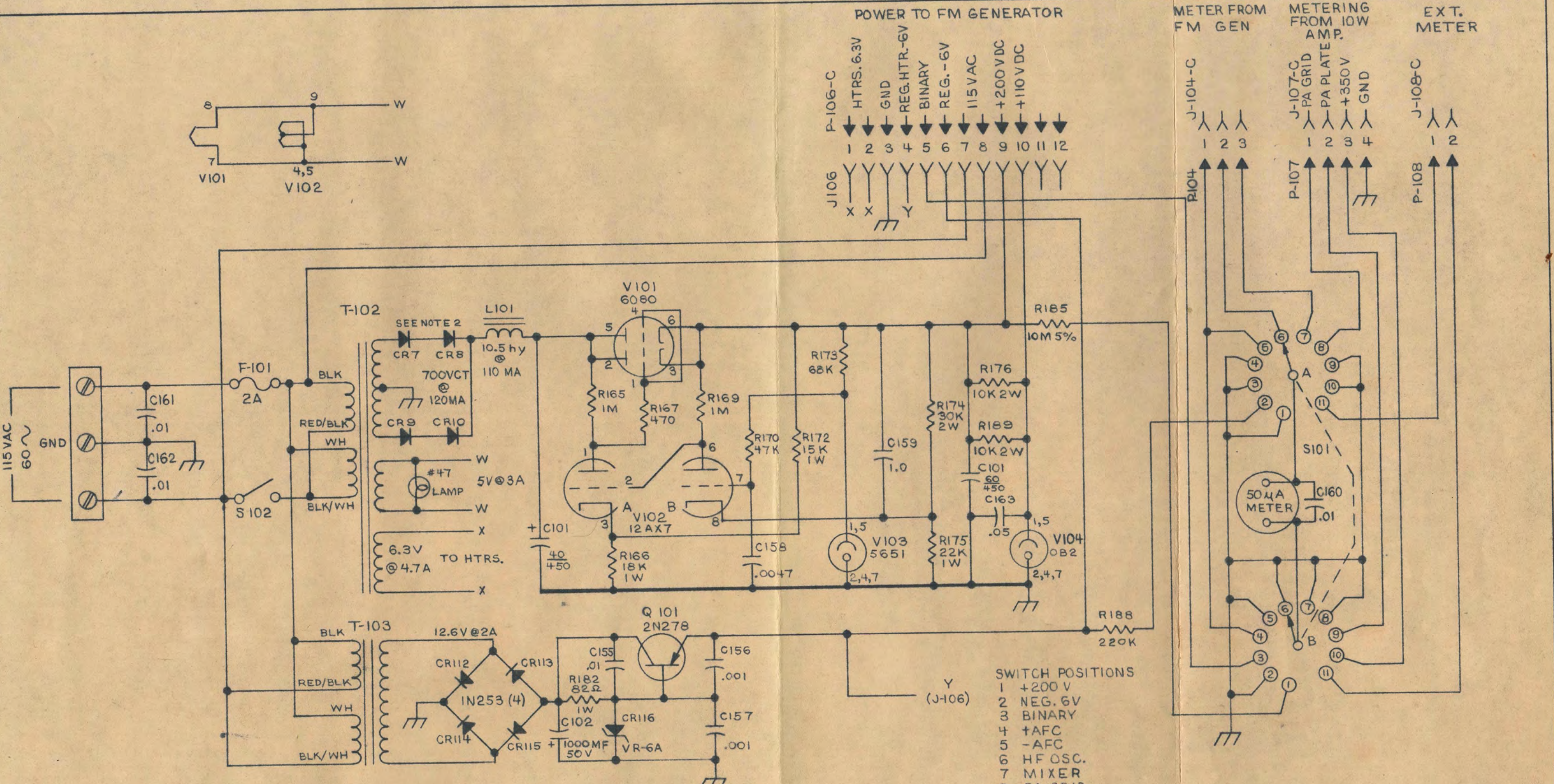
NOTES:

1. UNLESS OTHERWISE SPECIFIED: RESISTORS ARE IN OHMS 1/2 W ±10%. CAPACITORS ARE IN MICROFARADS.
2. TB-101 & T-101 ARE LOCATED ON POWER SUPPLY.
3. THIS UNIT, WITH THE EXCEPTION OF TB-101 & T-101, IS SHOCK MOUNTED.
4. * REFER TO INSTRUCTION MANUAL.
5. ★ DENOTES TRIM VALUE.
6. 1 AMP 600 PIV ALAVANCHE.
7. ▲ C106, C107, C144, C150, C121 ARE VITRAMON-PORCELAIN HIGH STABILITY.

ADD R176 3-67	R149 WAS 100Ω FXY 6/66	REDRAWN C135 WAS .0056	

MOSELEY ASSOCIATES, IN
SANTA BARBARA, CALIFOR

FM GENERATOR
MODEL LPE-10 TYPE H 6242



SWITCH POSITIONS
1 +200 V
2 NEG. 6V
3 BINARY
4 +AFC
5 -AFC
6 HF OSC.
7 MIXER
8 PA GRID
9 PA PLATE
10 +350 V
11 EXTERNAL

NOTES:
1. UNLESS OTHERWISE STATED:
   RESISTORS ARE IN OHMS 1/2 W ±10%
   CAPACITORS ARE IN MICROFARADS.
2. CR7, CR8, CR9, CR10 ARE 1 AMP 1000 PIV AVALANCHE.
3. FOR 240 V CONNECTION SEE DWG. 91A6195

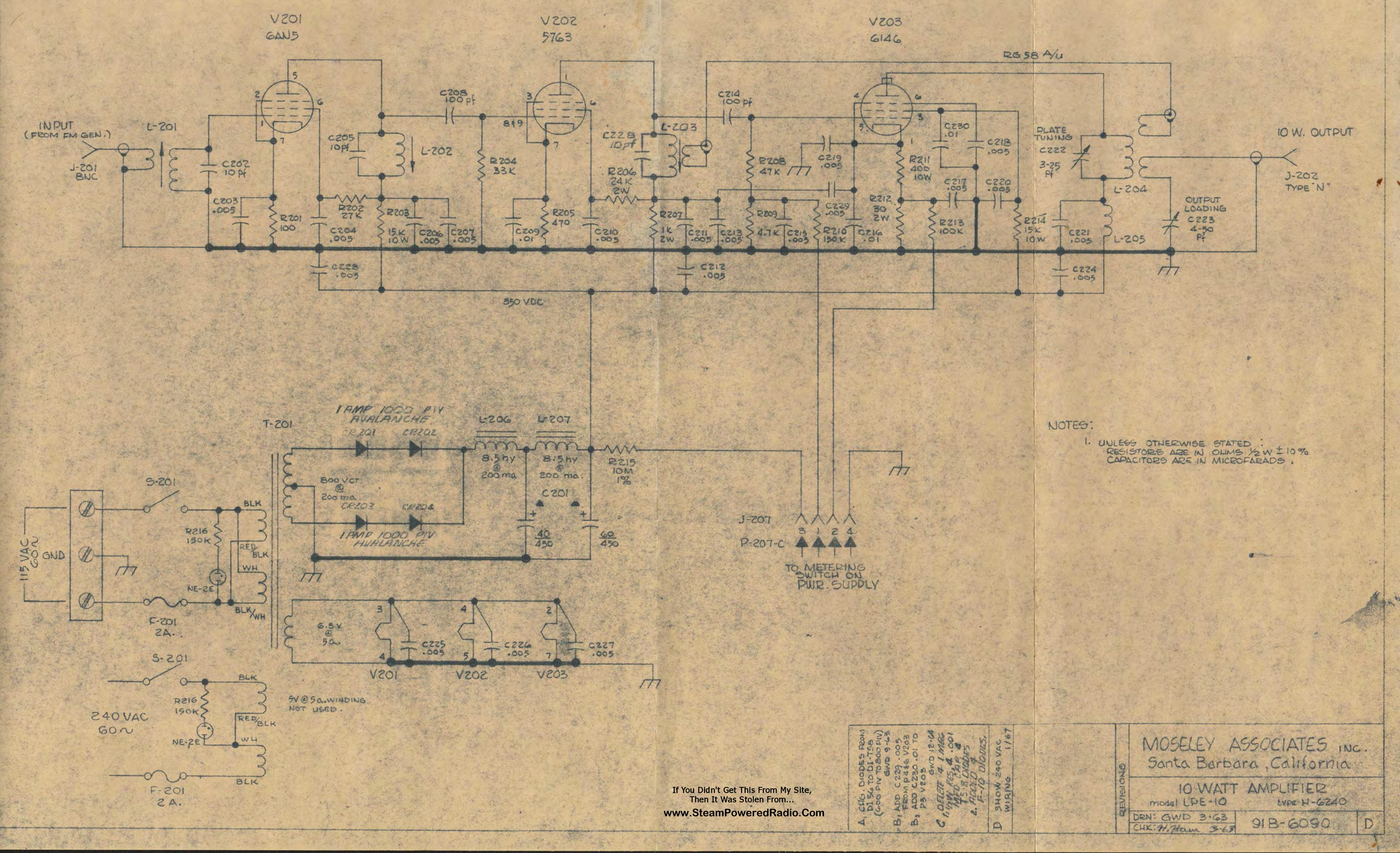
91C6089 REV. A & B SERIAL NO 759 & PRIOR

F | REDRAWN. SPLIT PRIMARIES. C101 WAS 20-20. FXY 6/66

MOSELEY ASSOCIATES, INC.
SANTA BARBARA, CALIFORNIA

FM GENERATOR POWER SUPPLY
MODEL LPE-10 TYPE H6242

DWN FXY 6/66
CHK H. Horn 6-66
91B 6089 F


V201
6AN5
V202
5763
V203
6146
RG 58 A/U
INPUT
(FROM FM GEN.)
J-201
BNC
L-201
C202
10 pf
C203
.005
R201
100
C205
10pf
L-202
C208
100 pf
R202
27K
R203
15K
10W
C204
.005
C206
.005
C207
.005
R204
33K
R205
470
C209
.01
C210
.005
C228
.005
350 VDC
C228
10pf
L-203
C214
100 pf
R206
24K
2W
R207
1K
2W
C211
.005
C213
.005
C212
.005
R208
47K
C219
.005
R209
4.7K
C215
.005
R210
150K
C229
.005
C216
.01
R211
400
10W
R212
30
2W
R213
100K
C230
.01
C218
.005
C217
.005
C220
.005
R214
15K
10W
PLATE
TUNING
C222
3-25
pf
L-204
C221
.005
L-205
C224
.005
OUTPUT
LOADING
C223
4-50
pf
10 W. OUTPUT
J-202
TYPE "N"
T-201
1 AMP 1000 PIV
AVALANCHE
CR201
CR202
800 VCT
@
200 ma.
CR203
CR204
1 AMP 1000 PIV
AVALANCHE
L-206
8.5 hy
@
200 ma.
L-207
8.5 hy
@
200 ma.
R215
10M
1%
C201
40
450
60
450
J-207
P-207-C
3 1 2 4
TO METERING
SWITCH ON
PWR. SUPPLY
S-201
R216
150K
NE-2E
F-201
2A.
115 VAC
60 ~
GND
BLK
RED/BLK
WH
BLK/WH
6.3 V
@
5a.
C225
.005
C226
.005
C227
.005
V201
V202
V203
S-201
240 VAC
60 ~
R216
150K
NE-2E
F-201
2A.
BLK
RED/BLK
WH
BLK
5V @ 5a. WINDING
NOT USED.
NOTES:
1. UNLESS OTHERWISE STATED:
RESISTORS ARE IN OHMS ½ W ± 10%
CAPACITORS ARE IN MICROFARADS.
REVISIONS
A. CHG. DIODES FROM D1-56 TO D1-T58 (600 PIV TO 800 PIV) GWD 9-63
B. ADD C229 .005 FROM R216 V203
B. ADD C230 .01 TO P3 V203 GWD 12-64
C. 1. DELETE 4 MEG RESISTORS & .001 CAPS. 2. ADDED 4 F-10 DIODES.
D SHOW 240 VAC WIRING 1/67
MOSELEY ASSOCIATES INC.
Santa Barbara, California
10 WATT AMPLIFIER
model LPE-10
type H-6240
DRN: GWD 3-63
CHK: H. Ham 3-63
91B-6090
D