Operating Instructions

For

HICKOK

Universal Crystal Controlled Signal Generator

Model 288X

The Hickok Electrical Instrument Company
Cleveland 8, Ohio, U.S.A.

OPERATING INSTRUCTIONS

for

UNIVERSAL CRYSTAL CONTROLLED SIGNAL GENERATOR

MODEL 288X

TEMPORARY BOOK

The new complete instruction book will be available within a few weeks and will be sent upon return of the Registration Card or upon request.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY

10514 Dupont Avenue
Cleveland 8, Ohio

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Before returning any equipment for service, under warranty or otherwise, the factory must first be contacted giving the nature of the trouble. Instructions will then be given for either correcting the trouble or returning the equipment. Address all service inquiries to The Hickok Electrical Instrument Company, 10514 Dupont Avenue, Cleveland 8, Ohio.

REGISTRATION CARD

The above guarantee is contingent upon the attached registration card being returned to the factory immediately upon receipt of the equipment.

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. Band A 100-300 kc
   b. Band B 300-850 kc
   c. Band C 850-2200 kc
   d. Band D 2.2-6.5 mc
   e. Band E 6.5-20 mc
   f. Band F 20-50 mc
   g. Band G 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: 0-450 kc variable sweep, 50 mc, modulating frequency - 60 cycles

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

      0-30 kc variable sweep, 1000 kc, 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 to 15,000 cycles

7. Crystal Controlled Output:
   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)

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

TECHNICAL DESCRIPTION AND DETAILS

1. One complete Model 288X consists of the following:

Quan.	Name	Type	Stock No.	Dimensions	Weight
1	Universal Crystal Controlled Signal Generator	288X	902-010	13"x16"x7"	33 lbs.
1	Instruction Book		2490-50		
1	Meter Lead		12450-98	42"	

2. TUBES: The tubes used are: Type 6C4, 6K8GT, 6SN7, 6SG7, 6X5GT and 6SJ7. All these tubes are the latest 6 volt heater type tubes and are operated at their normal rating to insure long life and uniform service.

3. POWER: The Model 288X includes a complete built-in power supply consisting of a transformer, rectifier and filter. It may be operated from any 110 volt a-c line, 40-60 cycle. Other voltages and frequencies are available at slight additional cost and upon request.

4. CIRCUITS: The variable radio frequency circuit utilizes the type 6C4 tube as a Colpitts type high stability radio frequency oscillator. This oscillator circuit is continuously variable from 100 kc to 110 mc in seven ranges. Each range is clearly marked on the main tuning dial and extends over more than 15" of scale length. One half of a type 6SN7 tube is used as the oscillator tube for the crystal controlled frequencies, either 100 kc or 1000 kc. The other half of the 6SN7 is used as a cathode follower. The 6X5GT tube is used as a full wave rectifier to supply approximately 150 volts rectified d-c to the associated equipment. The 6SJ7 tube is used as a negative resistance oscillator to provide the audio frequencies, 400 cycles fixed and 100 to 15,000 cycles variable when beat against the main r-f oscillator

The 400 cycle audio can be used to amplitude modulate the 100 kc to 110 mc variable oscillator, to frequency modulate the wide or narrow band internal frequency modulated oscillator or provide 400 cycle a-f output.

The triode section of the 6K8GT tube is used as the frequency modulated oscillator and is modulated by the 6SG7 quadrature tube. Radio frequency from the main variable oscillator is fed in at the grid of the pentode section of the 6K8GT and the tube acts as a mixer when frequency modulated output or variable audio frequency output is being generated.

4a. CRYSTAL CONTROL: By turning the band selector switch to the 100 kc position the radio frequency oscillator section is so connected that a 100 kc crystal controlled signal is delivered to the regular output network. This signal may be either modulated or unmodulated. With the range selector turned to the

1000 kc position, crystal control is established over a 1000 kc output which, likewise, may be either modulated or unmodulated.

5. RADIO FREQUENCY COILS: All coils but the one for the last range (50-110 mc) are high Q, adjustable iron-core type and are capacity trimmed. All coils are thoroughly impregnated to make them impervious to temperature and humidity changes.

6. METER: A precision decibel meter, which is calibrated directly in decibels from -10 to +38, is incorporated in the Model 288X. When this meter is connected across a 500 ohm line, the accuracy may be depended upon to within ±2%. The output meter has three ranges: -10 to +6 db, +6 to +22 db and +22 to +38 db. Provisions have been made for a capacity connection to the output meter so that the output may be taken directly from the plate of a tube.

7. OUTPUT MULTIPLIER CONTROL: Control used to provide step attenuation of the radio frequency and audio frequency outputs so that the output potentiometer, which is labeled OUTPUT CONTROL, may be used with maximum effectiveness.

NOTE

On the RF X1 position, the maximum output voltage is approximately 15 microvolts. This extremely low output is especially designed for the ultra high sensitivity receivers which require extremely low output voltage to eliminate a-v-c action, but may be so low that it cannot be picked up by insensitive receivers.

8. F.M. - A.M. SELECTOR: This control is used to select either wide band frequency modulation, which is 50 mc with a bandwidth sweep of 0-450 kc; the narrow band frequency modulation, which is a 1000 kc fundamental with a frequency sweep of 30 kc, or amplitude modulation. 50 megacycles was selected for wide band frequency modulation since the first harmonic of this will appear at 100 megacycles, which is approximately in the center of the present frequency modulated band. This oscillator can, therefore, be used to provide a frequency modulated signal in the center of the present band without resorting to the variable frequency oscillator.

9. OUTPUT SELECTOR: This is a five-position control with positions as follows:

OFF - EXT: In this position there is no internal modulation at any of the frequencies being generated. By applying an external modulating voltage to the input jack, labeled EXTERNAL MODULATION-AMP, the output frequency can be modulated by a suitable external audio frequency source. Also, in this position, the wide or narrow band frequency modulated oscillator can be frequency modulated by applying an external voltage to the jack labeled EXTERNAL MODULATION - FREQ.

400∿ AMP.: In this position the internal 400 cycle oscillator will modulate the main variable oscillator at 400 cycles throughout its range of 100 kc to 110 mc. Also, in this position, the 100 kc and 1000 kc crystal controlled outputs will be 400 cycle amplitude modulated.

400~ FREQ: In this position either the 1000 kc frequency modulated oscillator or the 50 megacycle frequency modulated oscillator is frequency modulated at 400 cycles with a sweep of approximately 150 kc for the 50 megacycle oscillator, or about 5 kc for the 1000 kc oscillator. Actually, of course, the latter output is seldom used. When beating the main variable oscillator against the internal frequency modulated oscillator to produce some other frequency than 1000 kc or 50 megacycles, a frequency modulated output signal is available which is continuously variable from 100 kc to 160 mc. 160 mc, of course, is the limit of the main oscillator (110 mc + 50 mc).

60~ FREQ: In this position the frequency modulated oscillator, previously mentioned, is wide band modulated at 60 cycles with a modulation sweep of 0-450 kc, or narrow band modulated 0-30 kc. This output is used for visual alignment and has a frequency range of 100 kc to 160 mc.

0-15 K.C. A.F.: In this position the output from the signal generator is a continuously variable audio frequency, ranging from 100 cycles to 15,000 cycles. The output frequency is controlled by means of the VARIABLE AUDIO FREQUENCY control.

10. SYNCHRONIZING SWEEP VOLTAGE: This voltage output may be used to supply the horizontal sweep for Cathode Ray Oscillographs when using frequency modulated output for visual alignment.

THEORY

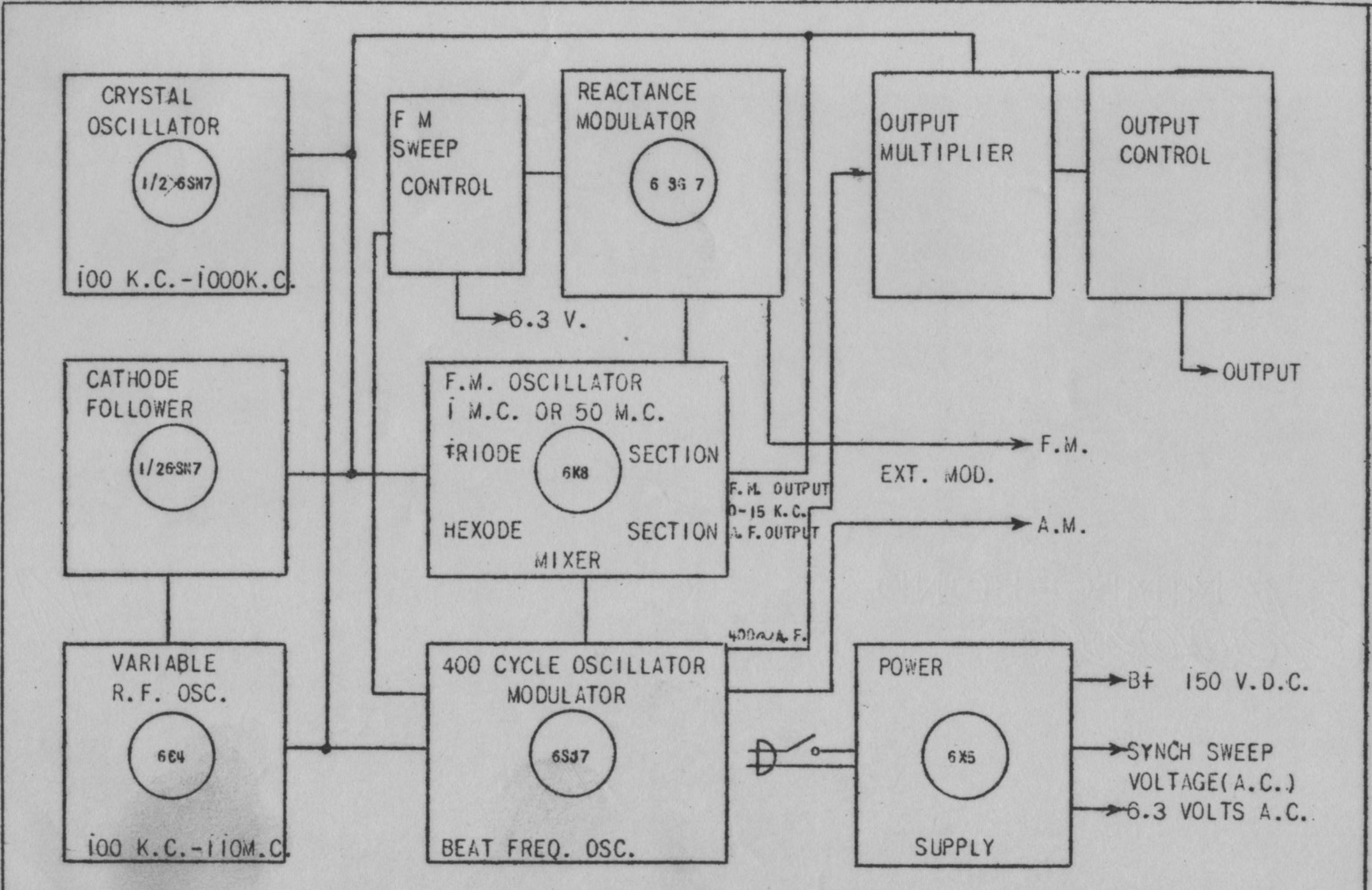
1. GENERAL: The basic circuit diagram for the Model 288X is shown in Figure 1. A brief explanation of it follows.

2. POWER SUPPLY: The power supply is of the usual type, consisting of a transformer, with a center-tapped high voltage (300 volt) secondary winding, a full-wave rectifier, type 6X5, and a resistive-capacitive filter network, and supplying approximately +150 volts d-c as B+ and 6.3 volts a-c for all heaters. A synchronized sweep voltage is taken from the 300 volt winding to supply horizontal deflection for cathode ray equipment.

3. VARIABLE R-F OSC - 100 KC - 110 MC: The unmodulated r-f signal, covering from 100 kc to 110 mc, may be utilized in a number of way

a. It is fed through an impedance matching cathode follower to the output controls where it can be picked up as unmodulated r-f, 100 kc to 110 mc.

b. It may be amplitude modulated, 30% at 400 cycles, then



CRYSTAL
OSCILLATOR
1/2 6SN7
100 K.C.-1000K.C.
F M
SWEEP
CONTROL
6.3 V.
REACTANCE
MODULATOR
6 SG 7
OUTPUT
MULTIPLIER
OUTPUT
CONTROL
OUTPUT
CATHODE
FOLLOWER
1/2 6SN7
F.M. OSCILLATOR
1 M.C. OR 50 M.C.
TRIODE SECTION
6K8
HEXODE SECTION
MIXER
F.M. OUTPUT
0-15 K.C.
A.F. OUTPUT
F.M.
EXT. MOD.
A.M.
VARIABLE
R.F. OSC.
6C4
100 K.C.-110M.C.
400 CYCLE OSCILLATOR
MODULATOR
6SJ7
BEAT FREQ. OSC.
400~A.F.
POWER
6X5
SUPPLY
B+ 150 V.D.C.
SYNCH SWEEP
VOLTAGE(A.C.)
6.3 VOLTS A.C.

Fig-I

fed to the output controls.

c. It may be fed to the mixer, through the cathode follower, to beat against the beat frequency oscillator to obtain the 0-15 kc a-f output.

d. It may be used in connection with the f-m oscillator to produce a f-m signal.

4. CATHODE FOLLOWER: The cathode follower utilizes one half of a type 6SN7 tube and acts as an impedance transformer for the variable r-f oscillator.

5. CRYSTAL OSCILLATOR - 100 KC-1000 KC: The output of the crystal controlled oscillator, which utilizes one half of a type 6SN7 tube and operates at either 100 kc or 1000 kc, may be used in several ways:

a. It may be fed directly to the output controls. Harmonics of either fundamental offer a wide frequency range at great accuracy (0.01%).

b. It may be amplitude modulated 30% at 400 cycles.

c.

6. 400~ OSCILLATOR - MODULATOR: The 400 cycle oscillator-modulator utilizes a type 6SJ7 tube and its output may be used as follows:

a. It may be fed directly to the output controls as a 400 cycle, audio frequency signal.

b. It may be used to amplitude modulate the variable r-f oscillator and the crystal controlled oscillator.

c. It may be used to modulate the f-m sweep oscillator.

7. BEAT FREQUENCY OSCILLATOR: Both the beat frequency oscillator and the main variable oscillator are fed into the mixer stage. The two frequencies are mixed in this stage and fed through the multiplier 0-15 KC AF position to the output. The main variable oscillator is adjusted to give zero beat with the beat frequency oscillator when the 0-15 KC control is in the zero position. Rotating the 0-15 KC control from 0 to 15,000 then gives a difference in frequency between the main oscillator and the beat frequency oscillator in accordance with the calibration of the control. The FM-AM Selector Switch is in AMP MOD position, Band Selector on A band and the Main Tuning Dial is at aprroximately 160 kc.

8. FM SWEEP: Potentiometer control determining the amount of sweep in accordance with setting of associated dials. There are three ranges available: 0 - 30 kc, 0 - 150 kc, 0 - 450 kc.

9. REACTANCE MODULATOR: The reactance modulator, utilizing a type 6SG7 tube, acts as a variable impedance across the tuned f-m oscillator circuit.

10. EXTERNAL MODULATION - AM - FM: Both the frequency modulated and

amplitude modulated circuits may be modulated from a proper external source by connecting this source to the EXTERNAL MODULATION AMP CNTRL. jacks, and operating the associated switches to the correct position for external modulation.

11. FM OSCILLATOR 1 MC - 50 MC:

a. 100 - 3000 kc Frequency Modulated Output, 1000 kc Oscillator, 30 kc Sweep - Frequency modulated signal above 3000 kc is seldom required for visual alignment of amplitude modulated receivers. It can be generated, however, if so desired. To produce this frequency the main oscillator is mixed in the mixer amplifier tube with the output from the 1000 kc frequency modulated oscillator. This mixer output is then fed to the multiplier, FM position to the output. The correct adjustment of the main oscillator to produce any frequency in this range is to adjust 1000 kc above or below the desired frequency. For example, if 456 kc frequency modulated signal is desired, the main oscillator should be set at 1456 kc which will result in an output frequency which is the difference between 1000 kc f-m oscillator and the 1456 kc main variable or 456 kc. When using this output for visual alignment, the 60 cycle frequency is used to modulate the frequency modulated oscillator and, while it is possible to frequency modulate this at 400 cycles, there would ordinarily be no occasion for a frequency modulated signal modulated at 400 cycles when aligning amplitude modulated receivers.

b. 1000 kc - 160 mc Frequency Modulated Output, 50 mc Oscillator, 0-450 kc Sweep, 60~, or 0-150 kc Sweep, 400~ - The alignment of frequency modulated or television receivers require wide band frequency modulated signals. The frequency modulated oscillator operating at 50 megacycles is fed into the mixer amplifier tube together with the signal from the main variable oscillator to produce this 1 mc - 160 mc output frequency. The output is then taken as previously mentioned, through the multiplier FM position to the output connection. The adjustment of the main oscillator to produce this frequency is identical to adjustment to produce the 30 kc frequency modulated output with the exception that the main variable oscillator should be set 50 megacycles above or below the frequency desired. For example, alignment of a wide band intermediate frequency stage of 3000 kc, the main variable oscillator would be set at 47 (50 mc - 3 mc) megacycles, or 53 (50 mc + 3 mc) megacycles and the output frequency would then be 3 megacycles frequency modulated at 0-450 kc or 0-150 kc.

If the frequency modulated signal desired is for alignment purposes the frequency modulated oscillator should be modulated 450 kc at 60 cycles, however, if the frequency modulated signal is to be used for testing purposes in the same manner as the conventional amplitude modulated oscillator is used for testing amplitude modulated receivers, then modulation should be 150 kc at 400 cycles. When this 400 cycles is used for modulation, the width of sweep is 150 kc, which is 75 kc either side of fundamental frequency and which is the standard for 100% modulation as established by the Federal Communications Commission.

OPERATION

1. PRECAUTIONS TO BE OBSERVED WHEN USING THE MODEL 288X:

   Be sure that the voltage and frequency being used correspond to the rating of the signal generator.

   Never connect the a-f or r-f output leads to any place in a receiver where d-c might be applied between this connection and the ground of the signal generator. Whenever connecting on to the plate of a tube or other d-c voltage point with the output lead, be sure to insert a blocking condenser to protect the output attenuator network from possibility of damage.

   Never attempt to use the output meter for alignment when using frequency modulated signal.

2. OPERATION CHART: The chart given below indicates the possible outputs available and the proper position for each control to obtain this desired output.

CHART #1

OUTPUT	BAND SELECTOR	OUT.-MULT.	FM-AMS	OUTPUT-SEL.	1	F.M.SWEEP
* UNMOD. or ext. mod. 100 KC to 110 MC	A to G	RF X1, 10, 100	A.M.	OFF - EXT.	2	Not used
* A.M. R.F. 100 KC to 100 MC	A to G	RF X1, 10, 100	A.M.	400 Cy. AMP.	3	Not used
* UNMODULATED 100 or 1000 KC crystal	100 or 1000 KC Crystal	RF X1, 10, 100	A.M.	OFF - EXT	4	Not used
* A.M. 100 or 1000 KC crystal	100 or 1000 KC Crystal	RF X1, 10, 100	A.M.	400 cy. AMP	5	Not used
* 100 KC to 111 MC FM for vis. align. AM Rec. 30 KC swepp	A to G	0-15 KC AF-FM	1000 KC 30 KC SWEEP	60 Cycle freq	6	0-30
** 400 Cycles A.F.	G	400 cycles AMP	A.M.	400 Cycle AF	7	Not used
** 0-15 KC A.F.	Dial for zero beat at approx 160 KC	0-15 K.C. A.F. FM	A.M.	0-15 KC A.F.	8	Not used
** 1[illegible] KC to 123 MC F.M. for visual ALIGNMENT	C to G	0-15 KCAF-FM	50 MC-450 KC SWEEP	60 cycle freq	9	0-450
** 1000 KC to 123 MC FM for testing	C to G	0-15 KCAF-FM	50 MC-450 KC SWEEP	400 cy. freq.	10	0-150
** 1000 KC to 123 MC FM for testing (Ext. Mod.)	A to G	0-15 KCAF-FM	50 MC-450 KC SWEEP	OFF - EXT.	11	Used
** 100 MC FM for testing (400 Cy. Mod.)	A	0-15 KCAF-FM	50 MC-450 KC SWEEP	400 cy. freq.	12	0-150
** 100 MC FM for testing (Ext. Mod.)	A	0-15 KCAF-FM	50 MC-450 KC SWEEP	OFF - EXT.	13	USED

* FOR A.M. RECEIVERS   ** FOR F.M. RECEIVERS

3. ZERO SETTING OF ATTENUATOR: As it is impossible to obtain a ground at zero potential, due to the fact that an appreciable amount of resistance always exists between the shield and ground, the shield will assume an r-f potential above ground which is the product of this resistance and the r-f current flow. When the attenuator is set at zero, the above mentioned potential is 180 degrees out of phase from the normal output potential. Zero output will be obtained when the attenuator is not on zero position, but advanced to such a position that the in-phase position will vary with frequency and the value of resistance to ground and usually increases with an increase in frequency. Therefore, adjust the attenuator to some advance position above zero of attenuator scale for zero output. On lower frequencies, which includes ranges A, B and C, zero output will be obtained at or near zero in the attenuator scale.

4. NEVER USE AN OUTPUT METER FOR ALIGNMENT WHEN USING FREQUENCY MODULATED SIGNAL: It is recommended that frequency modulation not be used above the broadcast band for the reason that little is to be gained by the alignment of the trimmers on the short wave band above a gain in amplitude which is readily indicated by a conventional output meter.

5. PERCENT ERROR IN FREQUENCY MODULATED OUTPUT: It is well also to note that the possibility of error in frequency output when using frequency modulation is considerably greater than the error when using straight amplitude modulated or single signal output. The reason for this being, first, there is accumulated error as a result of the error in the main r-f oscillator added to the error of the fixed for frequency modulated oscillator. Second, that a ½% error in the main oscillator could lead to a 3% or 4% error when using frequency modulation. A good example of this would be to assume that there was a ½% error in the main oscillator at 1100 kc. This ½% error would result in an error of 5.5 kc. If we were using the signal generator for frequency modulated output at, for example, 100 kc, the main oscillator would be set to 1100 kc to heterodyne against the fixed frequency modulated oscillator to produce a 100 kc frequency modulated output. This error of 5.5 kc which was evident at 1100 kc would show up not as a ½% error, but as an error of 5.5 kc in 100 or 5.5% error. It is advisable, therefore, to take this fact into consideration when making alignment using frequency modulated output at the lower frequencies. In case a question does come up as to whether or not the frequency modulated output is correct, it would be well to use the standard amplitude modulated output at the lower frequencies to check the circuit under test for possible frequency error.

6. DECIBEL METER: Start all measurements with the decibel meter on the high range, +22 to +38, as high voltage applied to the low range scale would damage the meter.

It may be desirable to evaluate a decibel meter reading in terms of voltage. This can be done by using the chart in the back of the book - USEFUL TECHNICAL DB DATA. This chart is based on the measurement being made across a 500 ohm termination.

APPLICATIONS

1. TRIMMERS AND PADDERS: Since one primary function of the signal generator is to align the trimming and padding condensers in a radio receiver, it is very essential that the operator understand thoroughly what is meant by a trimming and padding condenser, and how it is used in the receiver. A trimmer condenser is a small capacity variable condenser which is always connected in parallel with the tuned circuits. The tuned circuits may be simply an inductance, or it may be inductance paralleled by a main tuning condenser, but in either case, the trimmer condenser is connected across this. The value of the trimmer condenser seldom exceeds 40 micro-micro-farads. An analysis of a trimmer condenser action across a tuned circuit comprising an inductance and a variable condenser, assumed to vary from 15 micro-micro-farads to 300 micro-micro-farads, may be made.

   The trimmer condenser of 40 micro-micro-farads maximum is connected across this main tuning condenser. The effectiveness of thi trimmer will be at its maximum when the main tuning condenser capacity is at a minimum as the percentage of capacity supplied by the trimmer is then 40 divided by (40 plus 15) or nearly 70%.

2. PADDING CONDENSER: The padding condenser is a small variable condenser always connected in series with a tuning inductance or condenser. In this case, the padding condenser is as a rule of fairly high value, generally over two or three hundred micro-micro-farads. If we assume the case of a padder connected in series with a main tuning condenser of 15 to 300 micro-micro-farac it will be quite evident that the padding condenser will have its maximum effect when the main tuning condenser is all the way in, or in other words, at its maximum. Capacity of the two series condensers is still 15 and the slight change in the 300 padding condenser would have very little effect on the total overall capacity.

   In view of this, it should be remembered that whenever adjusting trimmer condensers, these adjustments should be made with the main tuning condenser all the way out, or at its minimum capacity, and whenever adjusting a padding condenser it should be tuned with the main tuning condenser all the way in. The common place in a radio frequency circuit where a paddeer is used is in the oscillat circuit of the superheterodyne receiver. In all other cases, almost universally, trimmers are used and condenser should be alig- ned at minimum capacity. It should be pointed out that the above notes on trimmers and padding condensers do not apply to trimmer condensers in intermediate frequency transformers as these are not paralleled by other tuning condensers.

3. CONNECTIONS OF THE SIGNAL GENERATOR TO THE RECEIVER: (See Fig. 2 which is the basic circuit employed in modern superheterodyne receivers, and Fig. 3, which shows the panel layout and connections

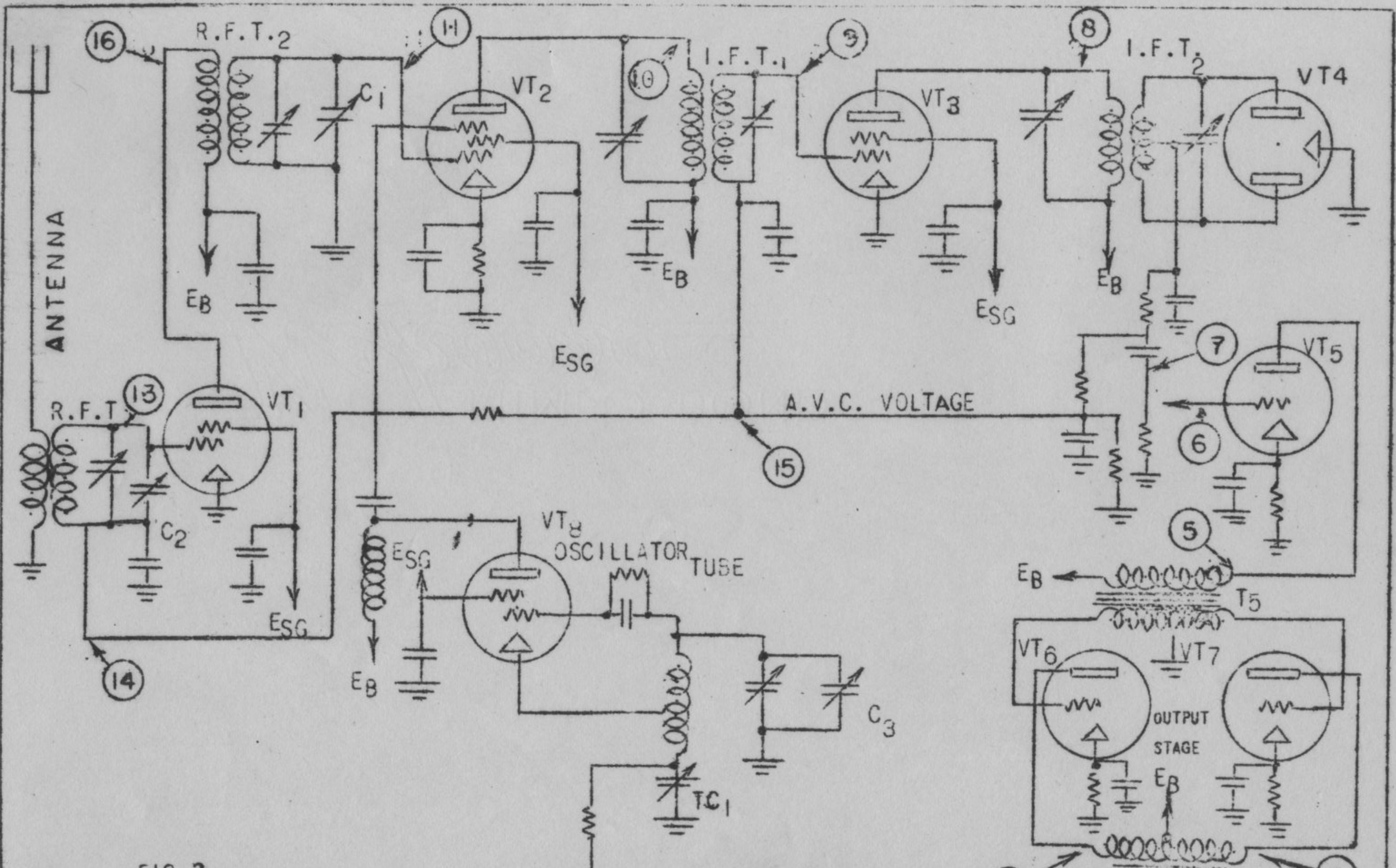


FIG. 2

BASE SUPERHETERODYNE RECEIVER CIRCUIT

to Model 288X signal generator.) Common procedure for locating trouble and aligning superheterodyne receivers when using a signal generator and output meter, is to start at the end of the audio frequency channel at the speaker and work towards the antenna post.

4. TESTING THE OUTPUT TRANSFORMER T6: Connect the ground from the signal generator to the ground or chassis of the receiver under test. Connect the output connector through a blocking condenser of approximately 1/2 microfarad to point 3 of output transformer T6. Connect low output connector B3 to one side of voice coil winding on transformer at point 1. Connect high output lead to point 2 on output transformer. Turn range selector on decibel meter to high range, that is, plus 22 to plus 38 decibels. Turn band selector to "OFF" position, line switch to "ON", multipliers to 400 cycles A.F., output control advanced to maximum. Selector switch to 400 cycle modulation. With this connection a 400 cycle audio frequency signal is being fed in through 1/2 of the primary of transformer T6 and if this half of the transformer is operating properly the voltage appearing on the secondary of voice coil winding should indicate on the decibel meter. It is quite probable that the meter selector switch will have to be turned down to the lowest or minus 10 to plus 6 DB range due to the low impedance of voice coils being used in modern receivers. To check the other side of primary of T6 the only change in the connection would be to connect the output from blocking condenser at point 4 rather than point 3 and this will give a check on the other half of the primary of this transformer.

5. CHECKING THE OUTPUT TUBES: Connections as previously outlined with the exception of the output connection: Disconnect this from the primary of the transformer T6 and remove the blocking condenser from the output lead, then connect the output lead directly to the grid of audio output tube VT6. A noticeable increase in the output meter should be obtained due to the amplifying action of VT6. Disconnect the output lead from VT6 and connect to the grid of VT7. This should give the same output indication on the decibel meter, but in this case, the amplifying action of VT7 is being checked in place of VT6.

6. CHECKING THE INPUT TRANSFORMER T5: Again leave all connections as previously outlined with the exception of the output connection and in this case, connect the 1/2 microfarad blocking condenser in series with the output lead. The output of the condenser connection should then go to the high side of the input transformer labeled T5. Again an increase in the output meter reading should be obtained due to the step-up ratio transformer T5. This gives a check on the operation of the transformer.

7. CHECKING THE FIRST AUDIO FREQUENCY STAGE: All of the connections as previously outlined, but with the exception that the output control should be connected either to the grid of VT5, as indicated by position 6, or at the high end of the audio volume control P1, as indicated in position 7. In the case where connection is made to point 6 of the grid of the first audio amplifier tube a noted

increase should be obtained in the decibel meter due to the amplifying action of VT5. If the connection is made at point 7 at the high end of the volume control the same amplification should be apparent if the volume control is advanced to a maximum position; whereas, if the control is retarded towards the ground end or towards the low output position, the signal should gradually be reduced as indicated by the output meter.

The foregoing procedure illustrates the method of checking the audio frequency section of a receiver when using a fixed frequency of 400 cycles. This is generally suitable for ordinary checking, however, cases may come up where the output of the receiver sounds distorted or fuzzy which could be caused by frequency discrimination in the amplifying stages or a defective speaker.

8. VARIABLE AUDIO FREQUENCY OUTPUT: When it is necessary to check the audio frequency response from a low frequency of approximately 100 cycles up to 8000 cycles, this can be done by merely re-arranging the controls on the signal generator to give a variable audio frequency output.

Turn the frequency band selector switch to the "A" position. Multiplier to 0-15 KC audio frequency. Output control advanced to a maximum. Selector switch to the 0-15 KC AF position, audio frequency calibrated dial to the zero position. Leave the output connection connected to either point 6 or point 7 and adjust the main tuning dial on the receiver to approximately 160 KC on the "A" band. At some frequency in this range it will be found that the audio frequency output reaches a zero beat. That is, a position at which tuning the dial either side will cause an increase in audio frequency. The signal generator is then properly set up to produce a calibrated variable audio frequency in accordance with the 0-15 KC dial in the lower right hand corner of the signal generator. By varying this dial between 100 and 15,000 cycles some point will probably be found where considerable distortion appears in the speaker output, or perhaps where there is a decided peak or falling off in the set at this point where the difficulty occurs and look for trouble in the transformers, by-pass condensers, resistors, etc.

9. I.F. R.F. ALIGNMENT--MODULATED SIGNAL: After having completely checked over the audio system and having put it in normal operating condition, it is then advisable to proceed to the intermediate and radio frequency stages and properly align these stages. One method is to use the amplitude modulated radio frequency and the other is to use frequency modulated output. In case amplitude modulated radio frequency is to be used the output meter may be left connected across the secondary winding of T6 or in lieu of this connector it may be inserted over the plate pin of one of the output tubes VT6 or VT7. In this case, be sure to start with the decibel meter range switch on the high position +22 to +38 decibel: The proper setting on the signal generator to produce amplitude modulated audio frequency output is as follows: Assume the intermediate frequency of the receiver under test is to be 175 KC, set the band selector switch to the "A" position, adjust the frequency

control to 175 KC, as indicated on the calibrated dial, set the multiplier to the RF X100 position, advance the output control to a maximum. Set the selector switch to 400 cycle modulation position.

Connect the output of the signal generator to a blocking condenser of approximately 1/2 microfarads or less to point 8 on the high end of the second intermediate frequency transformer IFT2. If this transformer is operating properly and the second detector VT4 and associated circuits are operating properly, an audible signal of 400 cycles should be heard in the speaker and the decibel meter should indicate that voltage was being delivered to the plates of one of the audio frequency tubes into which the meter was connected. It is not well to attempt to make an alignment of IF transformer T2 with the output connected into this transformer as the loading of the output circuit of the signal generator will tend to disturb the proper alignment of this transformer, however, this connection will give an indication as to whether or not this transformer and associated circuits between this transformer and output tubes are operating.

To align IF transformer IFT2 and check VT3 which is the first intermediate frequency amplifier tube, the output connection should be removed from position 8 and reconnected at the grid of VT3 as indicated by position 9. Then alignment of IFT2 may be effected for maximum reading of the output meter.

The first IF transformer as indicated by IFT1 could readily be checked by removing the output connection from position 8 and connecting it into position 10 thru a blocking condenser, however, again it would be impractical to attempt to align this transformer with this connection due to the loading of the signal generator on this transformer, therefore, proper alignment of this transformer should be effected by connecting the output of the signal generator to point 11, which is the grid of the first detector tube and then adjusting the trimmer on the first intermediate frequency transformer for maximum indication of the output meter.

10. CHECKING THE OSCILLATOR SECTION OF THE RECEIVER:

The tests made so far have indicated that the intermediate frequency and audio frequency sections have been operating normally The next step is to check the oscillator section of the receiver to determine whether or not this is operating across the entire band. The procedure in this case would be to leave the output of the signal generator connected to point 11, which is the first detector grid, and tune the receiver dial to the low end of a frequency range, for example, at 550 KC on the broadcast band. If the signal generator frequency is then adjusted to 550 Kilocycles, the local oscillator in the receiver should then be operating at the intermediate frequency of 175 Kilocycles, If, with this connection the signal is obtained at the speaker or in the output meter, it will be an indication that the oscillator section is operating properly at the low end of the dial. The same check should be made again at the center of the dial at approximately 1000 KC readjusting the oscillator to correspond to the reading on the receiver dial and again at the high end of 1500 KC.

11. ALIGNMENT OF THE RADIO FREQUENCY SECTION: In order to align the radio frequency section it is advisable to consult the manufacturers specifications on the particular receiver under test and determine at which frequency the radio frequency section should be aligned. In most cases, the alignment of the trimmer condenser is made at 1500 or 1600 KC on broadcast band and the alignment of the tracking condenser approximately 550 or 600 KC. A check on the RF transformer RFT2 could be made by tuning the main dial on the receiver to approximately 1500 KC and by adjusting the output from this signal generator to this same frequency, connect its output to a blocking condenser at point 16 or the high end of the primary of the second radio frequency transformer. Alignment, however, should not be effected with this connection as the loading of the signal generator might result in improper alignment at this frequency. The alignment of this section should be made with the output of the signal generator connected at the antenna post of the receiver or at point 13, which is the grid of the first radio frequency tube. The proper alignment procedure with the signal generator connected at the antenna post would be to adjust the trimmer C1, C2 and oscillator trimmer C3 for maximum response in the output meter. Then, retune the receiver to the low end of the dial at 550 or 600 KC and after readjusting the signal generator to correspond to this frequency, adjust tracking condenser TC1 for maximum output response. Sometimes it is advisable to rock the tuning section back and forth when making an alignment of TC1. Follow manufacturers' recommendations in this regard.

12. USE OF FREQUENCY MODULATION FOR R.F. AND I.F. ALIGNMENT: The use of frequency modulation necessitates the use of cathode ray oscillograph as an output and resonance indicator. If the oscillograph being used does not contain a demodulator it must be connected at the second detector load. If the oscillograph has a demodulator it will be connected any place from the antenna post on to the second detector load resistance.

13. CONNECTION OF THE SIGNAL GENERATOR TO THE AMPLITUDE MODULATED RECEIVER FOR FREQUENCY MODULATED ALIGNMENT: Fig. 3 illustrates the proper connections from model 238X signal generator to any oscillograph and receiver under test.

First ground the signal generator to the chassis or ground of the receiver and also to the ground of the oscillograph being used.

The connections for the sweep circuit voltage should be made from the right hand binding post to the horizontal plate connection of the oscillograph being used. The other side of the sweep circuit voltage is grounded and consequently circuit will be obtained from this to the oscillograph through the regular ground. The switch for the horizontal plate connection of the oscillograph should be turned to the external position and the horizontal gain control adjusted until the horizontal sweep is approximately 2/3 screen width. The connection from the signal generator to the receiver under test should be ground-to-ground as previously

CONNECTIONS FOR VISUAL ALIGNMENT

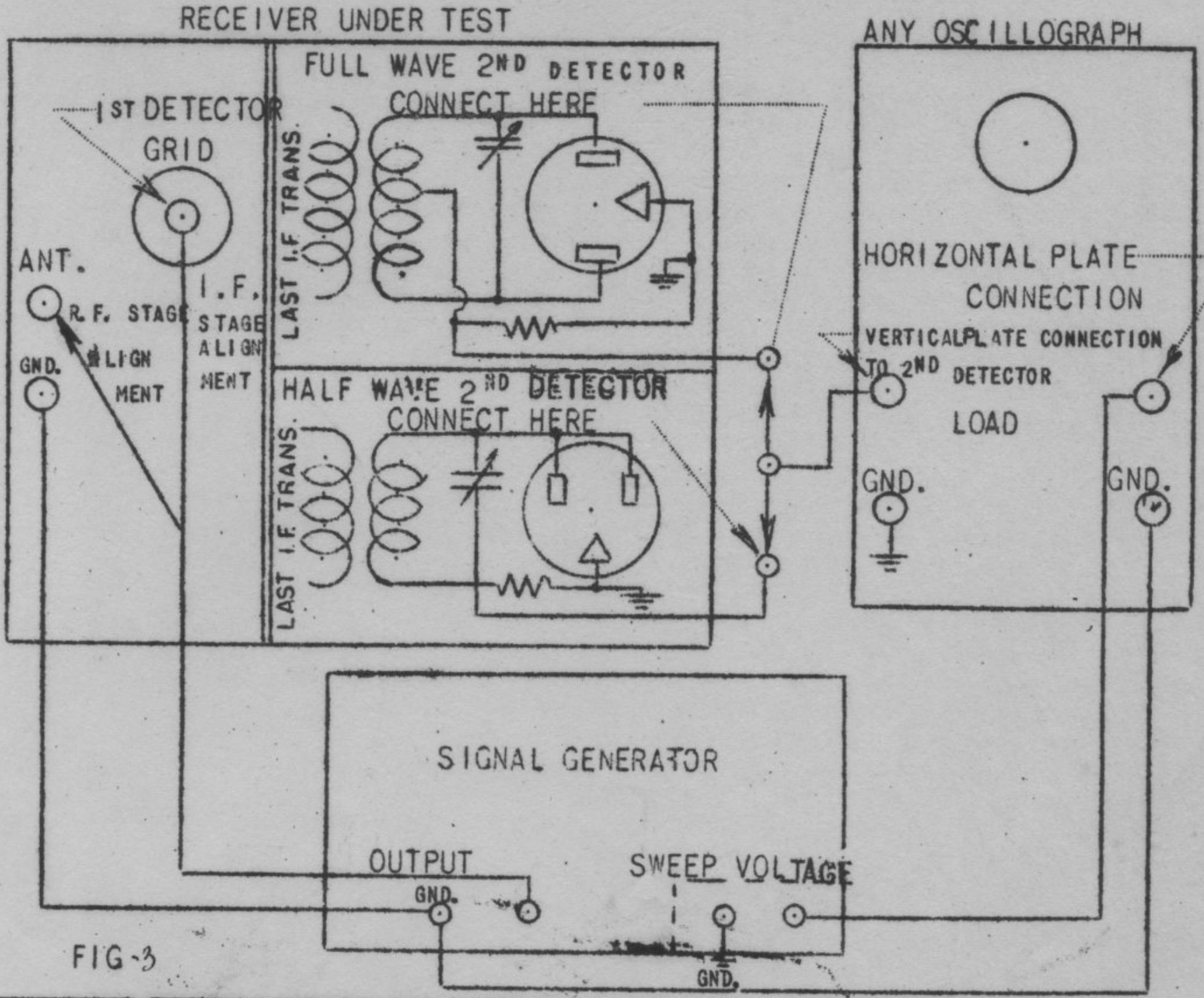


FIG-3

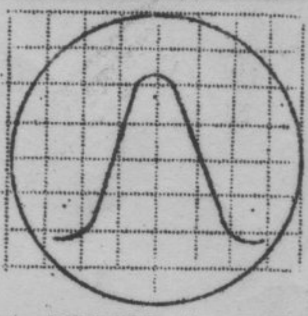


FIG. 4 PROPERLY ALIGNED AND TUNED

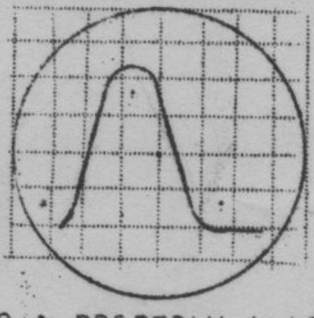


FIG. 5 PROPERLY ALIGNED TUNED BELOW PROPER FREQ.

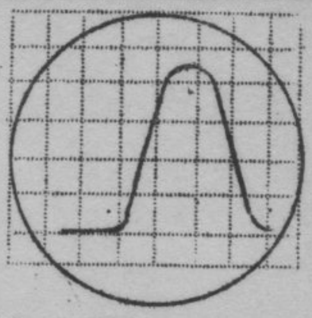


FIG 6 PROPERLY ALIGNED TUNED ABOVE PROPER FREQ

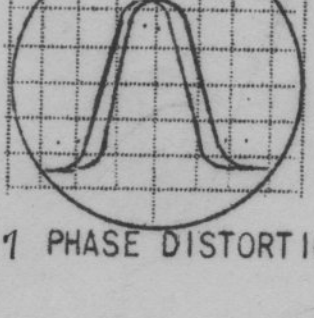


FIG. 7 PHASE DISTORTION

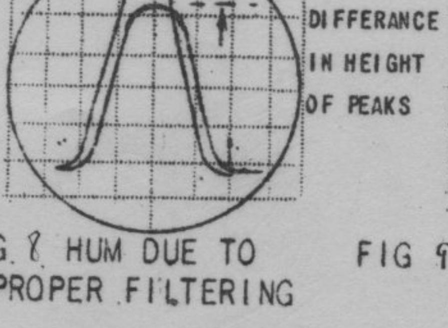


FIG. 8 HUM DUE TO IMPROPER FILTERING

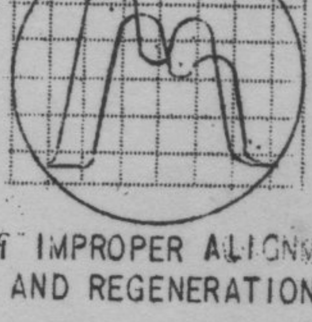


FIG 9 IMPROPER ALIGNMENT AND REGENERATION

mentioned, and the R.F. output connection to the antenna post, if alignment of radio frequency stage is desired, or to the first detector grid in the case of alignment of intermediate frequency stages only.

The connections from the receiver under test to the vertical plates of the oscillograph are illustrated under two headings. First, full wave second detector, and second, the half-wave second detector. The proper connection to the vertical plate is always at the high end of the load resistor on the second detector and in the case of full wave detection this will be found at the center tap of the last intermediate frequency transformer, whereas in the case of half wave detection it will be found at the low end of the last intermediate frequency transformer..

14. ALIGNMENT OF I.F. STAGES: With the connections as previously outlined and the receiver properly tuned and aligned the response curve should appear on the oscillograph as illustrated in Fig 4. That is, with symmetrical sides consistent with maximum amplitude and the two traces, that is, the forward and reverse trace completely coinciding. If the receiver is tuned to a lower frequency both curves should shift together to the left side of the screen, (Fig. 5), and as the receiver is tuned to a higher frequency, both curves should shift together to the right hand side of the screen, (Fig. 6).

It is quite possible to use the linear internal sweep on the oscillograph in lieu of the sweep circuit voltage as supplied by the Model 288X generator. However, in this case it is generally necessary to set several extra controls before alignment can proceed. The controls are the horizontal gain control; the sweep circuit oscillator step control; the sweep circuit oscillator vernier control; the synchronization switch and the horizontal locking control. By the use of the suggested generator all of these controls may be eliminated with the exception of the horizontal gain control thereby greatly simplifying the connection The actual response curve as viewed on the screen when using the internal sweep circuit oscillator, however, would be similar to these illustrated with the exception that the return trace should be eliminated and only the forward trace appearing on the screen.

15. ALIGNMENT OF R.F. STAGES: Disconnect the output from the signal generator from the fixed detector grid and connect to the antenna of the receiver under test.

16. THE OUTPUT frequency of the signal generator should be changed to correspond to manufacturers specifications on radio frequency alignment and the trimmers on the RF and oscillator sections should be adjusted to give the maximum amplitude consistent with symmetrical sides on the response curve.

As the oscillator trimmer T3 is adjusted it will probably be noted that the response curve will travel horizontally back and forth across the screen. Proper adjustment in this case would be to have the curve exactly centered in the screen when the dial setting on the receiver corresponded to the correct output frequency from the signal generator.

17. LOCATING TROUBLE WITH FREQUENCY MODULATED SIGNAL AND OSCILLOGRAPH:

MISALIGNMENT: When connecting up the oscillograph to a receiver it may be found in some cases that two humps or peaks appear in the response curve similar to Fig. 9 rather than a single symmetri curve as in Fig. 4. This would probably be caused by a misalignment of one of the intermediate frequency stages and the alignment of these stages should be checked and adjusted in an attempt to clear this condition up.

18. SHORTED TURN: If realignment will not correct this double peak as illustrated in Fig. 9 it is possible that there is a shorted turn in one of the intermediate frequency transformers. The effects of this shorted turn would be to decrease the inductance of the coil, thereby increasing its response frequency considerably above the proper value. In this case, of course, the remedy is to replace the defective transformer or correct the defective condition.

19. REGENERATION: In some cases where there is excess regeneration there will be a tendency for a double peak or hum similar to that illustrated in Fig. 9. This is usually traceable to defective or open by-pass condensers especially on the screen circuit. Double hump may also indicate over coupled circuits which may be satisfactory.

20. OSCILLATION: If regeneration is excessive it is quite possible that oscillation might occur. This is illustrated in Fig. 11. Corrective measures would be similar to those used for correcting regeneration.

21. PHASE DISTORTION: It is quite probable in the alignment of most receivers a certain amount of opening up of the two traces as illustrated in Fig. 7 will be present. A normal amount of this phase distortion should not be considered detrimental to the proper operation of the receiver, however, if the opening up of these traces gets as much as 1/4 or 3/8 of an inch it would be well to check the coupling capacitors and by-pass condensers for possibilities of being open.

22. HUM: If in aligning receivers a difference in the heighth of the two curves is noted as illustrated in Fig. 8, this will undoubtedly be caused by defective filtering in the power supply of the receiver and the correction in this case would be to replace the filter condensers or chokes in order to eliminate this hum.

23. AUDIO DISTORTION: If the signal generator were used as an audio frequency oscillator and fed through one of the audio frequency stages and a curve similar to Fig. 12 was obtained, it would be a definite indication of improper bias which would cause the voltag swing in one direction to be reduced whereas the swing in the lower direction would be normal. If a curve similar to Fig. 13 were obtained it would be a definite indication of an overload in the audio system.

FIG. 10

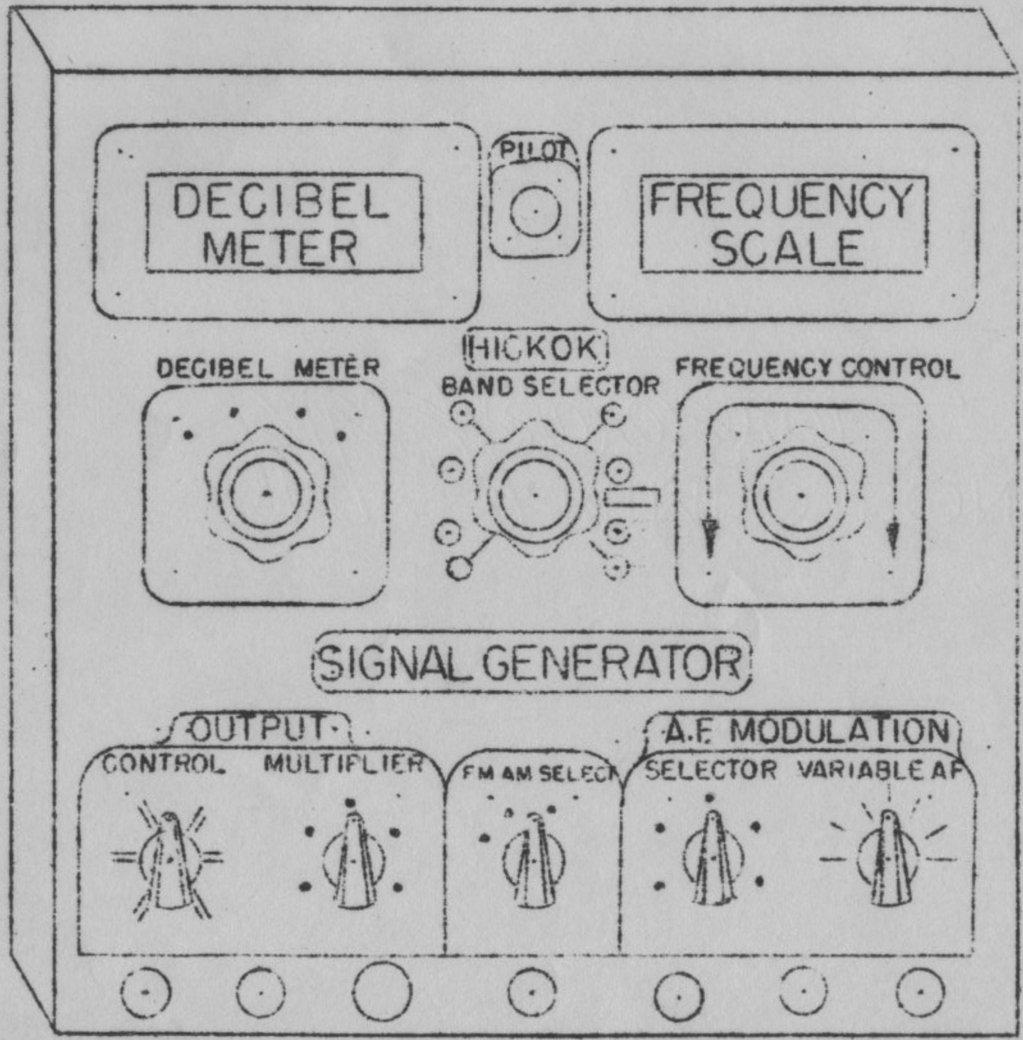


FIG. 11

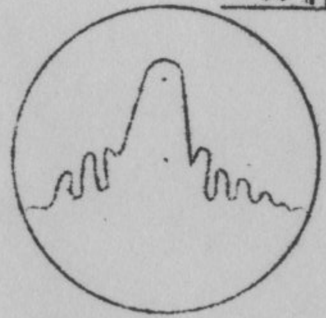


FIG. 12

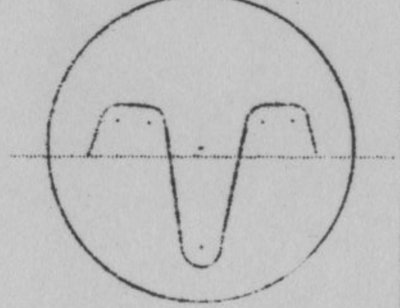
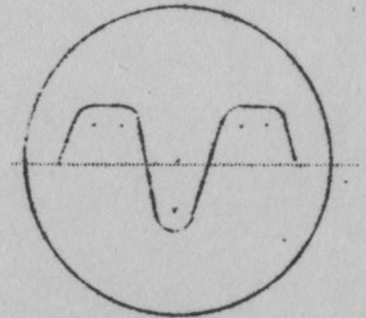


FIG. 13



24. USE OF PURE RADIO FREQUENCY OUTPUT: In general, there are two practical applications of the use of a pure radio frequency output. One of these is to check the calibration of your oscillator against known frequencies such as broadcast stations, etc.

The other use of the pure radio frequency output might be to check the automatic volume control voltage. In this test it is only necessary to feed the output of the signal generator to the antenna and ground post of the receiver and adjust the dial on the receiver to correspond to frequency being generated by the signal generator. For example, tune the receiver to 1000 KC and adjust the output of the signal generator for 1000 KC. By the use of an infinite resistance zero current voltmeter or vacuum tube voltmeter it is possible to measure the automatic control bias which is being supplied to the control grids of the first RF tube VT1 or the first intermediate amplifier tube VT3. In this test connect the indicating voltmeter through a fairly high resistance of 150,000 ohms or more to the control grid of VT1 or VT3. As the receiver dial is tuned to resonance of the output frequency of this signal generator, this control bias should increase appreciably and fall off again as the receiver is tuned beyond the resonance frequency. The voltmeter could also be connected to the low side of the secondary of the RF and IF transformers at point 14 or 15. If connections are made to these points it is not necessary to put an isolating resistor between the circuit under test and the vacuum tube or zero current voltmeter. In this connection it is well to point out that a voltmeter drawing any current at all cannot be used to accurately measure the voltage appearing at these points. These voltages are fed through high resistance networks designed so that there is no current being drawn through this circuit; therefore, the IR or voltage drop across the resistor R1 or R5 will be carrying current and a voltage drop will be produced at these resistors giving an incorrect reading on the voltmeter. At the present time there is commercially available only two types of voltmeters with which the measurement can be made, one being the zero current voltmeter and the other the vacuum tube voltmeter.

25. USE OF CRYSTAL CONTROLLED OUTPUT: To obtain crystal controlled output of either 100 or 1000 KC it is only necessary to turn the band selector switch to the 100 or 1000 KC position, depending upon the frequency desired. It is also possible to have the output frequency either modulated or unmodulated by turning the circuit selector switch to the 400 cycle modulated or pure R.F. position. When using the 100 KC crystal controlled output, harmonics of this will be available up to approximately 15 or 20 megacycles depending upon the sensitivity of the receiver. Of course, in the case of the lower priced receivers employing only one or two stages of amplification, it would probably be impossible to pick up the 100 KC output much beyond 3 or 4 megacycles.

The 1000 KC output harmonic can be used on almost any receiver up to 30 or 40 megacycles. On the more sensitive receivers this can easily be picked up to over 100 megacycles.

The incorporation of the crystal controlled output in signal generators serves two very definite functions. In the first plate, it serves as an excellent standard of frequency for calibration of the radio frequency and oscillator sections in all wave and multiband receivers since it provides an output signal accuracy better than 100th of 1% on every 100 KC channel from the low end of the broadcast band on up to the extreme high frequency end of any of the short wave bands. This frequency can be used with the conventional output meter for alignment work when it is amplitude modulated at 400 cycles.

It should be kept in mind that it is impossible to align intermediate frequency stages with the crystal control as its harmonics are 100 KC apart and almost all commercial intermediate frequencies fall between these harmonics. It is possible, however, to check the variable oscillators and signal generators at the intermediate frequency point by merely feeding the output of the crystal to some receiver which is tuned for a frequency which will be some harmonic of the intermediate frequency as well as some harmonic of the crystal frequency. For example, if it is desired to align the oscillator at 175 KC it is only necessary to turn the oscillator to the 100 KC crystal position and tune in the receiver very accurately at the 7th harmonic or 700 KC position on the dial. This will then establish an accurate 700 KC point. By switching the signal generator over to the "A" band and checking for maximum swing of the output meter when tuning at approximately 175 KC an accurate 175 KC signal can be obtained from the variable oscillator and this used for alignment of intermediate frequency stages. Other frequencies such as 456 could be obtained by setting the receiver to 900 KC and picking up the 9th harmonic of the crystal controlled 100 KC for maximum indication of the output meter. A very accurate 450 KC would then be established and whatever errors were apparent at 450 could be applied to 456 with extremely high degree of accuracy. For example, if 450 were actually found to come at 453 KC, the proper setting for 456 would be 459 KC to obtain a very accurate output. This same procedure may be used for checking the variable oscillator throughout any place in this range. For example, if it were desired to check the variable oscillator at 3500 KC it would only be necessary to tune some receiver in to the 35th harmonic of the 100 KC point and adjust it very accurately for maximum swing of the output meter. Switch over to 3500 KC on the variable oscillator and adjust this until maximum output meter indications were also obtained and when this has been done, of course, the test signal generator would be accurately adjusted for 3500 KC.

26. FREQUENCY MODULATED RECEIVERS: There are three fundamental differences between frequency modulated receivers and amplitude modulated receivers. These three differences are as follows:

FIRST: The use of wide band intermediate frequency amplifiers. The intermediate frequency amplifiers in amplitude modulated receivers are so designed that they will almost completely reject any signal which is as much as 10 or 15 KC different from that frequency to which the intermediate frequency amplifiers are tuned

In contrast to this, the intermediate frequency amplifiers of frequency modulated receivers or television receivers are so designed that they will pass a signal with very little attenuation which is as much as 100 KC either side of the frequency at which the intermediates are tuned. This is illustrated in Fig. 15.

In the case of amplitude modulated receivers, it is possible to feed an amplitude modulated signal through the intermediate frequency stages and align the trimming condensers on these stages for maximum output as indicated by an output meter and obtain a relatively good alignment.

In the case of wide band intermediate frequency stages of frequency modulated receivers, this can no longer be accomplished satisfactorily since the signal generator frequency being used for alignment can vary as much as 100 KC either side of the true frequency without getting an appreciable change as indicated on the output meter, or other indicating device. For this reason manufacturers of frequency modulated receivers recommend that the intermediate frequency stages be aligned by means of a wide band signal generator and oscillograph. The Model 288X signal generator is equipped with wide band frequency modulated signal generator specifically for this purpose.

27. SECOND: LIMITER TUBE: All frequency modulated receivers have following the last intermediate frequency transformer, a tube called the "Limiter Tube". It is the purpose of this tube to act as a gauge or valve between the output of the last intermediate frequency transformer and the input to the discriminator transformer, The tube is so connected that the output of the limiter tube is practically independent of any voltage fluctuation occurring in the input. In other words, the amplitude of the voltage being supplied to the grid might vary, for example, from 1 volt to 100 volts, whereas the output at the plate would be maintained constant at 1 volt. The reason for this limiter tube action is to eliminate amplitude changes which would be cause by static or other interfering noises or by the fading of the frequency modulated signal which may be expected at high frequenci

28. DISCRIMINATOR TRANSFORMER - TUBE: In contrast to the rectifier type detection with which we are familiar and which is generally associated with amplitude modulated receivers, the frequency modulating receiver uses a discriminator transformer and tube to detect or demodulate the frequency modulated signal and reproduce it as audio frequency. The action of this circuit is identical with the action of the conventional automatic frequency control discriminator transformer and tube circuit as explained later in this instruction manual. Essential difference being that the output voltage, which is generally used to control the frequency of the oscillator for AFC circuit used in amplitude modulated receiver, is used to feed the audio frequency amplifier tube. Briefly, the operation of this as a detector is as follows:

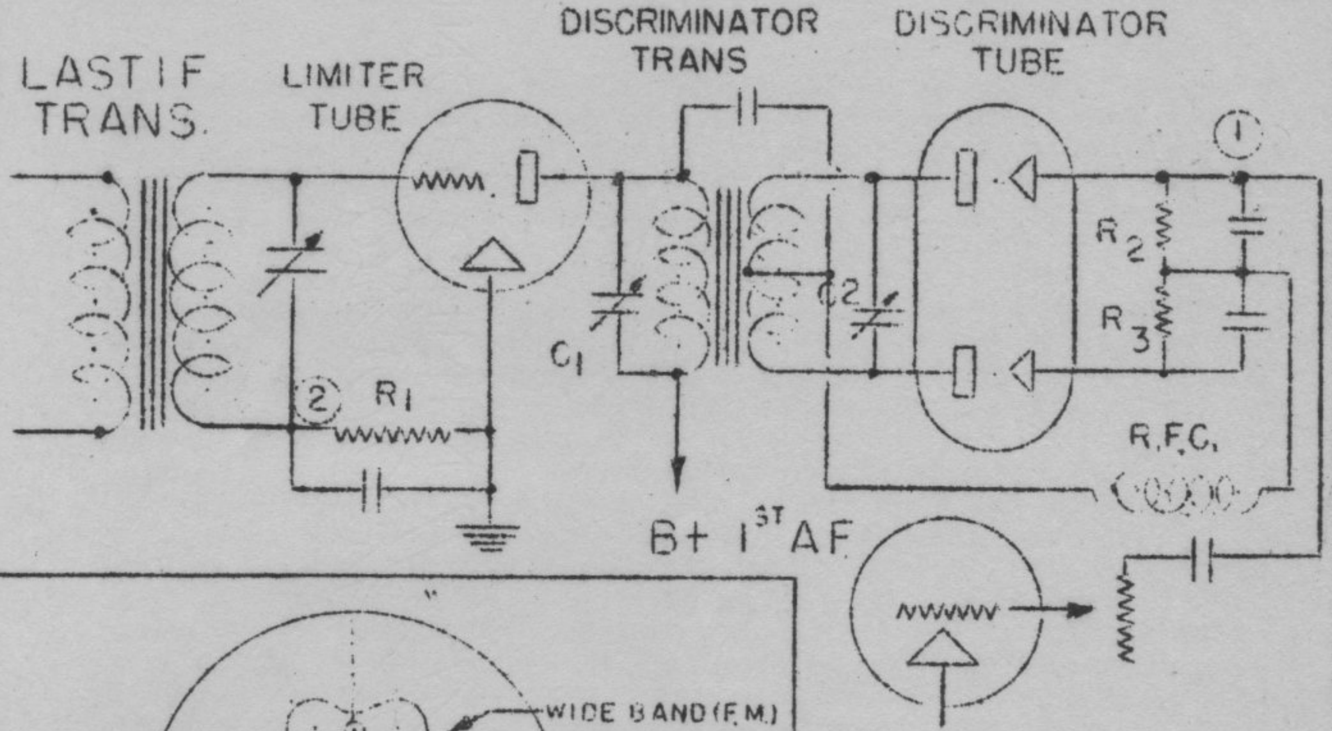


FIG 19

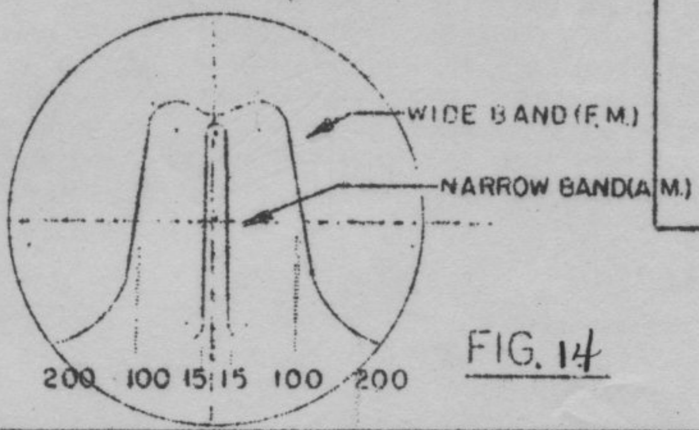


FIG. 14

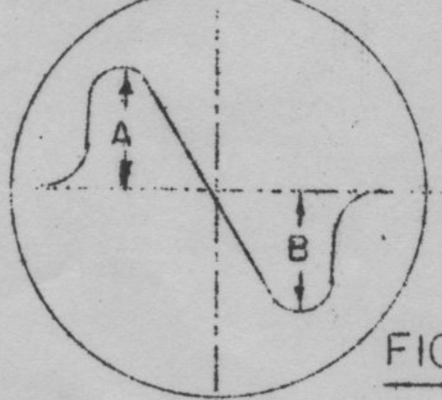


FIG. 15

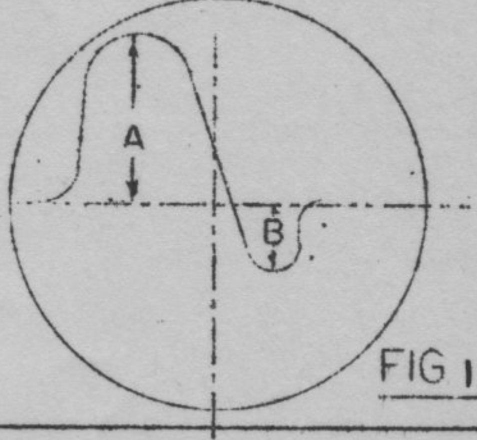


FIG 17

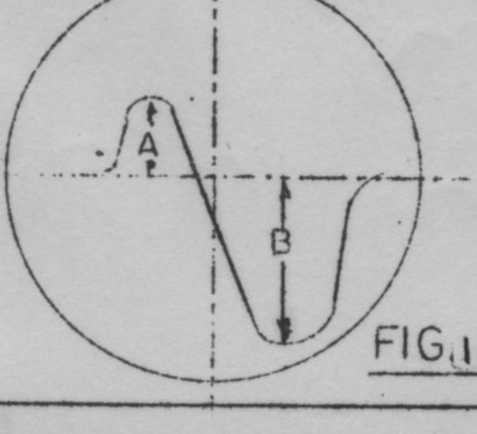


FIG. 16

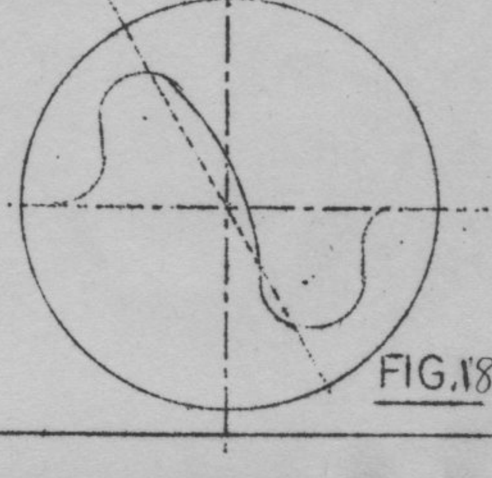


FIG. 18

If a signal is of the proper intermediate frequency and fed thru the intermediate frequency stages, it will first reach the limiter tube and be increased or decreased to some predetermined value depending upon the constants in the limiter tube circuit. This radio frequency at this predetermined value is then fed to the discriminator transformer, and then to the diodes of the discriminator tube. If the intermediate frequency transformers and the discriminator transformers are properly aligned, regardless of the magnitude of the voltage being delivered by the limiter tube, the D.C. voltage from point 1 to ground will be zero. If, However this frequency is increased above the frequency for which the discriminator transformer is tuned, the voltage at point 1 will become positive with respect to ground. Conversely, if the frequency is decreased below the frequency at which the discriminator transformer is tuned, the voltage at point 1 with respect to ground will become negative. By frequency modulating the signal which is being fed to the intermediate frequency transforme at some definite audio rate, we then have at the output of the discriminator tube, or between point 1 and ground, an audio frequency voltage which will be identical to the modulating voltage of the frequency modulated transmission. This audio frequency voltage is then fed to the first audio frequency amplifier tube and then on to the final A.F. stages and on to the speaker.

29. ALIGNMENT OF FREQUENCY MODULATED RECEIVERS: The only proper way to align frequency modulated receivers is by means of a wide band signal generator and oscillograph as previously mentioned. The procedure in alignment is as follows:

FIRST: Connect the vertical plates of the oscillograph at point 2, which is the limiter tube load resistance of the last intermediate frequency transformer. The ground should be connected to the ground or chassis of the receiver under test.

SECOND: Feed a wide band frequency modulated signal of the proper intermediate frequency in at the grid of the first detector tube. Then if, for example, the intermediate frequency of the receiver under test is 3 megacycles, the main variable oscillator should be set to 47 or 53 megacycles, giving a wide band frequency modulated signal at 3.0 megacycles - (See Principl of Operation.) Set the F.M.A.M. selector to 50 megacycles wide band frequency modulated signal and set the AF modulation selector to 60 cycles frequency modulated position. Set the output multiplier to FM and set the output control to maximum output.

THIRD: Adjust the trimmers on the intermediate frequency amplifie transformer to obtain a symmetrical response curve as illustrated in Fig. 15 for wide band frequency modulated IF signal.

FOURTH: Disconnect the input to the signal generator from point 2 and reconnect at point 1. If the discriminator transformer trimmer condenser C1 and C2 happen to have been properly adjusted, a response curve as illustrated in Fig. 16 will result. This is very unlikely and Fig. 17 illustrates the condition in which the capacity C2 is improperly adjusted on the low side of correct capacity, and Fig. 18 illustrates the condition in which capacity C2 is improperly adjusted on the high side of the correct capacity. It is then only necessary to adjust trimmer condenser C2 back and forth until the response curve on the cathode ray tube screen is centered and symmetrical with respect to all axis as illustrated in Fig. 15.

30. ADJUSTMENT OF CONDENSER C1: If condenser C2 has been properly adjusted, response curve as illustrated in Fig. 19 might result if capacity C1 were not properly adjusted. The adjustment of capacity C1 is done to bring the center part of the response curve to a straight line. If the capacity C1 has too much capacity, it may be curved upwards from a straight line, whereas if capacity C1 has too little capacity, it may be curved down from a straight line. In any event, adjust C1 until the curve as indicated in Fig. 19 most nearly shows a straight line. In the adjustment of C1 it may be found that the symmetry of the curve has been disturbed somewhat in which case it would be necessary to go back and readjust the tube to get the proper curve as illustrated in Fig. 16. The Hickok Oscillograph, Model 305? has been especially designed for use with frequencies and amplitude modulated receivers, and makes a very excellent unit for alignment as previously outlined.

31. ALIGNMENT OF R.F. STAGES: The alignment of radio frequency stages of frequency modulated receivers should also be made with an oscillograph, in which case the signal is fed in frequency modulated at the antenna and ground post with the oscillograph connected between point 2 and ground; the adjustment from the R.F. trimmer should be made to get a response curve as illustrated in Fig. 15.

32. ALIGNMENT OF OSCILLATOR ON FREQUENCY MODULATED RECEIVERS: The alignment of oscillator section of frequency modulated receivers should be effected as follows: Connect the oscillograph between point 2 and ground, set the main tuning dial of the frequency modulated receiver to some definite point, such as at the high end of the frequency modulated band, which will probably be approximately 106 magacycles. Feed a 106 megacycle frequency modulated signal in at the antenna post, which signal can be generated by setting the main variable oscillator 56 megacyles below 106 megacycles, or at 50 megacycles. Adjust the oscillator trimmer condenser until the response curve as illustrated in Fig. 15 is centered on the screen. If the oscillator trimmer condenser is adjusted with too much capacity, the entire curve will move towards the right of the screen, whereas if the oscillator condenser is adjusted with less capacity, the entire curve will move to the left of the screen. Merely adjust this oscillator trimmer condenser until the curve is centered on the screen and the oscillator is completely aligned.

33. ALTERNATE ADJUSTMENT OF FREQUENCY MODULATED OSCILLATOR: It is generally possible to align the oscillator or R.F. section of a frequency modulated receiver by using the first harmonic of the 50 megacycle frequency modulated oscillator as a source of signal.

In this case, of course, the dial should be adjusted to the first harmonic of 50 megacycles, or 100 megacycles, and all other adjustments made as previously noted. In this case the main variable oscillator should be turned to the "OFF" position, since it would not be needed.

34. ALIGNMENT OF FREQUENCY MODULATED RECEIVERS WITHOUT AN OSCILLOGRAP
It is possible to effect a partial alignment of a frequency modulated receiver without the use of an oscillograph, however, the problem becomes somewhat involved and requires considerable time and in addition to this, the alignment which is finally obtained would not be as good as though alignment were made in accordance with manufacturers instructions, which specify wide band signal generator and oscillographs. The procedure, however, in this case is as follows:

Disconnect load resistance R1 from ground and connect between it and ground a microammeter of approximately 200 or 300 microamperes full scale. Second, feed an unmodulated signal of the proper intermediate frequency in at the grid of the first detector tube and adjust the trimmer condensers on the intermediate frequency transformers for a maximum reading of the D.C. microammeter. The adjustment of these trimmer condensers will be found to be very broad due to the wide band characteristics of the intermediate frequency amplifier transformer. After the best adjustment which could be made has been effected, adjust the signal generator input approximately 50 or 100 KC below the proper intermediate frequency and note the reading on the D.C. microammeter. Then adjust the signal generator the same number of kilocycles above the proper intermediate frequency and then note the reading of a D.C. microammeter. If the intermediate frequency states had been aligned perfectly, the reading on the microammeter would decrease the same amount, when a signal was fed in above the proper intermediate frequency, that it decreased when the signal was fed in below the proper intermediate frequency.

It is quite probable that the first time alignment is made that this condition will not exist, and it will therefore be necessary to go back and realign the intermediate frequency and repeat the process until finally you have so adjusted them that the microammeter decreases the same amount when the frequency is decreased or increased above the proper intermediate frequency. Third, disconnect discriminator load resistance R3 from the ground and insert the 0-200 microampere meter between this resistance and ground. Fourth, with the same signal of the proper intermediate frequency being fed in at the first detector, adjust condenser C1 for the maximum reading of the microammeter. First, adjust condenser C2 until the microammeter reads zero. It will be found that as C2 is adjusted to increase capacity, that the microammeter will probably read upscale, whereas if it is adjusted to decrease capacity, the microammeter will go down to zero and then below scale. Adjust C2 until microammeter reads exactly zero.

35, USE OF D.C. VACUUM TUBE VOLTMETER: If a D.C. vacuum tube voltmeter such as the Hickok Model 110D, 203 or the D.C. vacuum tube voltmeter in the Hickok Traceometer, Model 156, is available it may be used in lieu of the D.C. microammeter as previously mentioned. In this case, connect the D.C. vacuum tube voltmeter across load resistance R1, that is, from point 2 to ground and make the adjustment as previously noted for the maximum reading of the D.C. vacuum tube voltmeter.

Likewise, the D.C. vacuum tube voltmeter can be connected between Point 1 and ground, and the adjustment made as previously noted first for maximum reading of the D.C. vacuum tube voltmeter when adjusting C1 and secondly for the zero reading of the D.C. vacuum tube voltmeter when adjusting C2.

36. R.F. ALIGNMENT: In R.F. alignment of frequency modulated receiver without an oscillograph, the signal should be fed in at the antenna and ground post of the receiver at the proper frequency, and in case of frequency modulated receivers tuning only for 88 to 106 megacycles the signal should be fed in at 106 megacycles and the dial on the receiver adjusted to this frequency.

Connect the D.C. vacuum tube voltmeter or microammeter in at load resistance R1 and adjust the trimmer on the R.F. tuning condenser for maximum reading of this meter. It will be necessary as in the case of intermediate frequency alignment, to check 100 KC above and 100 KC below this setting to insure that the alignments have been properly made.

37. ALIGNMENT OF OSCILLATOR: With all connections as previously outlined to the alignment of the R.F. section, adjust the oscillator trimmer condenser until maximum reading is obtained on these D.C. vacuum tube voltmeters or microammeters. Again it will be necessary to check either side of the fundamental frequency to make sure that the oscillator has been properly aligned.

USEFUL TECHNICAL DB DATA

POWER LEVEL DB	POWER 6MW AT 0 DB WATTS	VOLTS-BASED ON 6 MW AT 0 DB IN 500 OHMS	POWER LEVEL DB	POWER 6 MW AT 0 DB WATTS	VOLTS BASED 6 MW AT 0 DB IN 500 OHMS
- 10	0.0006	0.547	20	0.600	17.32
- 9	0.0007	0.614	21	0.755	19.43
- 8	0.0009	0.689	22	0.950	21.80
- 7	0.0011	0.773	23	1.197	24.46
- 6	0.0015	0.868	24	1.507	27.45
- 5	0.0018	0.974	25	1.897	30.80
- 4	0.0023	1.092	26	2.388	34.55
- 3	0.0030	1.226	27	3.007	38.77
- 2	0.0037	1.373	28	3.785	43.50
- 1	0.0047	1.543	29	4.766	48.81
0	0.006	1.732	30	6.000	54.77
1	0.007	1.943	31	7.553	61.45
2	0.009	2.180	32	9.509	68.95
3	0.011	2.446	33	11.97	77.36
4	0.015	2.745	34	15.07	86.80
5	0.018	3.080	35	18.97	97.40
6	0.023	3.455	36	23.88	109.2
7	0.030	3.877	37	30.07	122.6
8	0.037	4.350	38	37.85	137.5
9	0.047	4.881	39	47.66	154.3
10	0.060	5.477	40	60.00	173.2
11	0.075	6.145	41	75.53	194.3
12	0.095	6.895	42	95.09	218.0
13	0.119	7.736	43	119.71	244.6
14	0.150	8.680	44	150.71	274.5
15	0.189	9.740	45	189.74	308.0
16	0.238	10.92	46	238.86	345.5
17	0.300	12.26	47	300.7	387.7
18	0.378	13.75	48	378.5	435.0
19	0.476	15.43	49	476.6	488.1
			50	600.0	547.7

Observation of the foregoing table will disclose that for every 10 DB increase or decrease the power is increased or decreased 10 times. Also, that for every 3 DB increase or decrease the voltage is approximately doubled or halved. With this in mind values of DB power or voltage not given in the table could be estimated.

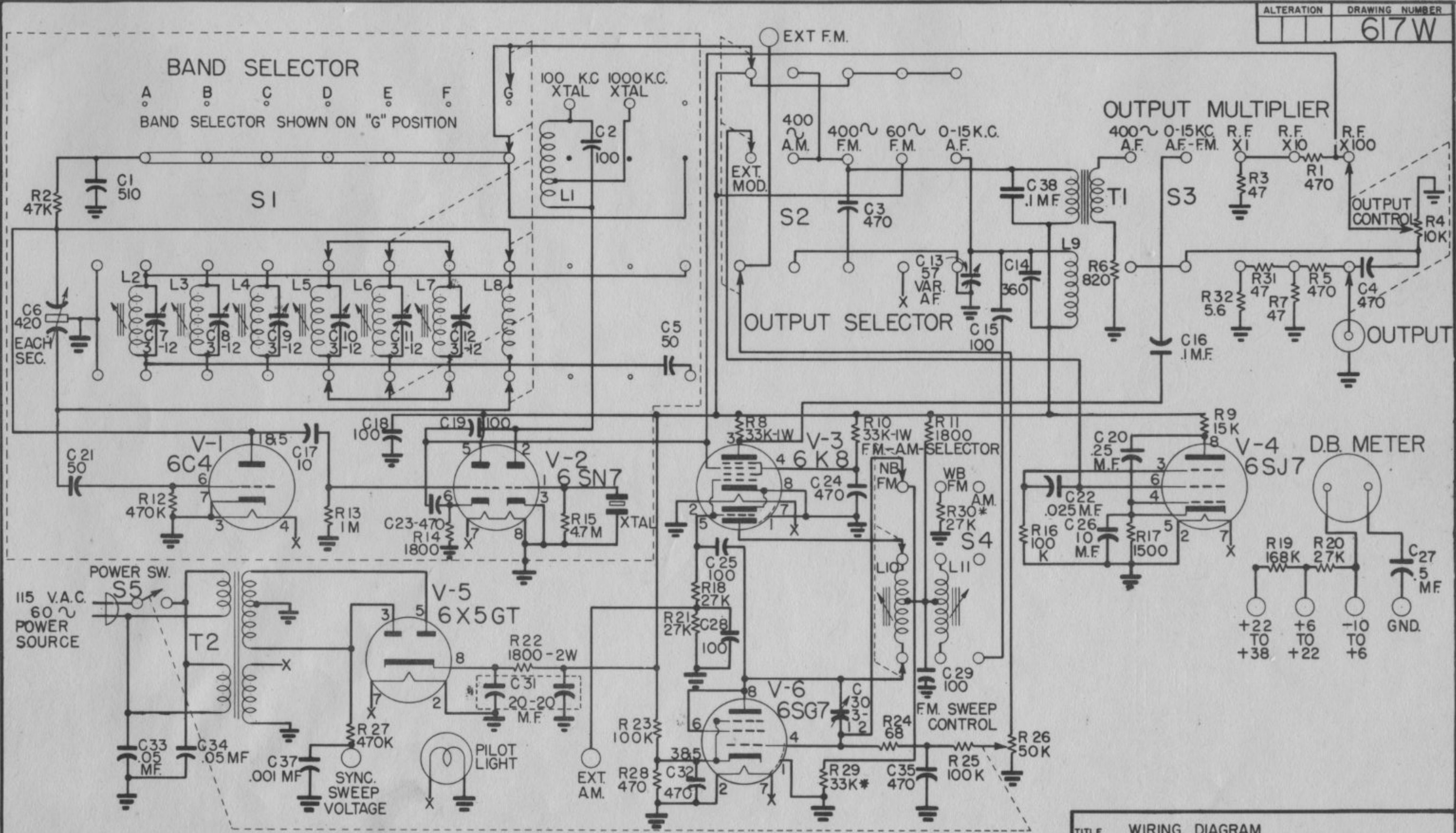
PARTS LIST FOR MODEL 288X

NOTE: - There is a minimum charge of $1.50 for the shipment of any one order.

REF SYMBOL	HICKOK CODE NUMBER	NAME AND DESCRIPTION	UNIT COST
M1	510-043	METER: 51X, decibel meter	$13.37
C1-3-4 C23-24 C32-35	3095-8	CAPACITOR: 470 mmf, 10%, 500 V, mica	.35
C2-15-18 C25-19 C28-29	3095-5	CAPACITOR: 100 mmf, 10%, 500 V, mica	.20
C5	3095-27	CAPACITOR: 47 mmf, 10%, 500 V, mica	.45
C6	3120-10	CAPACITOR: Variable, 420 mmf max. 12.5 mmf min.	2.00
C7-8-9 C10-11 C12-30	3115-1	CAPACITOR: 3-12 mmf, trimmer, ceramic	.45
C13	3120-1	CAPACITOR: Variable, 57 mmf, air	1.50
C14	3095-34	CAPACITOR: 360 mmf, 5%, 500 V, mica	.30
C16-38	3105-24	CAPACITOR: .1 mf, 400 V, paper	.20
C17	3095-2	CAPACITOR: 10 mmf, 10%, 500 V, mica	.20
C20	3105-13	CAPACITOR: .25 mf, 400 V, paper	.30
C21	3110-1	CAPACITOR: 50 mmf ± ½ mmf, ceramic	.70
C22	3105-7	CAPACITOR: .025 mf, 400 V, paper	.20
C26	3085-1	CAPACITOR: 10 mf, 25 V, electrolytic	.70
C27	3105-15	CAPACITOR: .5 mf, 200 V, paper	.45
C31	3085-7	CAPACITOR: 20-20 mf, 450 V, electrolytic	1.00
C33-34	3105-9	CAPACITOR: .05 mf, 400 V, paper	.20
C37	3095-9	CAPACITOR: 1000 mmf, 10%, 500 V, mica	.40

REF SYMBOL	HICKOK CODE NUMBER	NAME AND DESCRIPTION	UNIT COST
L1	3320-37	COIL: Oscillator crystal	$ 2.50
L2	3320-30	COIL: Oscillator "A" R-F	2.50
L3	3320-31	COIL: Oscillator "B" R-F	2.50
L4	3320-32	COIL: Oscillator "C" R-F	2.50
L5	3320-33	COIL: Oscillator "D" R-F	2.50
L6	3320-34	COIL: Oscillator "E" R-F	2.50
L7	3320-35	COIL: Oscillator "F" R-F	2.50
L8	3320-36	COIL: Oscillator "G" R-F	.10
L9	3320-38	COIL: Oscillator - beat oscillator	2.00
L10	3320-21	COIL: High Frequency-FM	2.00
L11	3320-12	COIL: Low Frequency-FM	2.00
R1-5-28	18475-53	RESISTOR: 470 ohms, 10%	.10
R2	18475-79	RESISTOR: 47,000 ohms, 10%	.10
R3-7-31	18475-89	RESISTOR: 47 ohms, 10%	.10
R4	16925-27	POTENTIOMETER: 10,000 ohms	.75
R6	18450-35	RESISTOR: 820 ohms, 5%	.10
R8-10	18550-37	RESISTOR: 33,000 ohms, 10%	.10
R9	18450-11	RESISTOR: 15,000 ohms, 10%	.10
R11-14	18450-52	RESISTOR: 1800 ohms, 10%	.10
R12-27	18475-90	RESISTOR: 470,000 ohms, 10%	.10
R13	18525-90	RESISTOR: 1 meg, 10%	.10
R15	18450-36	RESISTOR: 4.7 meg, 10%	.10
R16-23-25	18450-18	RESISTOR: 100,000 ohms, 10%	.10
R17	18450-5	RESISTOR: 1500 ohms, 10%	.10
R18-21	18475-39	RESISTOR: 27,000 ohms, 10%	.10
R19	18475-111	RESISTOR: 168,000 ohms, 5%, ½W	.10
R20	18475-92	RESISTOR: 27,000 ohms, 5%, ½W	.10
R22	18575-40	RESISTOR: 1800 ohms, 10%	.20
R24	18525-269	RESISTOR: 68 ohms, 10%	.10

REF SYMBOL	HICKOK CODE NUMBER	NAME AND DESCRIPTION	UNIT COST
R26	16925-47	POTENTIOMETER: 50,000 ohms, with a-c line switch, wire-wound	$ .90
S1	19912-111	SWITCH: 2 ceramic decks, 1 phenolic; 3 sections; 10 positions; rotary; Frequency Band Selector	1.75
S2	19912-113	SWITCH: 2 section; 5 positions; rotary; Output Selector	1.50
S3	19912-114	SWITCH: 2 sections; 5 positions; rotary; Attenuator	1.75
S4	19912-112	SWITCH: 1 section; 3 positions; rotary; FM-AM Selector	1.25
T1	20800-52	TRANSFORMER: Audio	1.75
T2	20800-58	TRANSFORMER: Power	
V1	20875-62	TUBE: 6C4 miniature	.80
V2	20875-19	TUBE: 6SN7GT	1.15
V3	20875-15	TUBE: 6K8GT	1.15
V4	20875-17	TUBE: 6SJ7GT	.95
V5	20875-22	TUBE: 6X5GT/G	.70
V6	20875-63	TUBE: 6SG7 metal	.95
Y1	3870-1	CRYSTAL: Dual frequency	9.25
	2360-15	BINDING POST: black	.40
	11500-11	KNOB: Hickok bar knob with pointer	.50
	11505-40	KNOB: Round with pointer and set screw	.70
	12270-5	LAMP, PILOT: #40 Mazda, 6-8 V	.15
	12450-98	LEAD: Assembly, red, 42", for meter	1.00
	19155-96	SHIELD: For miniature tube	.25
	19350-30	SOCKET: Octal, crimp-on	.15
	19350-31	SOCKET: Ass'y, panel light	.40
	19350-33	SOCKET: For miniature tube	.75



ALL VALUES FOR CAPACITORS ARE IN MMF. UNLESS OTHERWISE INDICATED.
ALL RESISTORS 1/2 WATT UNLESS OTHERWISE INDICATED.
✱ VALUES SHOWN FOR R-29 + R-30 ARE APPROXIMATE. EXACT VALUES DETERMINED IN PRODUCTION.
┼ (dot) =CONNECTION
┼ =NO CONNECTION.

TITLE	WIRING DIAGRAM		
USED ON	277 X - 288 X		QUANTITY
MATERIAL		S.A.E. GR.	SCALE X SIZE
TEMPER		FINISH	DATE 1 - 2 - 46
DRAWN S.S.	CHECKED	APPROVED 1 2 3 4 5 6 7	PART NUMBER 617 W