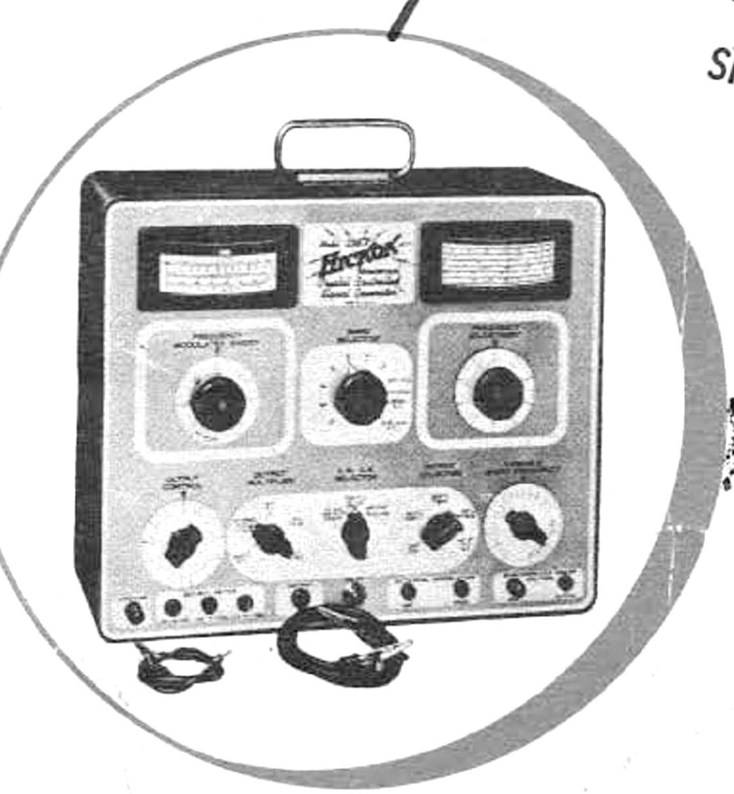
HICKOK

OPERATING INSTRUCTIONS

for

UNIVERSAL CRYSTAL CONTROLLED SIGNAL GENERATOR

Model 288X



Manufactured by

THE HICKOK ELECTRICAL INSTRUMENT COMPANY

10514 DUPONT AVENUE • CLEVELAND 8, OHIO

OPERATING INSTRUCTIONS

FOR

UNIVERSAL CRYSTAL CONTROLLED SIGNAL GENERATOR

MODELS 288X, 277X AND 277

THE HICKOK ELECTRICAL INSTRUMENT COMPANY

10514 Dupont Avenue
Cleveland 8, Ohio

Form 12-288X-3-47 (3)

Figure 1.1 - Universal Crystal Controlled Signal Generator, Model 288X

TECHNICAL DATA SHEET

(One Complete Unit)

Quan.	Name	Type	Stock No.	Dimensions	Weight
1	Universal Crystal Controlled Signal Generator	288X, 277X, 277		13"x16"x7"	33 lbs
1	Instruction Book		2490-50		
1	Meter Lead		12450-98	42"	

TECHNICAL CHARACTERISTICS

1. Power Supply Required: 105-125 V, 50-70 cycles, a-c
   Other voltages and frequencies are available on request and at a slight additional cost
2. Power Consumption: 20 watts at 115 volts
3. Amplitude Modulated - Pure R-F Frequency Ranges:
   - a. A Band 100-300 kc
   - b. B Band 300-850 kc
   - c. C Band 850-2200 kc
   - d. D Band 2.2-6.5 mc
   - e. E Band 6.5-20 mc
   - f. F Band 20-50 mc
   - g. G Band 50-110 mc
4. Frequency Modulated R-F Frequency Ranges:
   - a. Narrow Band (0-30 kc Sweep): 100 kc to 110 mc in 7 ranges
   - b. Wide Band (0-150-450 kc Sweep): 1 mc to 160 mc in 7 ranges
5. Modulation:
   - a. Amplitude Modulation: 400 cycle
   - b. Frequency Modulation: 50 mc, 0-450 kc variable sweep, modulating frequency - 60 cycles

     50 mc, 0-150 kc variable sweep, modulating frequency - 400 cycles

     1000 kc, 0-30 kc variable sweep, modulating frequency - 60 cycles
   - c. External Modulation: Frequency Modulation, variable 0-15,000 cycles
     Amplitude Modulation, variable 0-15,000 cycles
6. A-F Range: Fixed at 400 cycles
   Variable from 20-15,000 cycles
7. Crystal Controlled Output: - Models 288X, 277X
   - a. 100 kc, Unmodulated: 100-15,000 kc (utilizing harmonics)
   - b. 100 kc, 400 cycle Amplitude Modulated: 100-15,000 kc (utilizing harmonics)
   - c. 1000 kc, Unmodulated: 1000 kc-125 mc (utilizing harmonics)
   - d. 1000 kc, 400 cycle Amplitude Modulated: 1000 kc-125 mc (utilizing harmonics)

TECHNICAL DATA SHEET

TECHNICAL CHARACTERISTICS (Concluded)

8. Output: R-F - continuously variable from 0 to maximum (with multipliers X1, X10 and X100)

A-F - continuously variable from 0 to maximum, linear control, for both 400 cycle and variable outputs

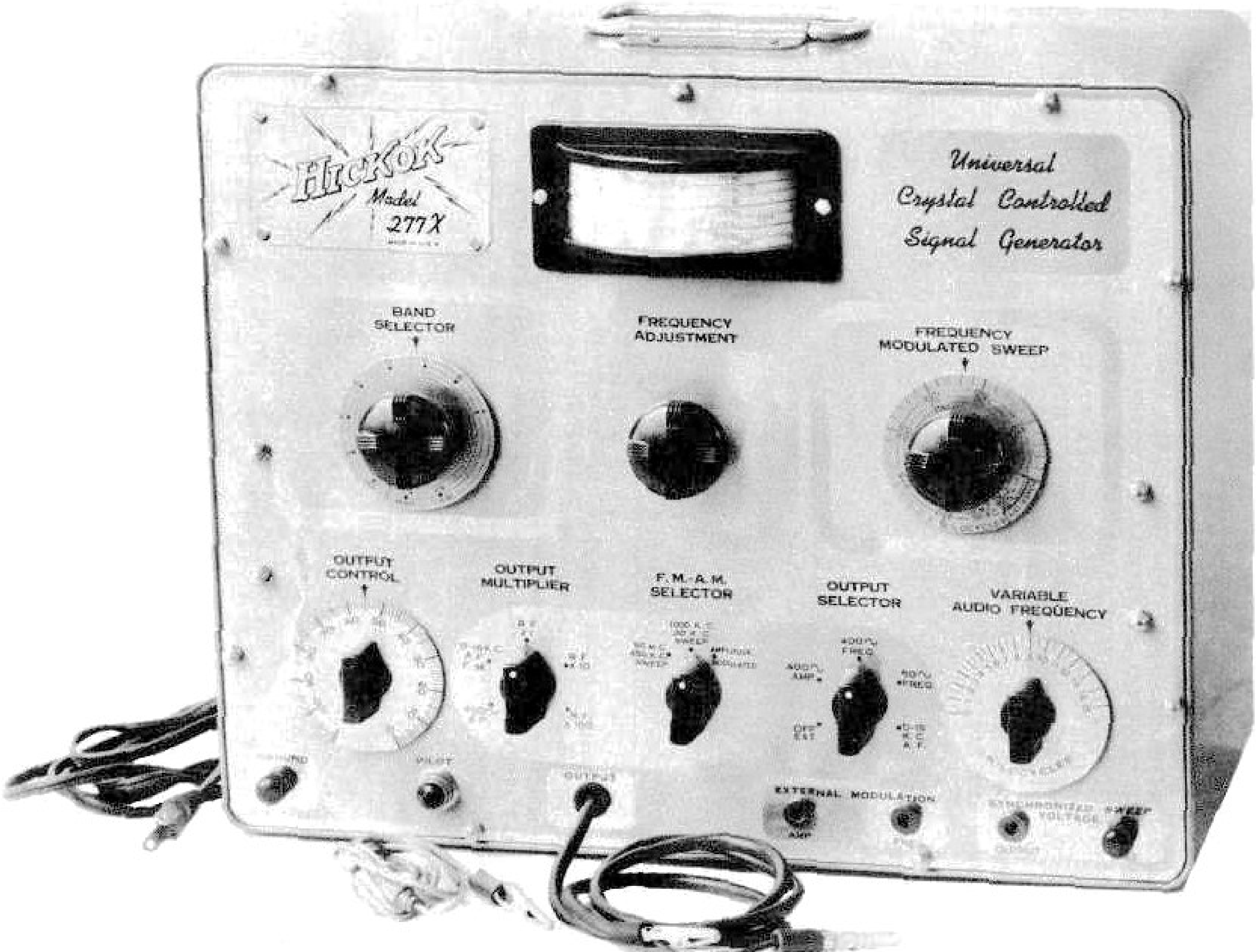
Synchronized Sweep Voltage: For horizontal deflection of oscillograph (60 cycle)

9. DB Meter Range: -10 to +6, +6 to +22, +22 to +38, Model 288X only.

10. Tube Complement:

	TUBE	STOCK NO.	FUNCTION
V1	6C4	20875-62	Main variable r-f oscillator
V2	6SN7GT	20875-19	Crystal oscillator and cathode follower
V3	6SN7GT	20875-19	Frequency modulated oscillator and mixer
V4	6SJ7GT	20875-17	Negative resistance oscillator, 400 cycle, fixed, and 0-15 kc, variable, a-f
V5	6X5GT	20875-22	Full-wave rectifier
V6	6SG7	20875-63	Reactance control tube
	#40	12270-5	Pilot lamp

V111



UNIVERSAL CRYSTAL CONTROLLED SIGNAL GENERATOR MODEL 277X

SECTION I DESCRIPTION

1.1 GENERAL

a. The Universal Crystal Controlled Signal Generator is manufactured as follows:

1. Model 288X with crystal control and decibel meter.

2. Model 277X with crystal control but without the decibel meter.

3. Model 277 with neither crystal control nor decibel meter. The crystal can be easily installed later, however, as these units are completely wired for crystal operation.

b. As this instruction book is written for the unit with both the crystal control and the meter, it may be used for all of the units.

1.2 PURPOSE

These Universal Crystal Controlled Signal Generators are specifically designed to meet the many and varied needs of the radio engineer and service man working with frequency and amplitude modulated receivers and with television equipment. The wide range in radio-frequencies and audio-frequencies available, with the many choices of type of modulation makes these models most versatile and practical instruments. There are minor differences in the models but, in general, they may be used for the same purposes.

1.3 BRIEF DESCRIPTION

a. Physical

The Model 288X, with decibel meter and crystal, is illustrated in Figure 1.1. The Model 277X is shown on Page viii, the difference in appearance due to the omission of the decibel meter from the panel. The Model 277 is similar in appearance to the Model 277X. The panel is satin-smooth finished and the case has blue hammertex finish with louvres in the back for cooling and a handle at the top for carrying. Four blister feet are furnished on both the bottom and the back so that the instrument may be conveniently used in either a horizontal or vertical position. All panel controls scales and connectors are clearly marked.

b. Functional

The Models 288X, 277X and 277 will perform the following electrical functions (which will be modified by the omission of the crystal or meter):

1. Produce frequency modulated signal - variable with respect to bandwidth, frequency and output level - for testing and alignment of frequency modulated receivers, amplitude modulated receivers and television equipment.

2. Produce amplitude modulated signal - variable with respect to frequency and output level - for testing and alignment of amplitude modulated receivers and other electronic devices requiring a wide range in amplitude modulated signal.

3. Produce an audio frequency signal - variable with respect to frequency and output level - for testing audio amplifiers and speakers.

4. Produce an accurate crystal controlled signal of 100 kc or 1000 kc - amplitude modulated or unmodulated. When the harmonics are utilized it is especially adaptable for easily checking dial calibration of the receivers. (Models 288X and 277X only).

5. Indicate and measure voltage and power outputs by means of the self-incorporated decibel meter. (Model 288X only).

c. Electrical

The basic circuit of a Model 288X is shown in block diagram form in Figure 1.2. The circuit will be explained more fully in Section II, Theory.

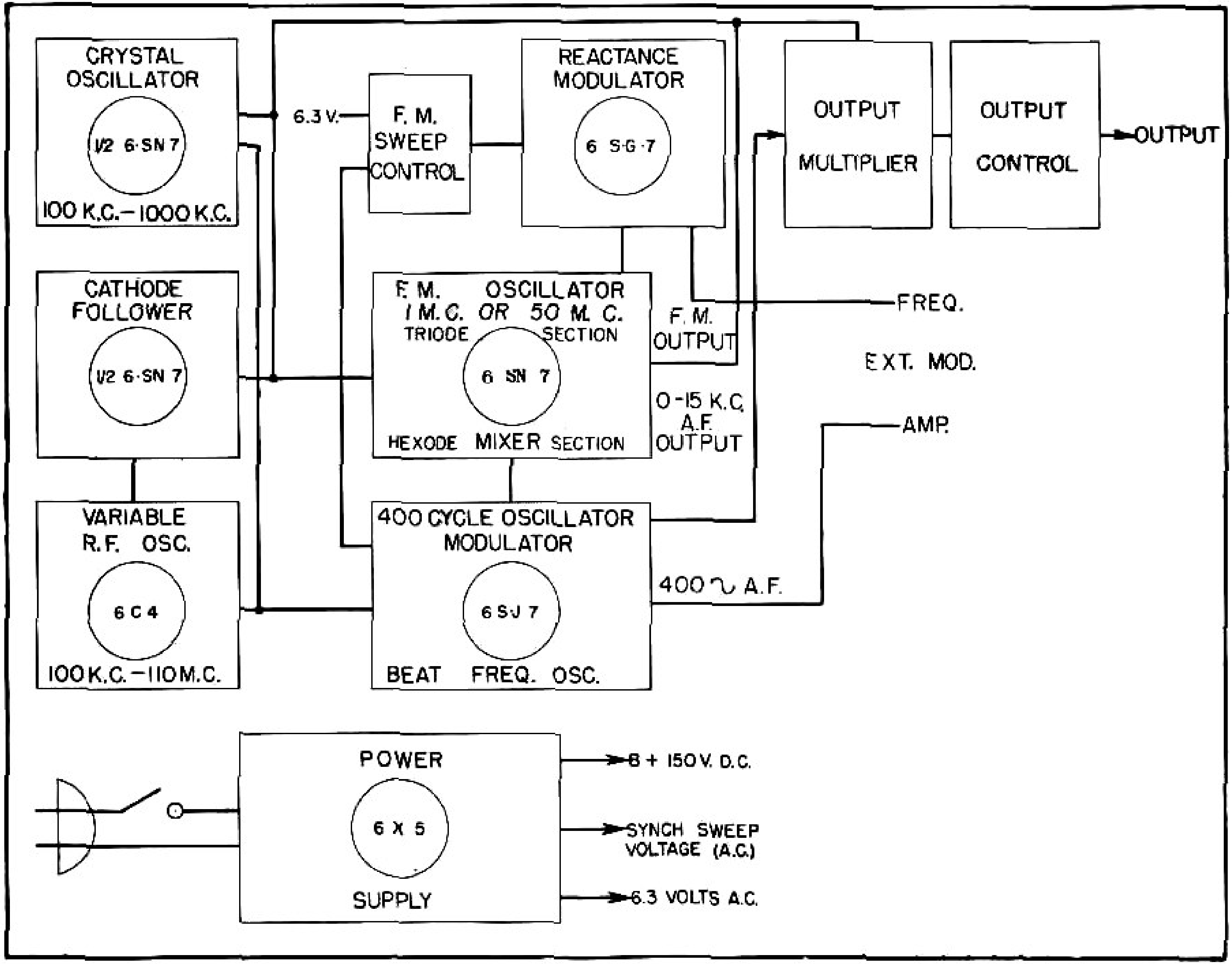


Figure 1.2 - Basic Circuit, Block Diagram, Model 288X

d. Components

The output lead and a-c power line are permanently attached to the signal generator. A red, unshielded lead, 42" long, with an alligator clip on one end and a pin tip on the other is furnished for the decibel meter. This lead is shown in Figure 1.3.

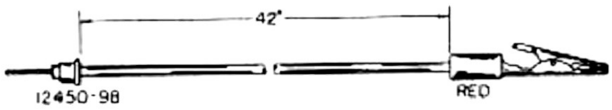


Figure 1.3 - Test Lead

SECTION II THEORY

2.1 GENERAL

A thorough understanding of the theory of the operation of any instrument will enable the user to obtain greater utility and satisfaction from the instrument. For this reason the following brief explanation of the Hickok Signal Generators, Models 288X, 277X and 277 is given. The discussion of the decibel meter pertains only to the Model 288X and the discussion of the crystal controlled oscillator does not pertain to the Model 277, but in all other respects the three models are electrically identical.

2.2 POWER SUPPLY

The power supply shown in Figure 2.1, is the conventional type power supply operating, normally, from a 105-125 V, 60 cycle a-c power supply line. The primary of power transformer, T2, as shown, is wired in parallel, for 115 volt operation but, if desired, it may be wired in series for 230 volt operation. Each side of the primary of the transformer is bypassed to ground through C33 and C34 which serve as a filter for the radio frequency to prevent its leakage back through the power supply main. The high voltage secondary winding is center-tapped to ground and supplies approximately +175 volts from each side of the winding to ground. A 6.3 volt winding, one side of which is at ground, supplies the heater voltage for all tubes. The rectifier tube, V5, type 6K5GT, and the filter network are conventional and supply approximately 150 volts d-c at approximately 35 mils.

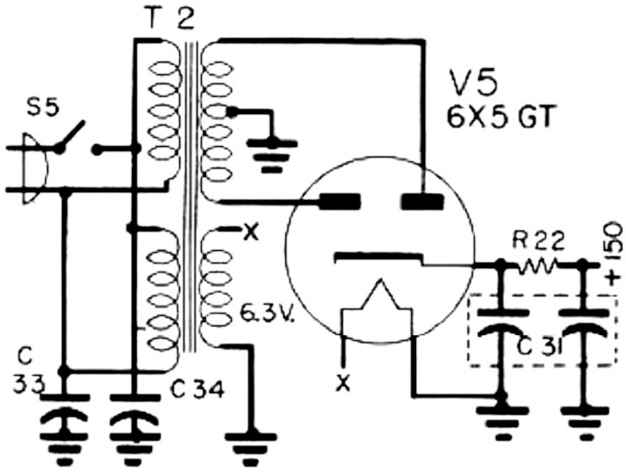


Figure 2.1 - Power Supply

2.3 RF MAIN VARIABLE OSCILLATOR

The main variable oscillator, shown in Figure 2.2, covers a frequency range of 100 kc to 110 mc, in seven bands. It consists of a type 6C4 miniature ultra-high frequency oscillator tube used in a shunted Colpitts type oscillator circuit with tuning accomplished by means of a split stator variable air condenser, C6, together with seven coils, L2 - L8, inclusive. The first six of these coils are trimmed for capacity by means of trimmer condensers C7 - C12, and also permeability tuned for inductance by means of powdered iron core tuning slugs, The output of the oscillator is taken through capacitor C17 to the grid of the cathode follower, V2.

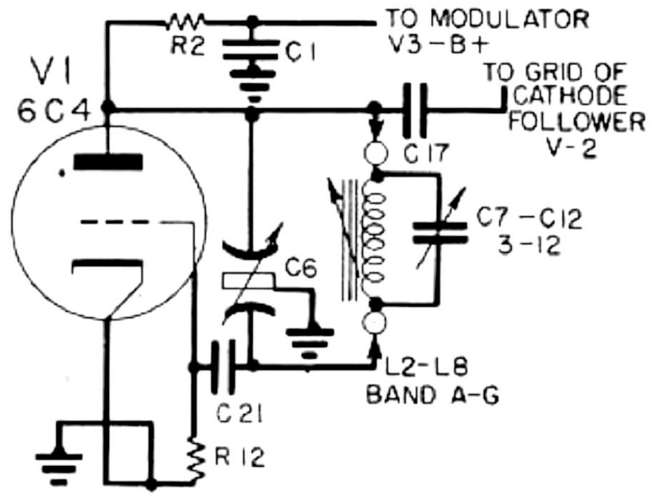


Figure 2.2 - RF Main Variable Oscillator

2.4 CATHODE FOLLOWER

The purpose of a cathode follower, shown in Figure 2.3, is to effect a high impedance input with a light loading effect on the circuit to which it is connected with a relatively low impedance output without appreciably sacrificing or losing voltage in the cathode follower stage. The output of the main variable oscillator is fed to the cathode follower input circuit, consisting of coupling condenser C17, the grid of the cathode follower tube, V2, type 6SN7, and grid resistor R13, which presents a high impedance to the oscillator and, therefore, prevents loading from a capacitive or resistive stand-point. The output of the cathode follower, taken through capacitor C23, is at essentially the same voltage as that applied to the grid, however, it is delivered at a very low impedance. This has the advantage that the output voltage can be made almost independent of the load to which it is connected.

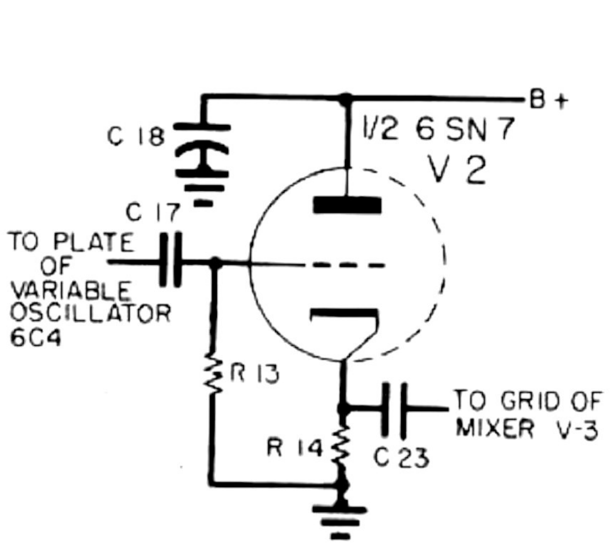


Figure 2.3 - Cathode Follower

2.5 400~ MODULATOR - BEAT FREQUENCY OSCILLATOR

As shown in Figure 2.4, the type 6SJ7 tube, V4, is used in a negative resistance oscillator circuit to generate either 400 cycle audio frequency or approximately 160 kc radio frequency. The primary of transformer T1 is tuned to 400 cycle audio frequency by means of capacitor C38. Inductance L9 is tuned to 160 kc r-f by means of capacitor C14. When used as a 400 cycle audio frequency oscillator, the output of this oscillator is used to modulate either the main variable oscillator at 400 cycles, at approximately 30% modulation, or it may be used to modulate the wide band frequency modulated oscillator, bandwidth variable 0-150 kc. When used as a radio frequency oscillator, at 160 kc, the output of this oscillator is heterodyned in the 6SN7 mixer, V3, circuit with the main variable oscillator. Condenser C14, carrying the calibration dial, 0-15 KILOCYCLES, in effect varies the frequency of the r-f oscillator so that the mixed output will be a variable audio frequency from 0-15 kilocycles.

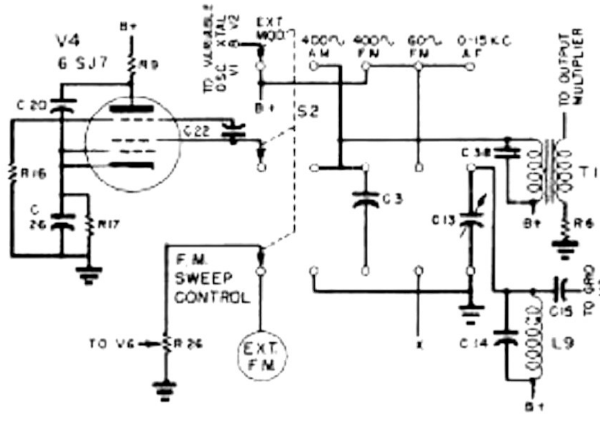


Figure 2.4 - 400~Modulator - Beat Frequency Oscillator

2.6 FM OSCILLATOR - MIXER

a. An illustration of the generation of frequency modulation is shown in Figure 2.5. The main characteristic of a frequency modulated signal is that the frequency is constantly changing while the output voltage remains constant. Starting at the fundamental frequency, the frequency gradually increases to its maximum, decreases through the fundamental to its minimum and then returns to the fundamental frequency, completing the cycle. The maximum and minimum frequencies are determined by the bandwidth of the f-m oscillator. In the illustrated case, the bandwidth is 15 kc either side of the fundamental 1000 kc. In the Universal Crystal Controlled Signal Generators the bandwidth may be either 0-30 kc, 0-150 kc or 0-450 kc. The rate at which the cycle is completed may also be variable. In these models the rate is either 60 or 400 cycles.

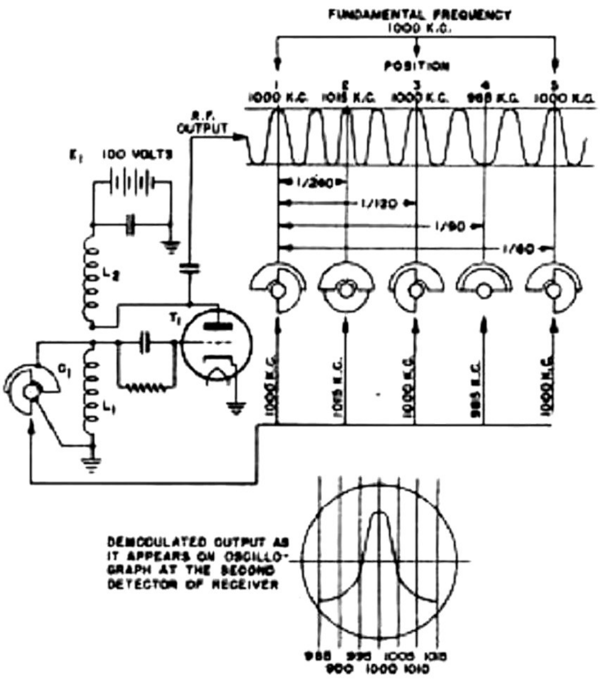


Figure 2.5 - Frequency Modulation

b. As shown in Figure 2.6, one half of the type 6SN7 tube, V3, is used as a triode r-f oscillator to operate at either 1 mc, when utilizing inductance L10, or at 50 mc, when utilizing inductance L11. Either of these signals may be frequency modulated by means of the type 6SG7 reactance tube, V6. The 6SG7 circuit is the electronic equivalent of the mechanically operated variable capacitor of the circuit given in Figure 2.5. The control of the band width of frequency modulation is the potentiometer R26. In the case of the narrow band f-m oscillator (1 mc), the sweep may be varied from 0-30 kc, utilizing 60 cycle modulating frequency. When using the wide band f-m oscillator (50 mc) the sweep may be varied from 0-450 kc utilizing 60 cycle modulation or 0-150 kc utilizing 400 cycle modulation. The oscillator can also be externally modulated. The remaining section of the 6SN7, V3 is used as a mixer stage to hetrodyne either the 1 mc or 50 mc frequency modulated signal with the signal from the main variable oscillator, V1, 6C4, thereby resulting in a variable frequency modulated output covering a range between 100 kc to 160 mc.

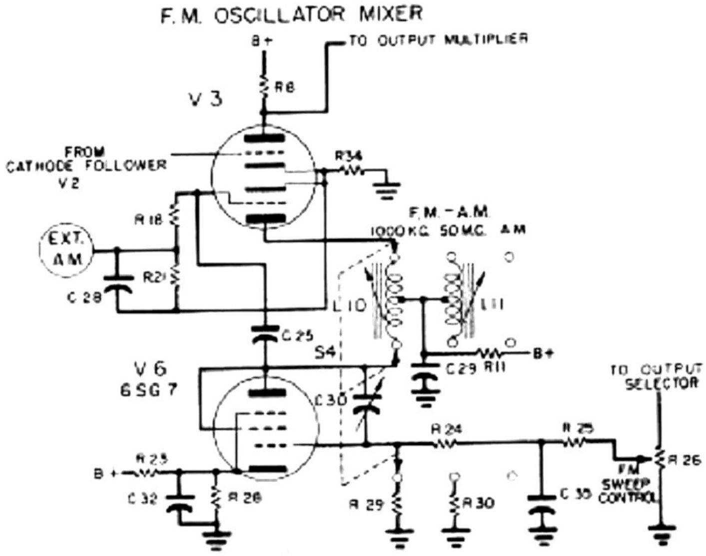


Figure 2.6 FM Oscillator - Mixer

2.7 CRYSTAL OSCILLATOR

A dual frequency crystal oscillator is incorporated, utilizing one-half of a type 6SN7 tube, V2, as shown in Figure

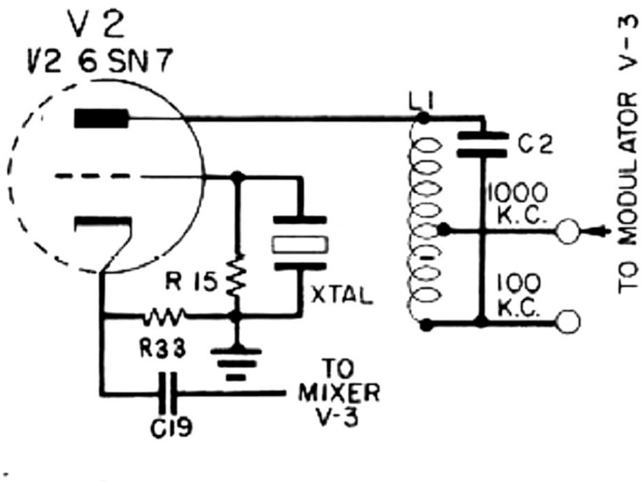


Figure 2.7 - Crystal Oscillator

2.7, to provide output frequencies of either 100 kc or 1000 kc. The crystal is maintained in the grid circuit at all times with B+ voltage from the modulator tube, V3, fed in at either the 100 kc or 1000 kc position of L1. The crystal controlled output voltage is fed to the OUTPUT MULTIPLIER network.

2.8 OUTPUT MULTIPLIER

As shown in Figure 2.8, the output multiplier circuit of the Model 288X consists of a two section, five position switch and associated components, including the potentiometer control, R4, OUTPUT. In the 400 cycle A-F position, the output from the secondary winding of the audio frequency transformer, T1, is fed directly to the OUTPUT control and then to the output cable. The 0-15 KC AF FM position connects the output from the plate of the mixer tube, V3, to the OUTPUT control directly, and then to the output cable. In positions RF X1, X10 and X100, the output is attenuated, by means of an attenuator network before appearing at the output cable.

2.9 DECIBEL METER

The decibel meter, shown in Figure 2.9, consists of a conventional copper oxide rectifier meter and its associated circuit. The meter may be used to measure output voltages ranging from 0 to 140 volts or decibel power levels ranging from -10 db to + 38 db. As the db meter scale is calibrated on the basis of 0 db = .006 watts (6mw) when used across a 500 ohm termination, the voltage readings and db readings correspond only when the meter is connected across a 500 ohm termination. There is a blocking condenser in the decibel meter circuit which permits its use in circuits having a d-c component. The frequency characteristics of the decibel meter are such that negligible error will be encountered throughout the audio frequency spectrum to approximately 20,000 cycles.

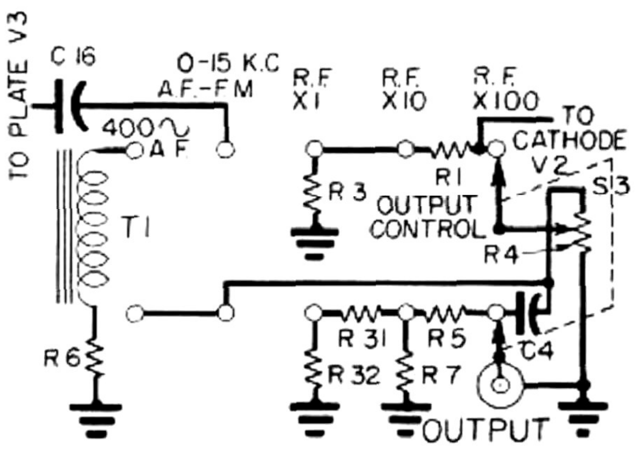


Figure 2.8 - Output Multiplier

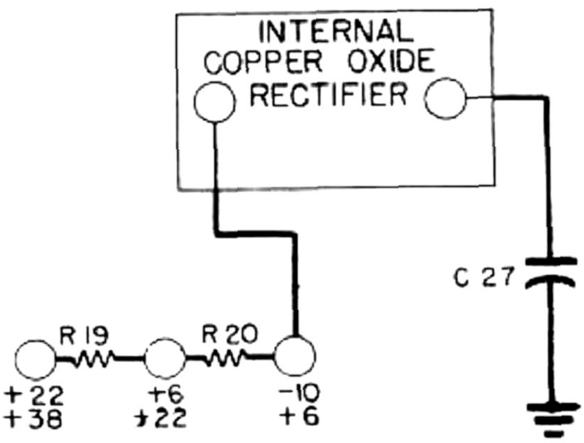


Figure 2.9 - Decibel Meter

SECTION III OPERATION

3.1 CONTROLS AND THEIR FUNCTIONS

a. The location of the controls of the Model 288X is shown in Figure 3.1 and a brief explanation of their function is given in subsequent paragraphs to facilitate their use in obtaining the desired output.

b. FREQUENCY MODULATED SWEEP - a dual purpose control which is used as the a-c line power switch and also as a control of the bandwidth of the sweep for frequency modulated output. To place the instrument in operation, turn the control clockwise until the line switch is closed which will be indicated by an audible click and the lighting of the pilot light. The position of this control, when not operating as a bandwidth sweep control, has no effect on the operation of the equipment.

c. BAND SELECTOR - A ten-position control: the first seven position, Bands A through G, select various frequency ranges from 100 kc to 110 mc, the next two positions select either the 100 KC or 1000 KC crystal frequency and the last position selects the 0-15 KC audio frequency.

d. FREQUENCY ADJUSTMENT - Control of the frequency within the range selected by the BAND SELECTOR switch. Calibration of the dial permits interpolation of the scale if desired.

e. OUTPUT CONTROL - Linear potentiometer control of the r-f and a-f output voltage of the signal generator.

f. OUTPUT MULTIPLIER - A five-position control of the output of the signal generator. Positions RF X1, RF X10 and RF X100 are the three output levels of r-f signal. Position 0-15 KC AF FM, in conjunction with the OUTPUT SELECTOR switch, selects either the 0-15 kc audio frequency output or any of the frequency modulated outputs. Position 400~ AF selects the 400 cycle, fixed, audio frequency output as an audio signal or for amplitude modulation.

g. FM - AM SELECTOR - A three position control:

1. AMPLITUDE MODULATED for all outputs other than frequency modulated outputs.

2. 1000 KC 30 KC SWEEP for the 1000 kc signal frequency modulated with a bandwidth of 0-30 kc.

3. 50 MC 450 KC SWEEP for the 50 mc signal frequency modulated with a bandwidth of either 0-150 kc or 0-450 kc.

h. OUTPUT SELECTOR - A five-position switch selecting the various types of outputs.

1. OFF EXT for unmodulated radio frequency output or either frequency or amplitude modulation from an external source.

2. 400~ AMP for 400 cycle amplitude modulation and for 400 cycle, fixed, audio frequency signal.

3. 400~ FREQ for 400 cycle modulating frequency used for frequency modulating the 50 mc, 0-150 kc sweep output.

4. 60~ FREQ for 60 cycle modulating frequency used for frequency modulating either the 1000 kc, 0-30 kc sweep, or 50 mc, 0-450 kc sweep, output.

5. 0-15 KC AF for an audio frequency variable 0-15 kc.

i. VARIABLE AUDIO FREQUENCY - a calibrated variable control of the audio frequency output from 0 to 15 kilocycles.

j. SYNCHRONIZED SWEEP VOLTAGE (Gnd-Output) (To be used in conjunction with cathode ray equipment) - Output connections for a 60 cycle voltage from the power supply for supplying the horizontal sweep of an oscillograph.

k. EXTERNAL MODULATION (Amp-Freq) - AMP: connection permitting amplitude modulation from an external source; FREQ: connection permitting frequency modulation from an external source.

l. PILOT - Indication of power being supplied the signal generator.

m. OUTPUT - Attached shielded output cable for the output signal.

n. DECIBEL METER (-10 to +6, +6 to +22, +22 to +38) - pin jacks for connection to the combination a-c voltmeter and decibel meter at one of the three ranges available.

o. GROUND - Binding post for connecting the ground of the signal generator

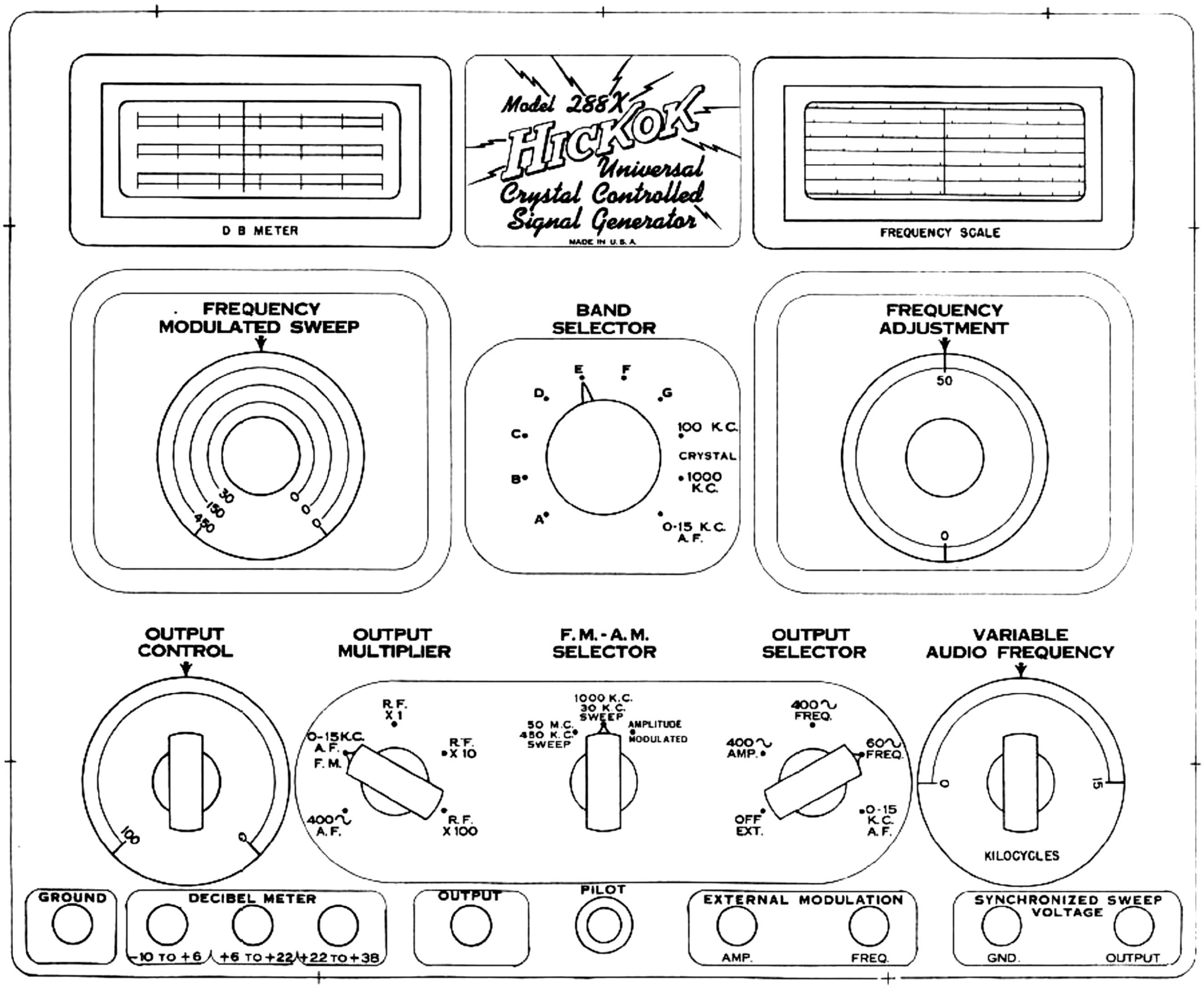


Figure 3.1 - Panel View, Model 288X

SIGNAL OUTPUT *See Note 4	FREQ MOD SWEEP	OUTPUT SELECTOR	BAND SELECTOR	FREQUENCY ADJUSTMENT	OUTPUT CONTROL	OUTPUT MULTIPLIER	FM-AM SELECTOR	VARIABLE AUDIO FREQUENCY
1. Unmodulated RF 100 KC - 110 MC	Power ON	OFF EXT	Desired frequency range	Desired frequency	Adjust control for the desired output level	Desired RF multiplying factor	AMPLITUDE MODULATED	Control may be left in any position except when Audio Frequency 0-15 KC output is desired, then setting of control will be dependent upon the audio frequency desired, 0-15 KC.
2. Amplitude Modulated RF 100 KC - 110 MC								
a. 400~, Fixed	Power ON	400~ AMP	Desired frequency range	Desired frequency		Desired RF multiplying factor	AMPLITUDE MODULATED	
b. Externally Modulated	Power ON	OFF EXT	Desired frequency range	Desired frequency		0-15 KC AF FM	AMPLITUDE MODULATED	
3. Frequency Modulated RF 100 KC - 110 MC								
a. 1000 KC, 0-30 KC Sweep	Power ON, 0-30	60~ FREQ	Desired frequency range. See NOTE 1	Desired frequency. See NOTE 1		0-15 KC AF FM	1000 KC 30 KC SWEEP	
b. 50 MC, 0-150 KC Sweep	Power ON, 0-150	400~ FREQ	Desired frequency range. See NOTE 2	Desired frequency. See NOTE 2		0-15 KC AF FM	50 MC 450 KC SWEEP	
c. 50 MC, 0-450 KC Sweep	Power ON, 0-450	60~ FREQ	Desired frequency range. See NOTE 2	Desired frequency. See NOTE 2		0-15 KC AF FM	50 MC 450 KC SWEEP	
d. 50 MC, Externally Modulated 0-15 KC Sweep	Power ON	OFF EXT	Desired frequency range. See NOTE 2	Desired frequency. See NOTE 2		0-15 KC AF FM	50 MC 450 KC SWEEP	
4. Audio Frequency, 0-15 KC	Power ON	0-15 KC AF	0-15 KC AF	See NOTE 3		0-15 KC AF FM	AMPLITUDE MODULATED	
5. Audio Frequency, 400~, Fixed	Power ON	400~AMP	Any position	Any position		400~AF	AMPLITUDE MODULATED	
6. Frequency Modulated AF 0-30 KC Sweep	Power ON, 15	60~ FREQ	C	985 or 1015 kc		0-15 KC AF FM	1000 KC 30 KC SWEEP	
7. Crystal Controlled Frequency								
a. 100 KC, Unmodulated	Power ON	OFF EXT	100 KC	Any Position		Desired RF multiplying factor	AMPLITUDE MODULATED	
b. 100 KC, Modulated	Power ON	400~ AMP	100 KC	Any Position		Desired RF multiplying factor	AMPLITUDE MODULATED	
c. 1000 KC, Unmodulated	Power ON	OFF EXT	1000 KC	Any Position		Desired RF multiplying factor	AMPLITUDE MODULATED	
d. 1000 KC, Modulated	Power ON	400~ AMP	1000 KC	Any Position		Desired RF multiplying factor	AMPLITUDE MODULATED	

NOTE 1: This frequency will be the frequency which is either the sum or difference of 1000 kc and the desired frequency. I.e., for 456 kc, i-f alignment, this frequency is either 1456 kc or 544 kc.

NOTE 2: This frequency will be the frequency which is either the sum or difference of 50 mc and the desired frequency. I.e., for 3 mc i-f alignment, this frequency is either 47 mc or 53 mc.

NOTE 3: This will be at approximately 170 kc, A Band. Adjustment should be made so zero beat is obtained with the VARIABLE AUDIO FREQUENCY control at 0 position.

NOTE 4: For connections of the Decibel Meter for any given test see Chart 1, page 15.

to that of any associated equipment; also is the ground connection for the DECIBEL METER.

3.2 OPERATION CHART

a. The operation chart indicates the proper setting for each control in order to obtain a given output. The sequence of operation is from left to right.

b. The generator normally operates from a 105-125 volt, 60 cycle, a-c power source, unless especially wired otherwise. As several minutes are required for the tubes to come up to stable operating temperatures and as the equipment draws only 20 watts, it is recommended that it be left on if it is to be used frequently throughout the day.

CAUTION

Do not connect the output of the signal generator across any source of appreciable voltage, either a-c or d-c. The internal resistance of the output network is very low and the application of an external voltage might damage the resistors in this network. If it is necessary to connect the output of the generator across a source of a-c or d-c voltage, a series condenser should be connected between the red output clip and the point at which the output voltage is being applied.

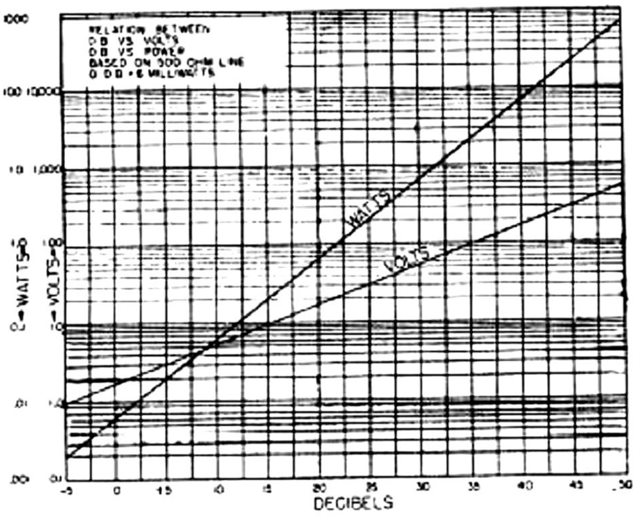


Figure 3.2 - DB-Voltage Conversion Chart

3.3 DECIBEL METER

ALWAYS start with the decibel meter connected at the highest range if the decibel level or the voltage to be measured is not known as this will minimize the possibility of damaging the meter due to overload.

a. Connect from the pin jack of the proper range to the equipment under test, using the GROUND binding post as the ground of the meter circuit.

b. Read the decibel level from the upper scale or the a-c voltage from the lower scale of the meter. A conversion chart, which evaluates the decibel or voltage reading in terms of power is given in Figure 3.2. When the termination is other than a 500 ohm termination, use the correction factor chart given in Figure 3.3.

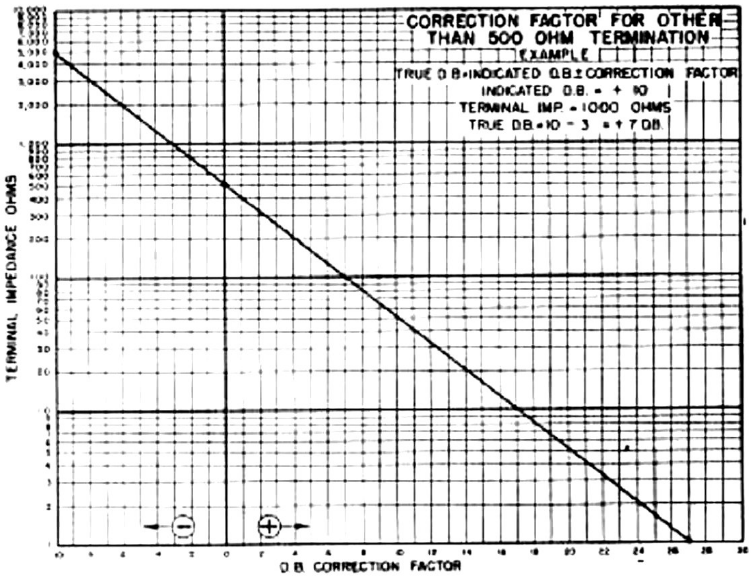


Figure 3.3- Correction Factor for Other Than 500 Ohm Termination

c. The decibel or voltage value may be easily converted to a power reading by simply locating the known value on the correct curve and determining the associated power reading. The decibel meter is calibrated in terms of a matching load of 500 ohms. If the load across which measurement is to be made is other than 500 ohms, a correction factor is needed. The correction factor chart, shown in Figure 3.3, will enable the user to determine this factor in terms of db.

4.1 GENERAL

In general, all of the models may be used for the same purpose. Should the Model 277X be purchased, a voltmeter may be used, in many cases, to replace the decibel meter. As the applications indicated here are general in nature, the specifications of the manufacturer should be consulted in making all tests. A basic circuit diagram of the seven tube amplitude modulated superheterodyne receiver which is referred to throughout the following discussions is shown in Figure 4.1. Frequency modulated receiver circuits have, in addition to the stages shown, limiter and discriminator (2nd detector) stages. (Frequency modulation is discussed in detail in Section II, Theory, Paragraph 2.6).

4.2 ALIGNMENT OF RADIO RECEIVERS (Broadcast Band)

a. I-F Alignment

1. Some intermediate frequency stages are tuned by means of trimmer condensers and others by means of variable powdered-iron core inductors. The object in i-f alignment is to adjust either until the maximum output is obtained as indicated by the indicating means used. This indicating means may be either vacuum tube voltmeter, decibel meter, a-c voltmeter, or oscilloscope in the case of amplitude modulated receivers but an oscilloscope should be used in the case of frequency modulated receivers.

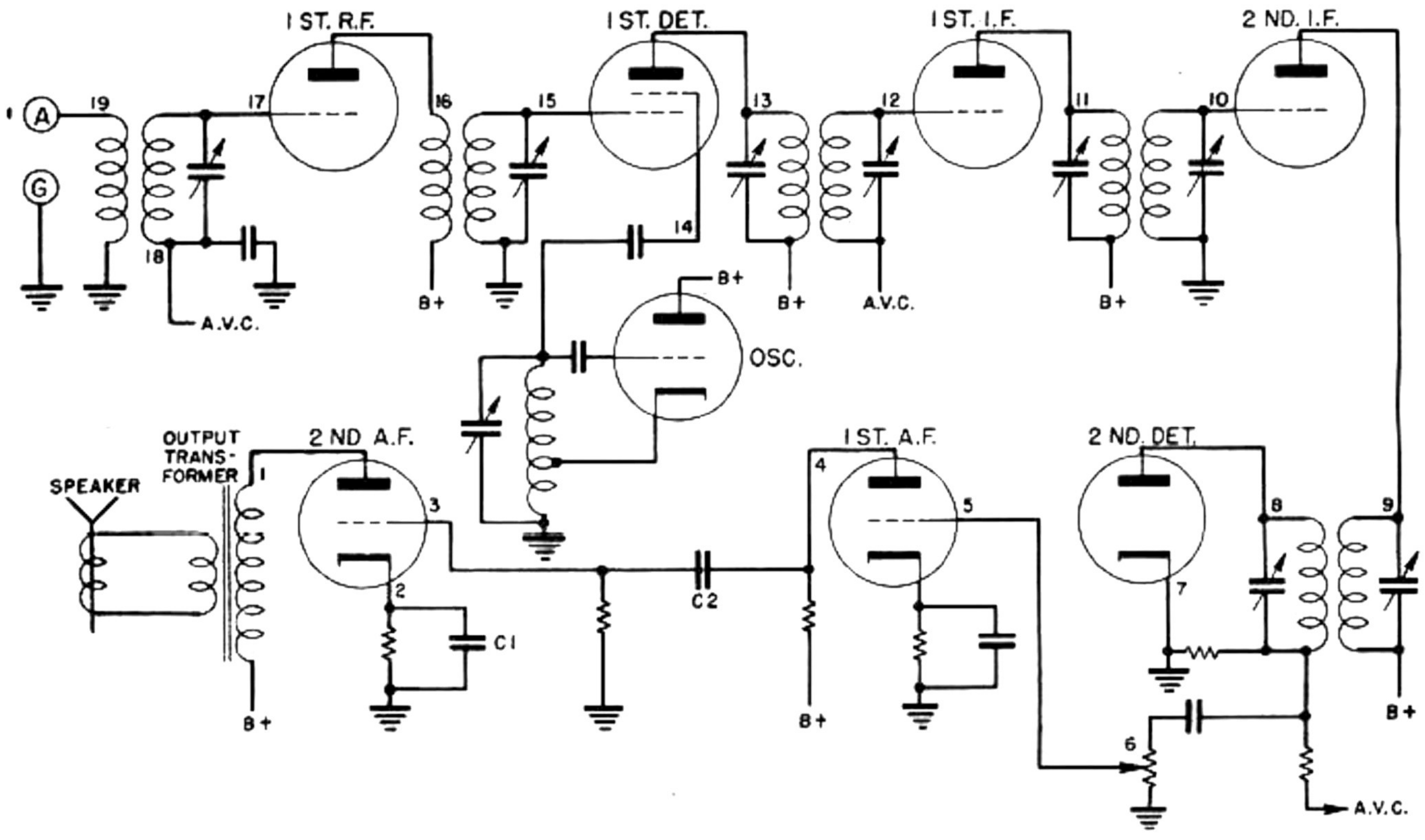


Figure 4.1 - Basic Circuit, Superheterodyne Receiver

2. Feed the output of the signal generator, tuned to the proper i-f frequency (determined from manufacturer's specifications), in accordance with Chart 1. In most cases, a blocking condenser should be connected between the output lead of the signal generator and the receiver to prevent a direct current path back to ground which might short out the automatic volume control voltages applied to the control grid as this could cause misalignment.

3. Using the output indicator and connections shown in Chart 1, Page 15, adjust the trimmer condensers or the iron cores of the inductors for correct alignment.

NOTE: To prevent the possibility of automatic volume control action interferring with correct alignment, use the lowest possible signal level which will give a satisfactory indication of the meter. When making an alignment of receivers that have provision for varying the selectivity of the intermediate frequency stages, turn the selectivity control to the maximum position before making alignment.

b. Oscillator Alignment.

1. All superheterodyne type of receivers have a local oscillator which operates, in most cases, at a frequency which is the sum of the receiver intermediate frequency and the frequency for which the receiver is tuned. In ultra-short wave receivers, however, the oscillator may operate at a frequency which is the difference of the two frequencies. This local oscillator heterodynes with the received signal to produce the intermediate frequency of the receiver.

2. Many oscillators, especially those in the more elaborate receivers, have provisions for tracking the oscillator with the main tuning dial, both at the low and high end of the band. The oscillator is generally tracked at the low end by means of a padder condenser or variable iron core of the oscillator tank coil. The high frequency end of the band is always tracked by means of a trimmer condenser generally connected directly across the oscillator coil or the tuning condenser.

3. Alighment of the oscillator should be started at the low frequency end of the band if provisions are made for tracking at that end.

4. Set the signal generator to produce the desired frequency and tune the receiver to the same frequency. The frequency and connection of the indicating medium is indicated in Chart 1. Make adjustment of the padder condenser or the iron core until correct alignment is obtained.

c. RF Alignment

1. Most receivers, except those of the communication type, have no provisions for tracking the r-f stages at the low frequency end of the dial and, therefore, alignment of the r-f stages are made only at the high frequency end of the dial. In the case of broadcast receivers, this is in the vicinity of 1500 kc. Alignment of r-f stages may be made with the signal either variable r-f or a harmonic of the crystal controlled oscillator. The general procedure is as follows:

(a) Set the signal generator to produce the frequency at the upper end of the band, approximately 1500 kc for broadcast receivers.

(b) Tune the receiver to this frequency.

(c) Connect the indicating means as shown in Chart 1 then adjust the trimmer condensers on the r-f stages for maximum output as indicated by the meter.

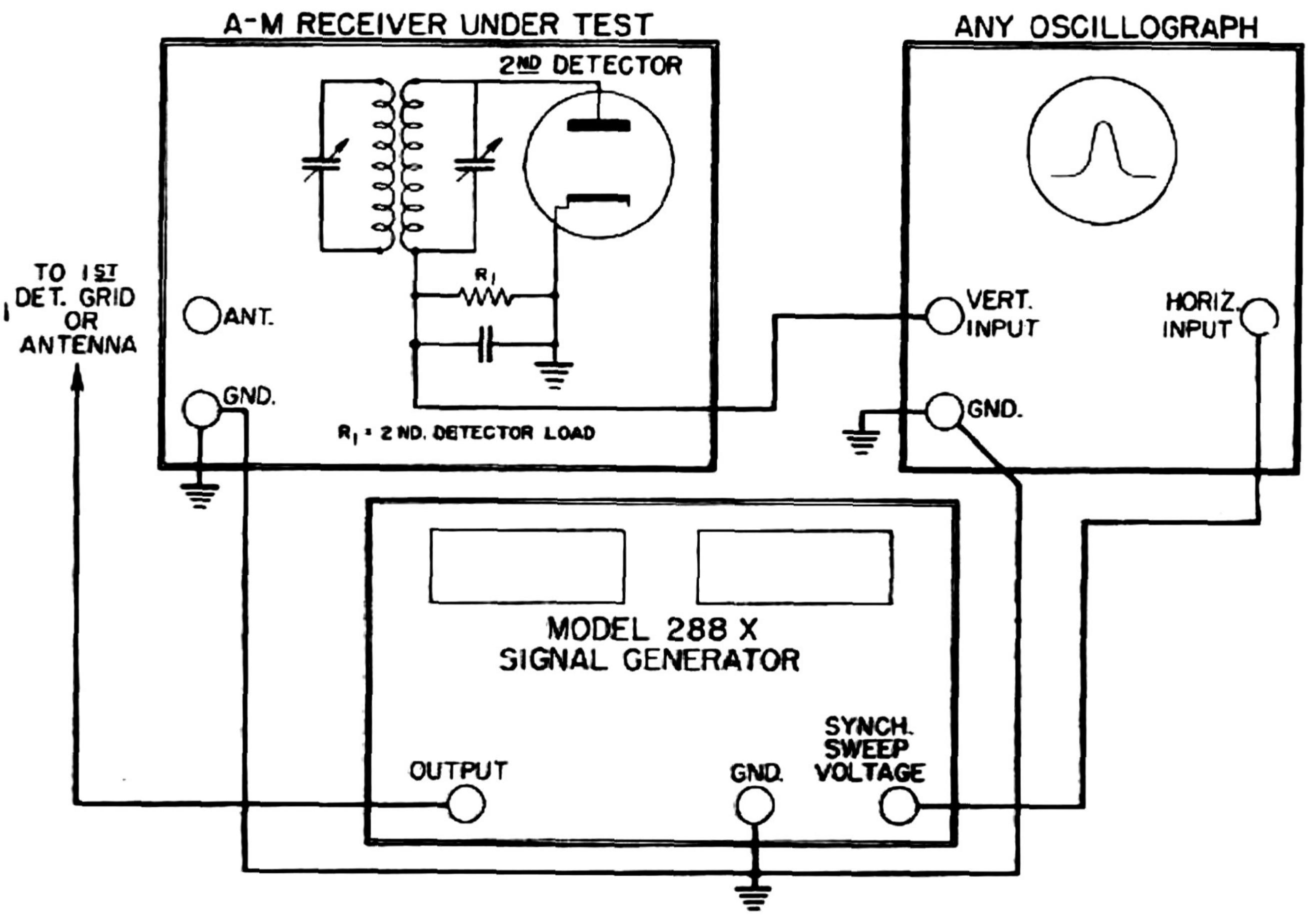


Figure 4.2 - Interconnections for Alignment

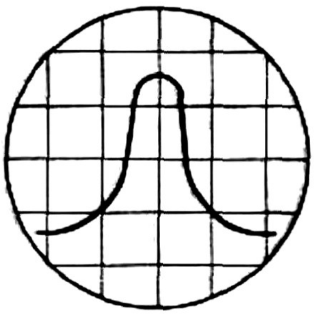


FIG. 4.4

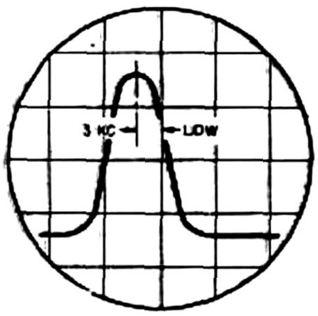


FIG. 4.5

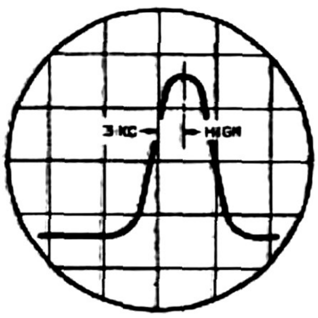


FIG. 4.6

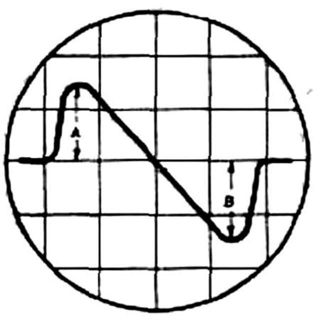


FIG. 4.7

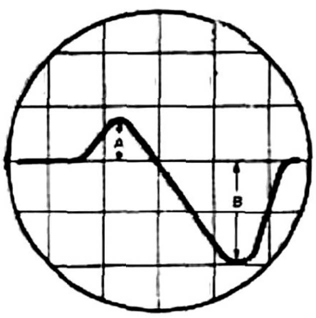


FIG. 4.8

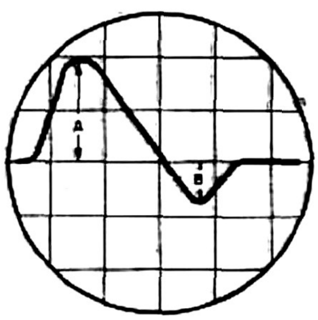


FIG. 4.9

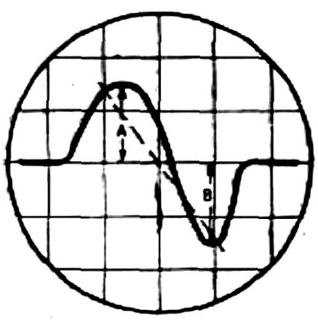


FIG. 4.10

Figure 4.4 - Correct Alignment, Any Stage
Figure 4.5 - Correct Alignment, Any Stage, Tuned Below Proper Frequency
Figure 4.6 - Correct Alignment, Any Stage, Tuned Above Proper Frequency
Figure 4.7 - Discriminator Transformer, Correct Alignment
Figure 4.8 - 4.9 - Discriminator Transformer, C2, Improperly Adjusted,
$A = E_{R2}$ $B = E_{R3}$
Figure 4.10 - Discriminator Transformer, Secondary Correctly Aligned, Primary incorrectly Aligned

ALIGNMENT CHART FOR BROADCAST RECEIVERS (Chart I)

The following chart summarizes the alignment effected, the signals required, the indicating medium required, the points of connection for both, and the alignment adjustment necessary for the alignment of the stages of both amplitude and frequency modulated receivers. In conjunction with this chart, reference is made to the text for greater detail on the alignment to be made and to Figure 4.2 which shows the interconnections of the oscillograph, signal generator and the receiver. All points given are with reference to the basic circuit of the superheterodyne receiver, illustrated in Figure 4.1, and the discriminator circuit illustrated in Figure 4.3. The oscillograms which will be obtained when making alignment by means of the oscilloscope are shown in Figure 4.4 - 4.10.

Stage A-M	Freq.	Signal Type	Connect Signal Generator	Type Indicator	Connect Indicator	Align
A-M Receivers						
I-F	I-F	Unmod	1st det. Grid	VT VM	2nd det. load	I-F transformers
I-F	I-F	A-M 400	1st det. Grid	Db Meter	A-F stage	I-f transformers
I-F	I-F	F-M 30 kc sweep	1st det. Grid	Scope	2nd det. load	I-f trimmer, see Figures 4.4, 4.5
OSC	550 kc	Unmod	Ant.	VT VM	2nd det. load	Osc padder
OSC	1500 kc	Unmod	Ant.	VT VM	2nd det. load	Osc trimmer
OSC	550 kc	A-M 400	Ant.	Db Meter	A.F stage	Osc padder
OSC	1500 kc	A-M 400	Ant.	Db Meter	A.F stage	Osc trimmer
OSC	550 kc	F-M 30 kc sweep	Ant.	Scope	2nd det. load	Osc padder, see Figures 4.4, 4.6
OSC	1500 kc	F-M 30 kc sweep	Ant.	Scope	2nd det. load	Osc trimmer, see Figures 4.4, 4.6
RF	1500 kc	Unmod	Ant.	VT VM	2nd det. load	R-F Trimmers
RF	1500 kc	A-M 400	Ant.	Db Meter	A-F stage	R-F Trimmers
RF	1500 kc	F-M 30 kc sweep	Ant.	Scope	2nd det. load	Trimmers, see Figures 4.4, 4.6
F-M Receivers						
I-F	I-F	F-M 450 kc sweep	1st det. Grid	Scope	Limiter resistor, R1	I-f, see Figure 4.4
Disc-Pri	I-F	F-M 450 kc sweep	1st det. Grid	Scope	Disc load resistor, R2-R3	Disc pri-see Figures 4.7 - 4.10
Disc-sec	I-F I-F	F-M 450 kc Sweep	1st det. Grid	Scope	Disc load resistor R1-R3	Disc sec - see Figures 4.7 - 4.10
OSC	90 mc	F-M 450 kc sweep	Ant.	Scope	Disc Load resistor, R1-R3	Osc trimmer to center pattern, Fig. 4.7
OSC	106 mc	F-M 450 kc sweep	Ant.	Scope	Disc Load resistor, R1-R3	Check for Fig. 4.7

d. Limiter and Discriminator Alignment.

1. In frequency modulated receivers there is at least one, and sometimes two, limiter stages ahead of the discriminator (2nd detector) stage. See Figure 4.3. The general procedure for the alignment of frequency modulated receivers is similar to that for the alignment of amplitude modulated receivers except that, in the alignment of various stages, it is necessary to have either a sensitive microammeter, preferably zero-centered, a vacuum tube voltmeter, such as the Hickok Models 125, 203 or 110D, or cathode ray equipment such as the Hickok Model 305.

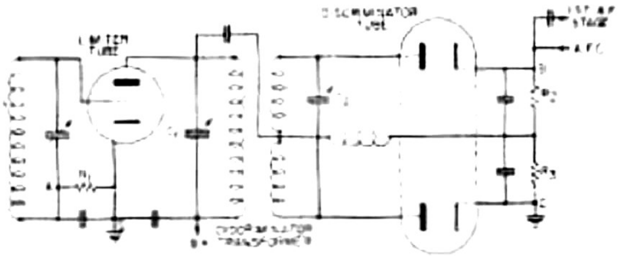


Figure 4.3 - Discriminator Circuit

2. Figure 4.3 illustrates a typical limiter and discriminator circuit. If no scope is available it will be necessary in the alignment of all i-f and r-f stages and the local oscillator preceding the limiter stage, to either disconnect the limiter load resistance, R1, from ground and insert a microammeter, or to connect a vacuum tube voltmeter across R1, and use either meter as an indicator of alignment of the preceding stages. The alignment procedure will be identical to that for amplitude modulated receivers.

3. To align the limiter (last i-f) stage, leave either the vacuum tube voltmeter or microammeter connected as for aligning preceding i-f stages, and adjust C7 until a maximum reading is indicated by the meter.

4. To align the primary of the discriminator transformer, connect the vacuum tube voltmeter across the output discriminator load, R3, or the microammeter in series with the load, R3, and adjust C1, for maximum indication of the meter.

5. To align the secondary of the discriminator transformer, connect the vacuum tube voltmeter across the entire load resistance, R2 and R3, or the microammeter in series with the load, and adjust C2. As C2 is adjusted, the voltage will change polarity, passing through zero. Correct alignment is indicated by zero voltage or zero current reading.

6. Figures 4.4 - 4.10 illustrate the types of traces to be expected when aligning the discriminator circuits by means of an oscilloscope. These figures are referred to in Chart 1.

4.3 CHECK OF A-F STAGES

a. Gain of 1st A-F Amplifier Stage -- All connections are made in reference to Figure 4.1. Connect the decibel meter either at the primary of the output transformer (point 1), or across the voice coil of the speaker, and feed a signal in at the grid of the audio frequency output stage (point 3). Note the reading of the indicating meter, and, maintaining the signal level constant, transfer the signal to the grid of the 1st A.F. (point 5). The gain of the stage can be calculated from the increase in the meter reading. If the tube is a triode, the gain may not exceed 10. However, if it is a pentode, the gain may be as high as 50 or 100.

b. Gain of 2nd A-F Amplifier Stage

1. If a sensitive voltmeter, such as the Hickok Model 203, is available the gain of the 2nd a-f amplifier stage may be determined. If an audio frequency output of the Model 288X is connected in at the grid (point 3) of the second audio frequency amplifier stage, and this stage operates normally, an appreciable signal should be heard at the speaker. The actual gain can be checked by connecting the indicating meter between the plate (point 1) and ground, and feeding a signal of known voltage (measured by the sensitive voltmeter) from the Model 288X in at the grid (point 3). The ratio of the output voltage to the input voltage will be a measure of the stage gain. This stage gain should normally vary between approximately 10 and 50, depending upon the type of tube being used.

4.4 USE OF CRYSTAL CONTROLLED OUTPUT

a. The alignment of the radio frequency stages and the oscillator stages of a receiver is greatly facilitated if the 100 kc or 1000 kc crystal controlled output of the Model 288X is used as the entire dial of the broadcast band can be checked every 100 kc or, in the case of short wave receivers, every 1000 kc, with a single setting of the crystal by simply tuning to the harmonics of the crystal controlled oscillator. In addition to the speed with which this enables the entire band to be checked and calibrated, the crystal accuracy, 0.01%, assures far more accurate results than can normally be obtained by using the continuously variable oscillator.

b. At frequencies over 3 or 4 megacycles, it is not advisable to use the 100 kc crystal for alignment as the harmonics are so close together that they might be wrongly identified and the receiver might be misaligned. This, however, would not be the case when using the 1000 kc crystal since, at these frequencies, its harmonics would be so widely separated that misalignment due to this cause would be practically impossible.

c. In cases where the receiver is badly out of line, it is possible that a wrongly identified harmonic will be tuned in. For example, the dial might be set for 600 kc but the receiver may be so far out of line that it would receive the 7th harmonic (700 kc) better than the 6th. If this error were not detected, the entire receiver would be misaligned. To preclude any possibility of such misalignment, check the receiver dial at 1000 kc using the 1000 kc crystal. It will be at the same position as the 10th harmonic of the 100 kc crystal. The next signal tuned in on the low side of the 10th harmonic position will be the 9th harmonic. This position can now be used as a reference point for the 8th harmonic, etc. This can be repeated in either direction from the 10th harmonic reference point.

d. The short-wave bands of the receiver may be aligned with the use of either the 100 kc crystal or the 1000 kc crystal, using the same general procedure.

4.5 FIDELITY MEASUREMENT

a. Fidelity is a quality of reproduction and is determined by a combination of two factors - electrical and tonal. The ear is the measuring stick for the tonal quality. The Model 288X is used to electrically check fidelity. The Model 288X is used to generate audio frequency output, 0-15 kc. With the use of an output indicator, a fidelity characteristic curve, as shown in Figure 4.11, may be obtained.

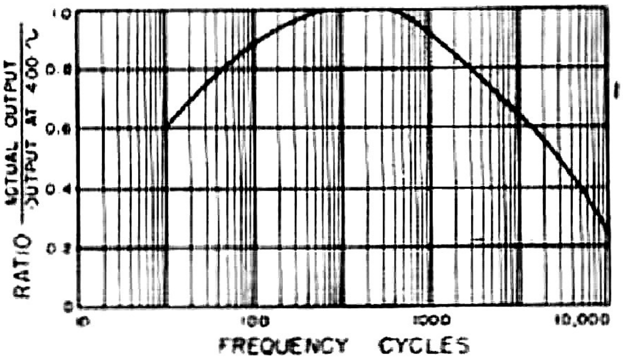


Figure 4.11 - Typical Receiver Fidelity Curve

b. To obtain the data necessary for a fidelity curve, proceed as follows:

1. Connect the decibel meter across the voice coil or across the equivalent non-inductive load substituted for it.

2. Connect the output of the Model 288X, adjust to produce 50 cycles to 15,000 kc, to the input a-f section of the receiver.

3. Adjust the a-f output level of the Model 288X until a convenient decibel meter reading is obtained with 400 cycles as the audio frequency. It is important that the a-f level delivered to the receiver under test be maintained constant.

4. Vary the frequency from approximately 50 cycles to approximately 10,000 cycles. Note the readings of the decibel meter, taking enough values to obtain sufficient data for a fidelity curve. If the decibel meter is not available, a similar curve would be obtained by plotting voltage readings instead of

decibel readings.

4.6 TROUBLE-SHOOTING IN RECEIVERS AND OTHER ELECTRONIC DEVICES

a. General - The Model 288X, when properly used, is a very valuable instrument for locating trouble in electronic devices. In the case of radio receivers it is advisable in locating faults, to start at the speaker or output stage and work back towards the antenna. All following information on trouble-shooting is with reference to the basic circuit of the superheterodyne receiver, illustrated in Figure 4.1.

b. Speaker - Permanent magnet types of speaker can be tested by connecting the audio frequency output from the Model 288X directly to the voice coil, and varying the frequency throughout the audio range.

c. Output Transformer - The output transformer can be checked by connecting the audio output of the Model 288X to the primary of the transformer being tested. Due to the step-down ratio of the transformer, very little signal will be obtained at the speaker during this check. Maximum signal output will be obtained at the frequency to which the transformer is tuned. It is imperative in making this test that a blocking condenser be inserted between the output lead and the connection to the transformer.

d. Cathode Bypass Condenser, 2nd A-F Amplifier - A check of the cathode bypass condenser, C1, can be made by connecting the decibel meter across this condenser and feeding a signal in at the grid of the tube. If the condenser is functioning normally, very little voltage should be developed between point 2 and ground. An open bypass condenser would result in a voltage between point 2 and ground equal, approximately, to the signal voltage being applied to the grid. The same would be true of the cathode bypass condenser of the 1st a-f amplifier.

e. Input Condenser - A check of the input coupling condenser, C2, can be made by feeding the signal in at the plate (point 4) of the preceding audio frequency amplifier. No change in output is to be expected if this condenser is operating normally.

f. Volume Control - The volume control can be checked by feeding the signal in at the high end of this control (point 6). The audio frequency coupling condenser can be checked by connecting to point 7.

g. Intermediate Frequency Stages

1. Adjust the Model 288X to produce the proper intermediate frequency for the receiver under test and feed it in at the secondary of the last i-f transformer (point 8). A signal will be obtained as indicated by the indicating meter. Due to the loading effect of the generator on the secondary of this transformer, tuning will be found to be very broad.

2. Connect the output of the generator to the primary of the last i-f transformer (point 9). An increase in signal strength may be expected and the broadness of tuning greatly reduced. This is only a test of whether or not the operation of the last i-f transformer is normal, and, under no conditions, should an attempt be made to align the trimmers of the last i-f transformer with connections at point 8 or point 9. Alignment should be made with the signal connected at the grid of the second i-f amplifier tube (point 10).

3. Connect the Model 288X to the grid of the second i-f amplifier tube (point 10). An appreciable gain should be indicated either by the increase in the indicating meter reading or by the fact that a smaller signal is required for a given output. The gain will vary between 10 and 25 per stage. The last i-f transformer may be aligned with the signal fed in at point 10.

4. The output transformer for the first i-f amplifier stage can be checked by connecting the signal to the plate of the tube (point 11). Normally, very little difference in over-all gain, over and above the amplification which is obtained when feeding in at point 10, is

to be expected when feeding signal in at the primary of this transformer. No attempt should be made to align this transformer with the signal generator connected at point 10 or 11. However, alignment may be made with the signal connected to the grid of the first i-f amplifier tube (point 12). In connecting to the grid of this tube, an appreciable gain of 10 or 25 is to be expected.

5. The first i-f amplifier transformer can be checked by connecting to point 13.

h. Checking 1st Detector Section - In checking the first detector performance, the Model 288X may be used as a substitute for the local oscillator, if it is thought that the trouble lies in this section. Disconnect the local oscillator, or remove the oscillator tube, and use the signal generator to replace it as a source of voltage for the first detector section. It is necessary either to have two signal generators or to be able to tune the receiver in to a strong local broadcasting station in order to obtain the beat frequency (i.f.). For example, if the i-f of the receiver under test is 456 kc, and the local broadcast station tuned in were at a frequency of 1000 kc, the Model 288X should be set to produce 1456 kc, pure r-f, and a beat frequency of 456 kc will result. The signal from the Model 288X is fed in at the injector grid (point 14). If all other parts of the receiver are operating normally, the broadcast signal should be received.

i. R-F Stages

1. The signal generator may be used to check the r-f stages by first tuning the receiver to some frequency within the range covered by the receiver - for example, 1000 kc in the case of broadcast receivers. The signal generator output, at a frequency of 1000 kc, may be fed in at the grid of the first detector (point 15). The reading of the decibel meter should be noted and then the output of the signal generator should be connected to the primary of the second r-f transformer (point 16). An increase in the meter reading will be noted due to the fact that, with the signal generator connected at point 15, the tuning stage feeding the grid of the 1st detector is thrown out of resonance due to the capacity loading of the signal generator connection. When the signal is connected to point 16, the transformer operates normally. The secondary of the transformer remains tuned and an overall gain is noted. No attempt should be made to align the trimmer condensers across the r-f transformer with the signal generator connected to these transformer secondaries.

2. By connecting the signal generator to the grid of the first r-f amplifier tube, an increase should also be noted in the output due to the amplifying action of the first r-f amplifier tube. Connection at the antenna post (point 18) should also give an increased signal.

5.1 GENERAL

As the Model 288X has been built in accordance with the Hickok high standards of quality, material and workmanship, no maintenance other than routine checks should be necessary. A Schematic is given in Figure 7.1 and chassis views are given in Figure 5.1 and 5.2 to aid in the location of component parts for trouble - shooting and replacement, if necessary. In the event that trouble occurs, it is suggested that our engineering staff be consulted as they will be glad to give any assistance possible. It is requested that the suggestions given in "Returning Equipment for Repair," page vii, be followed if it becomes necessary to return the unit.

5.2 TUBE MAINTENANCE

Failure in operation, in most cases, is likely to be caused by failure of tubes. These tubes are operated well within their ratings to insure long life but may, in time, need replacing. All tubes except the main variable oscillator, V1, type 6C4, and the crystal controlled oscillator and cathode follower tube, V2, type 6SN7, are easily accessible when the unit is removed from its case. To remove V1 and V2, remove the r-f shield first. The type 6C4,(V1) is a miniature type tube and has a special shield which has to be removed first. To do this, turn the shield slightly to release the catch, then lift straight out.

5.3 RE-ALIGNMENT

When the 6C4 main variable oscillator tube is replaced, the characteristics of the new tube may differ sufficiently from the replaced tube to neccessitate re-alignment of the oscillator unit. Variable powdered-iron core inductors, at the low frequency end, and negative temperature coefficient ceramic capacitors, at the high end of the band, are used for alignment. The Models 288X, 277X and 277 are high precision types of instrument and will need suitable standards to make any realignment. Realignment data is available and will be supplied upon request.

5.4 CRYSTAL INSTALLATION

All leads to the crystal are wired in and need only to be connected to the crystal for operation. The crystal may be obtained from the Hickok Electrical Instrument Company, see Parts List, Section VI.

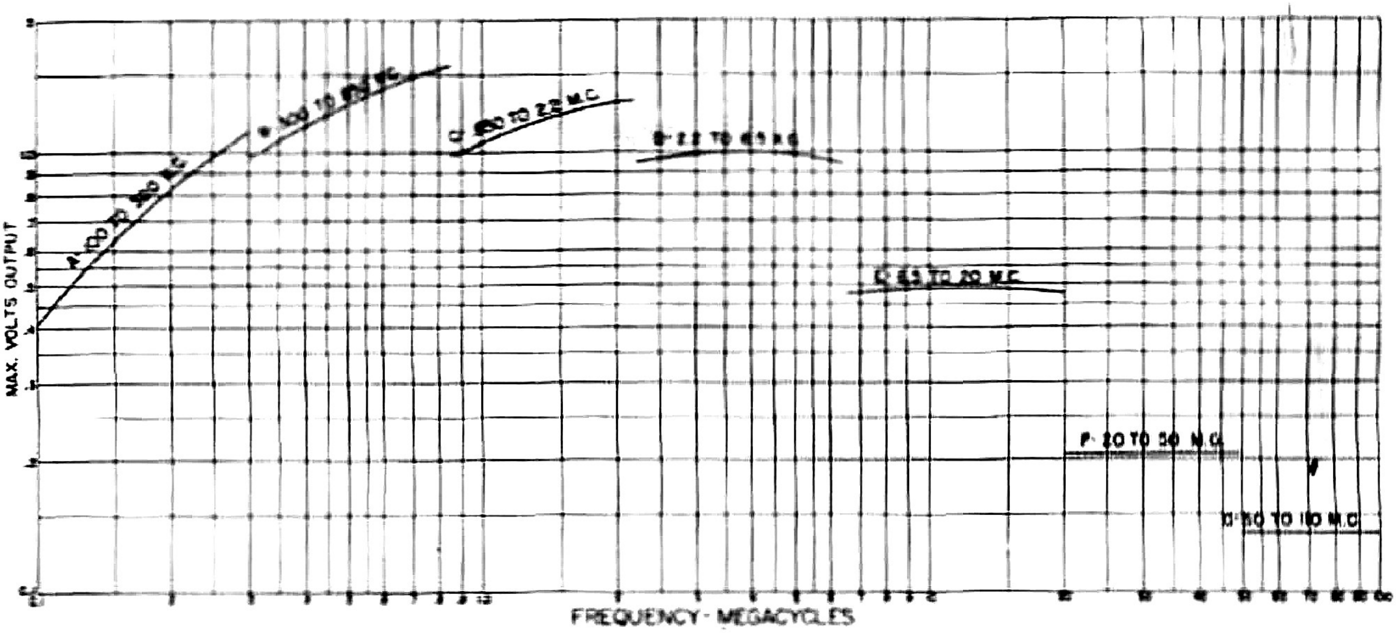


Figure 5.3 - Maximum Voltage Output

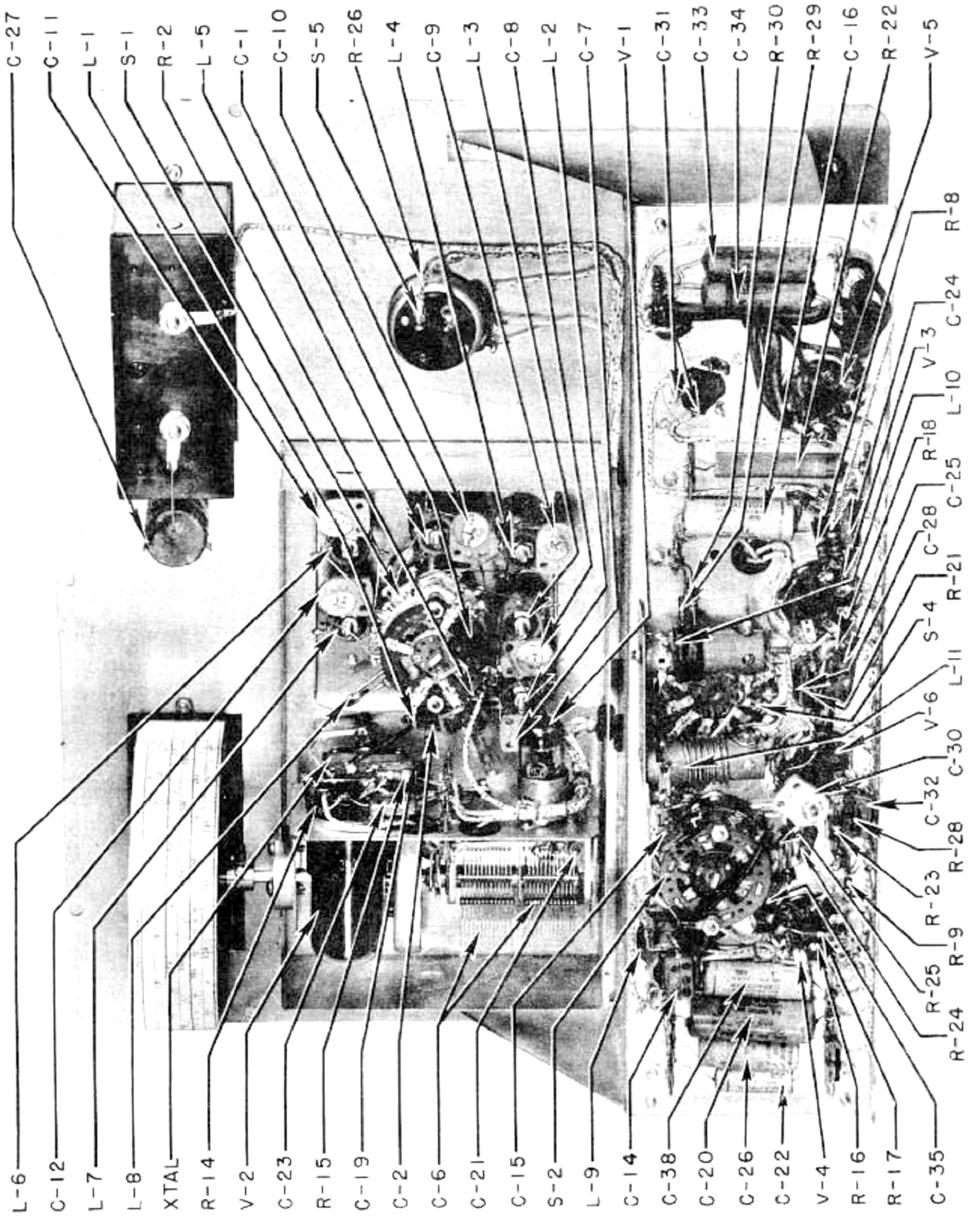


Figure 5.1 - Model 288X, Case Removed, Rear View

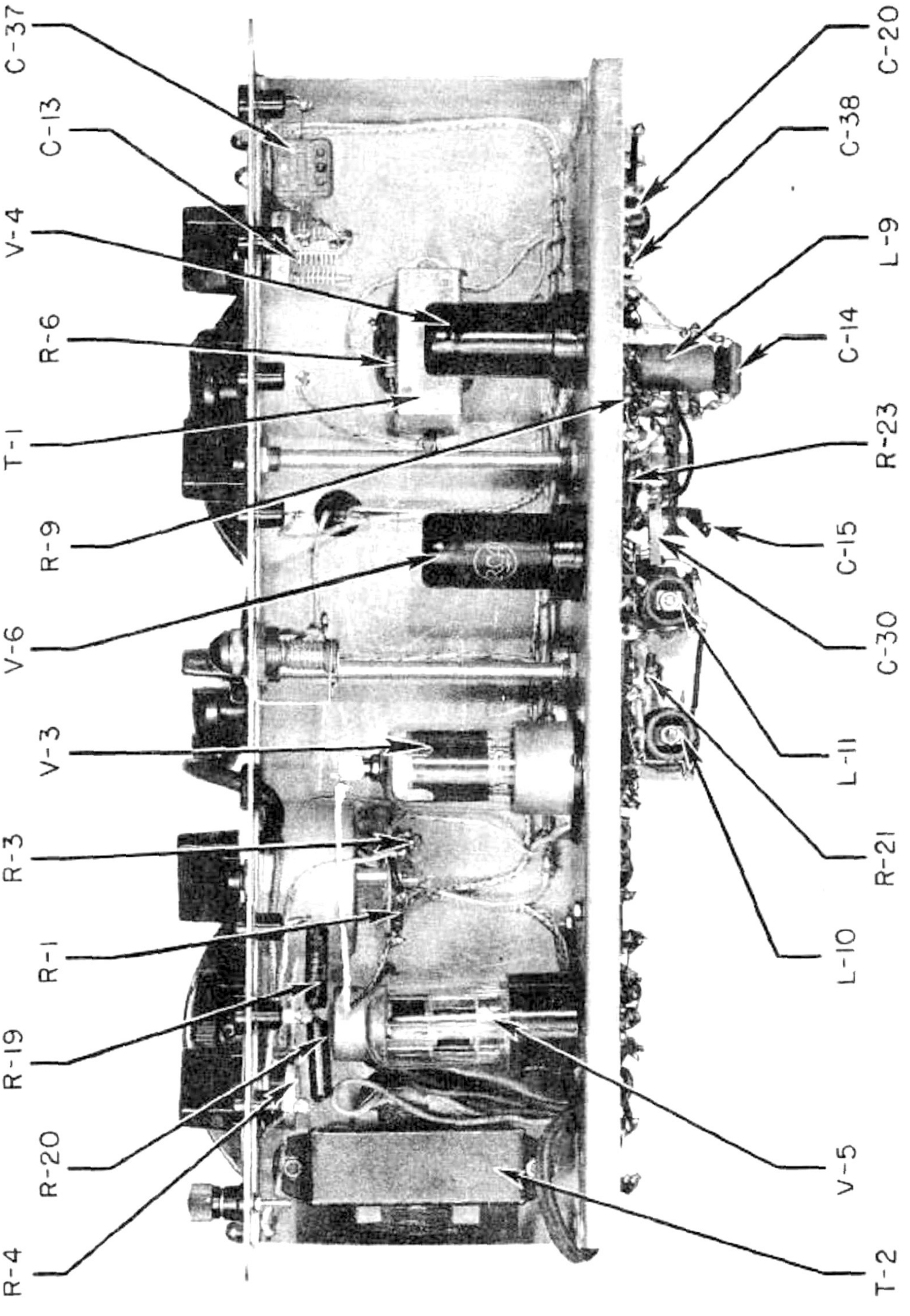


Figure 5.2 - Model 288X, Case Removed, Bottom View

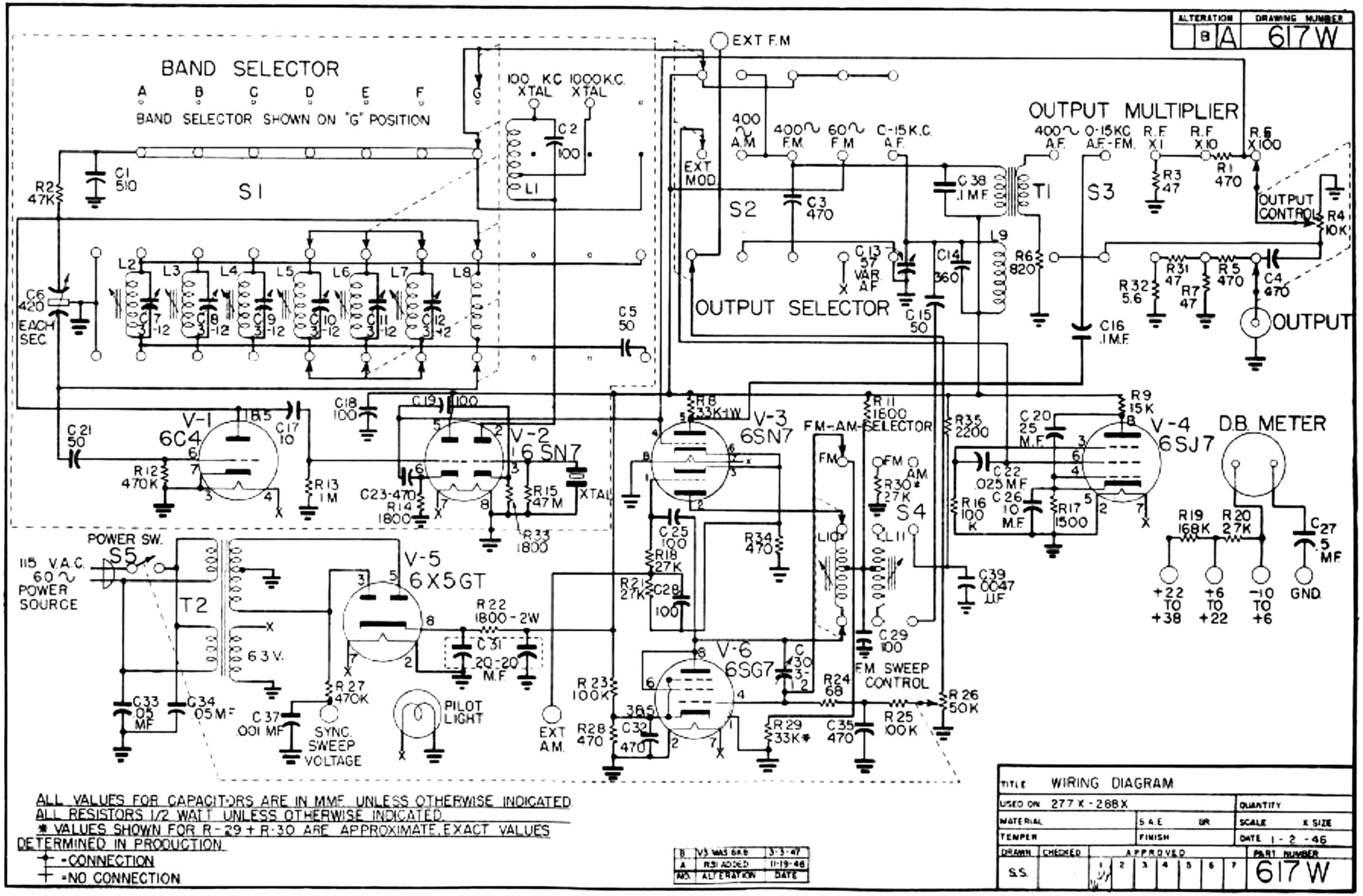


Figure 7.1 - Schematic, Model 288X