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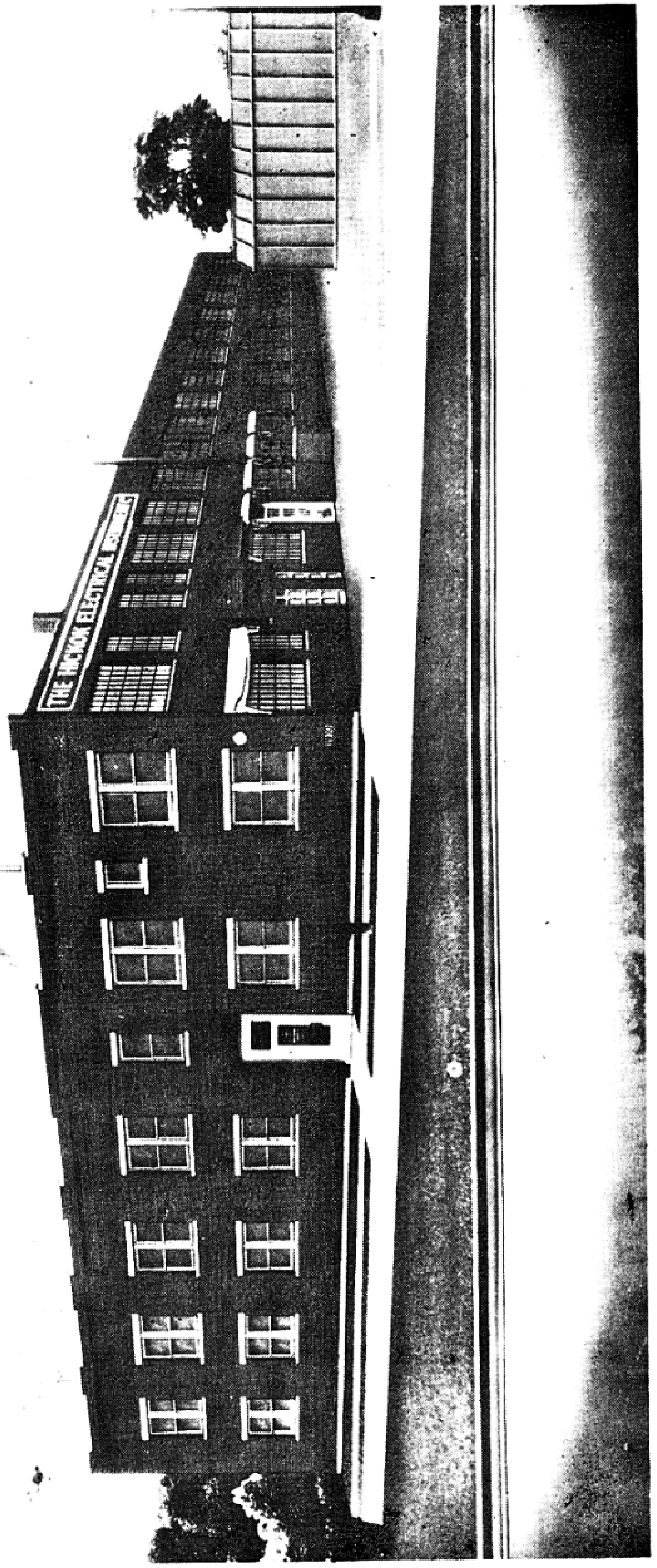


Main Office and Factory of The Hickok Electrical Instrument Co.
Cleveland, Ohio.

Back Cover

HICKOK

CATHODE RAY OSCILLOGRAPH

OPERATION AND APPLICATION

Treatise on the Theory of the Cathode Ray Tube:- the operation and application of Cathode Ray devices

PRICE 50c

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
Cleveland, Ohio

Note:
Some hand written notation in this manual may pertain to model RFO-5, not RFO-4.

INTRODUCTION

● The Cathode Ray Tube and associated apparatus has opened the way for further study of the higher frequencies. This booklet describes the Hickok Model RFO-4 Oscillograph, developed in our own laboratories.

● The Cathode Ray Tube acts very much like any indicating Voltmeter: the beam (or ray), when influenced by a voltage or voltages, will move in proportion to the impressed voltage or voltages.

● The beam of the Cathode Ray has no weight and, therefore, can move very rapidly; it has negligible inertia, therefore, it can follow changes very quickly.

● The ray (or beam) in rapid motion throws patterns on the flourescent screen and these patterns appear as continuous lines due to retentivity or persistence of vision.

● Keep in mind that the normal zero is in the exact center of the screen; that a voltage applied to the horizontal plates will cause the beam to move horizontally; that a voltage applied to the vertical plates will move the beam vertically. This forms the beginning of your study and complex patterns will be more easily understood.

● Very low voltages are often encountered. Therefore amplifiers are provided for each of the sets of deflector plates. The insertion of the amplifiers reverses the polarity of the input.

● The ensuing pages describe the various sections into which the completed instrument is divided; the operation is explained, and a few popular and useful applications are given.

● The Hickok Cathode Ray Oscillograph has countless uses. Some of these will suggest themselves; some will be discovered by you; others may be found by study of available text books.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
CLEVELAND, OHIO

January 15, 1940

Lithographed in U.S.A.

Index

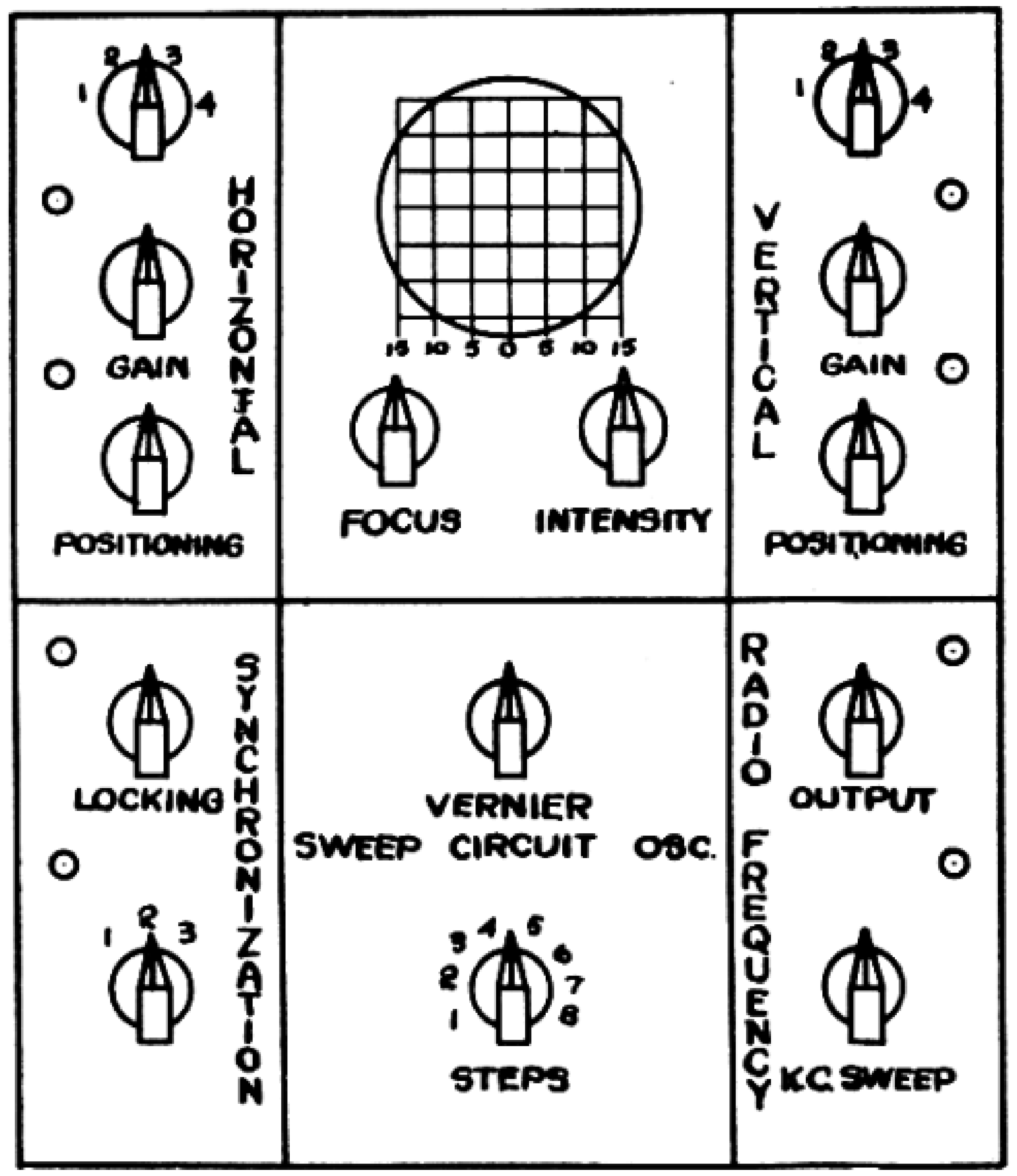
DESCRIPTION OF THE HICKOK RFO-4

CATHODE RAY OSCILLOGRAPH

¶1 The instrument panel is sub-divided into six functional panels. Each panel is blocked off separately to simplify the operation of the panel.

¶2 These six panels are:

1. Tube focus and intensity
2. Horizontal Control
3. Vertical Control
4. Synchronization Control
5. Sweep Circuit Oscillator
6. Radio Frequency Modulator (Wobbler)



OSCILLOGRAPH PANEL

1. Tube Focus and Intensity Panel

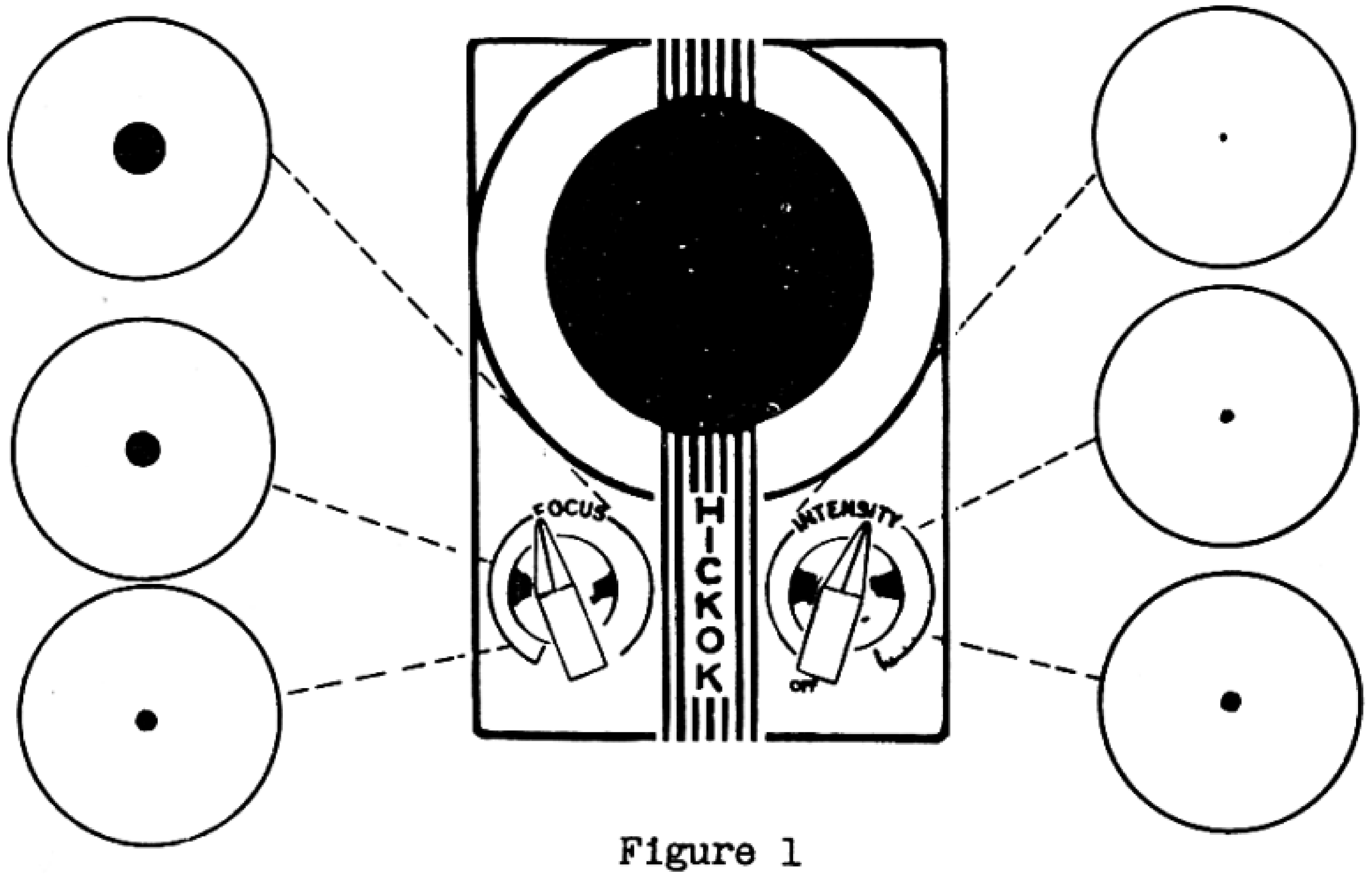


Figure 1

¶3 This panel section contains the face of the Cathode Ray Tube, the Focus Control and the on-off switch. Turning the Intensity Control clockwise switches the A.C. line current on. When the tubes are fully heated, the intensity or brilliance of the spot or line is governed by this control. The Focus Control regulates the diameter or size of the spot (or line).

¶4 These two controls should be set for minimum readable brilliance and smallest spot thus obtaining long tube life.

¶5 Special Precaution: Never leave the beam in one spot for long periods of time. If you do, the screen may become streaked or burned.

- Tube Life

¶6 With intelligent average use the tube supplied with this equipment should give many months and in some cases even many years of satisfactory service.

¶7 There are three common causes of tube failure:

First: Mechanical breakage of the glass envelope, or internal parts due to rough handling.
Second: Burning of the screen as previously mentioned.
Third: Loss of Emmission of the cathode.

¶8 The first two of these, of course, are not covered by the tube manufacturer's guarantee and so no adjustment can be expected. The third, however, will generally occur within the first two or three hours of operation if it is going to occur at all and an adjustment may be expected.

2. Horizontal Control Panel.

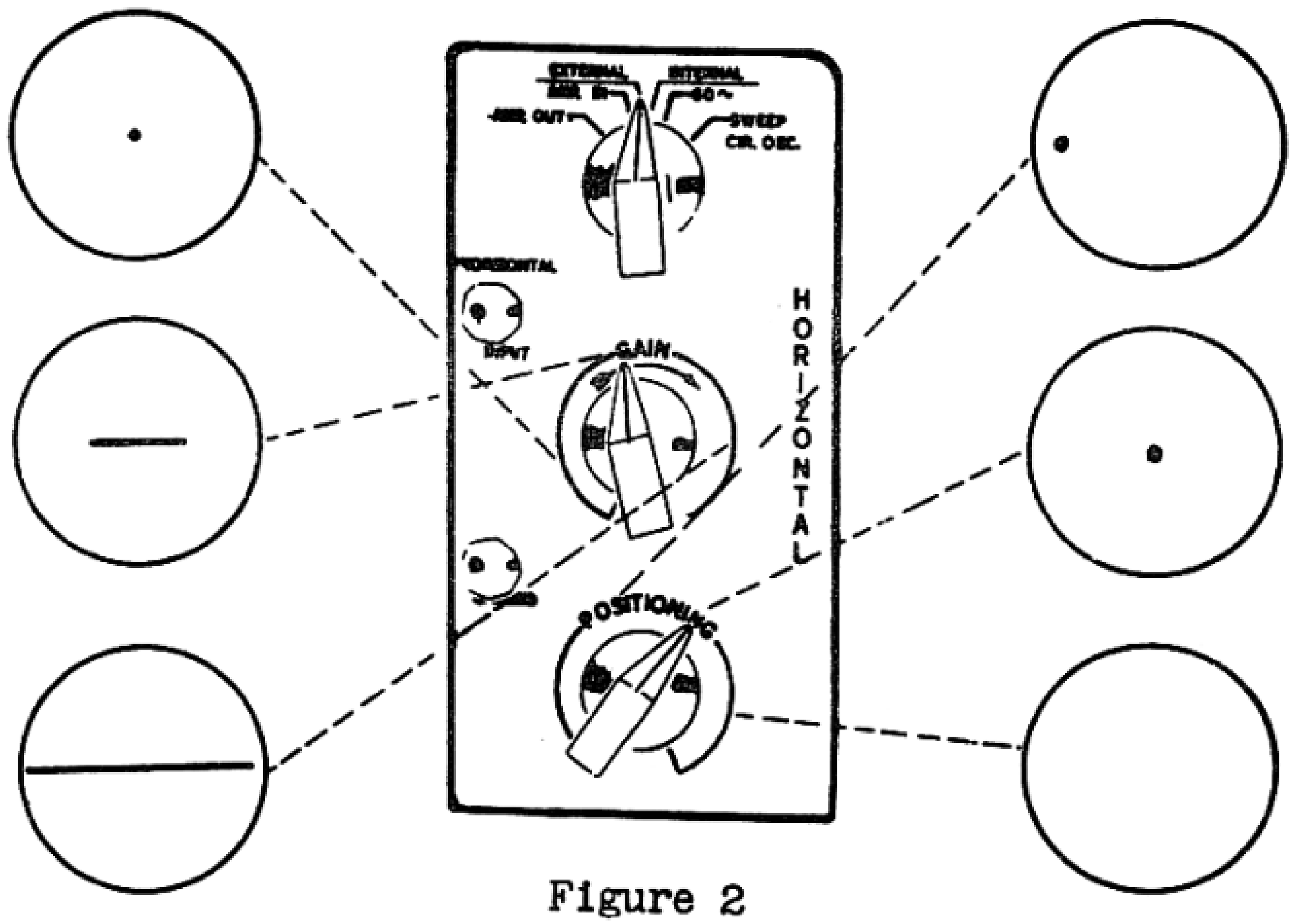


Figure 2

¶9 This section contains the main controls for the horizontal sweep of the cathode ray.

¶10 The selector switch has four positions:

a. Amp. Out. In this position the Horizontal Input and Ground binding posts are directly connected through a blocking condenser to the horizontal plates of the Cathode Ray Tube.

b. Amp. In. When the switch is turned to this position an amplifier is introduced between horizontal plates and the horizontal input circuit from the Horizontal Input and Ground binding posts.

c. 60 Cycles. This position connects an internal 60 cycle voltage to the horizontal plates of the Cathode Ray Tube.

d. Sweep Cir. Osc. With the switch in this position, the Sweep Circuit Oscillator is connected to the horizontal plates of the Cathode Ray Tube through the amplifier. The Sweep Circuit Oscillator will be explained later.

¶11 Gain Control. This knob increases the amplifier gain on the horizontal plates when the selector switch is on Amp. In or Sweep Cir. Osc. It is otherwise out of the circuit.

¶12 Positioning. This control moves the horizontal trace to the left or right and is used mainly to center the pattern.

3. Vertical Control Panel.

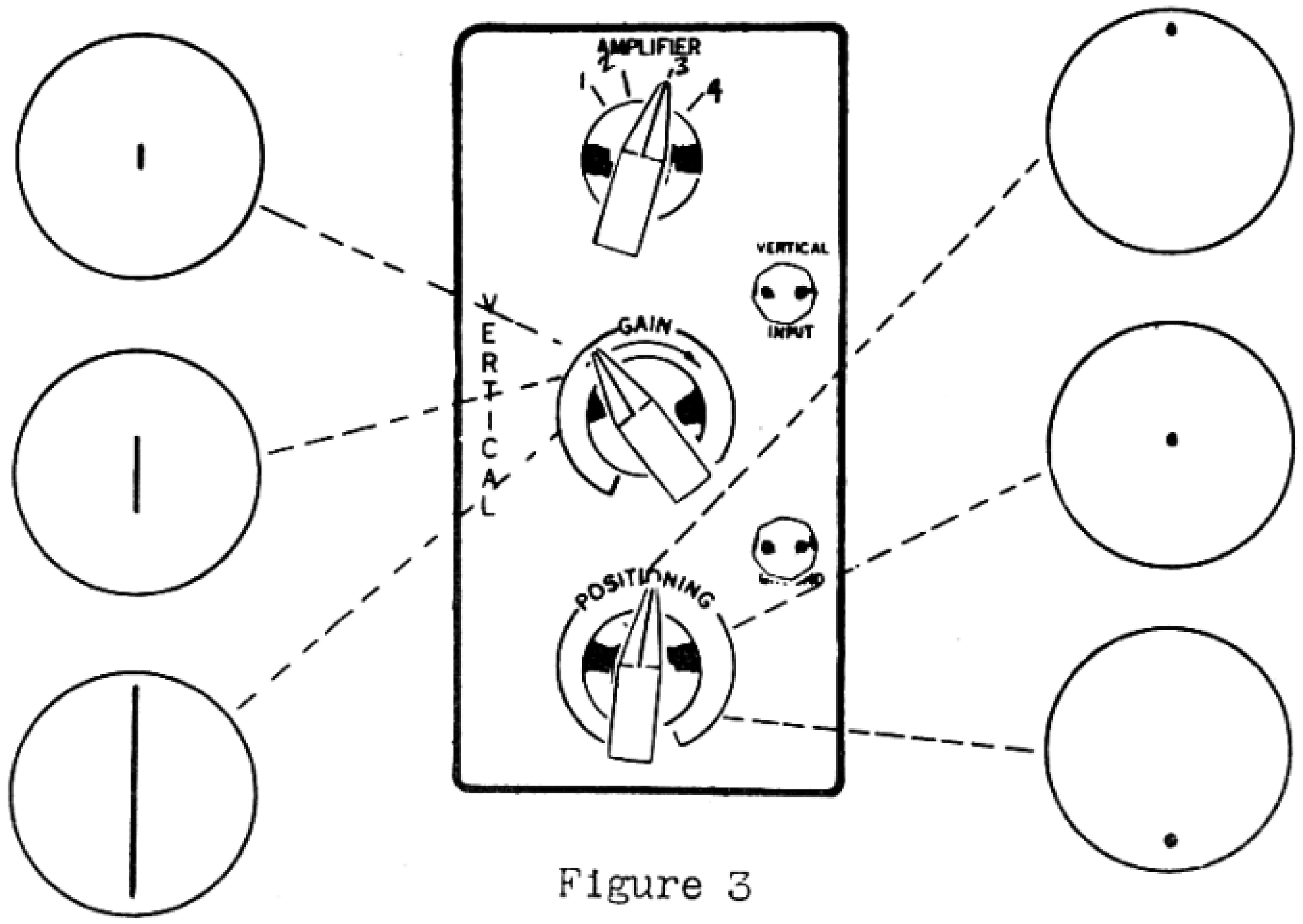


Figure 3

¶13 This section contains the main controls for the vertical plates of the Cathode Ray Tube.

¶14 The selector switch has Four positions-

1 Standard Amplifier In. In this position a high gain low frequency amplifier is in the vertical input circuit, amplifying any voltage connected to Vertical Input and Ground binding posts.

2 Video Amplifier In. In this position a low gain wide band video amplifier is in the vertical input circuit, amplifying any voltage connected to Vertical Input and Ground binding posts.

3 Demodulator. In this position radio frequency voltages applied to the vertical input binding post may be fed to the demodulator tube, and the demodulated output will be applied to the input of the vertical amplifier and thru this to the vertical plate.

4 Amplifier Out. With the switch in this position, the amplifier is cut out, thus making direct connections to the Vertical Input and Ground binding posts (through a blocking condenser).

¶15 Gain Control. This knob controls the gain through the vertical amplifier and is in circuit only when the amplifier is connected.

¶16 Positioning. This control serves to position the vertical trace and is used to center this trace.

● Vertical input and ground binding posts are also incorporated in this panel.

4. Synchronization Control Panel.

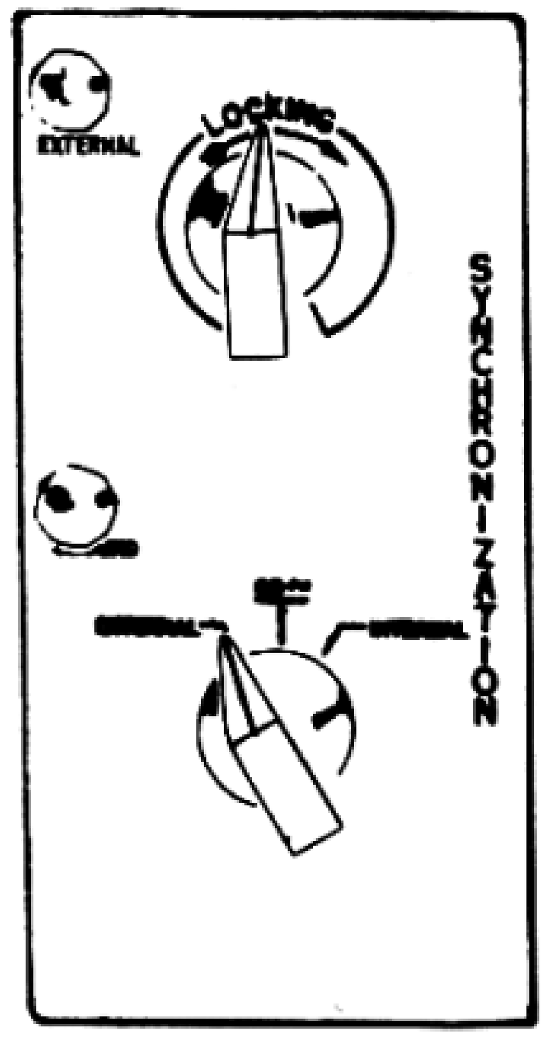


Figure 4

¶18 This section controls the synchronization of the horizontal sweep with the vertical. The theory being that a small voltage taken from the vertical plates or some other desirable source will tend to keep the pattern stationary on the screen. This will be explained in detail later on.

¶19 The rotary switch located in the lower part of this section has three positions:

External. In this position the synchronization circuit is connected to binding posts External and Ground.

Return Eliminator. In this position the return trace will be eliminated when using a 60 cycle sinusoidal voltage for horizontal sweep. This will be found particularly useful for AF and RF response curves as explained later.

Internal. When the switch is turned to this position, the horizontal sweep frequency may be synchronized with any vertical frequency.

¶20 Locking Control. This controls the locking voltage applied to the horizontal plates in respect to the position of the selector switch connections. Advancing this control increases the locking.

¶21 The controls on the synchronization panel will be effective only when the sweep circuit oscillator is being used for the horizontal deflection of the beam.

5. Sweep Circuit Oscillator.

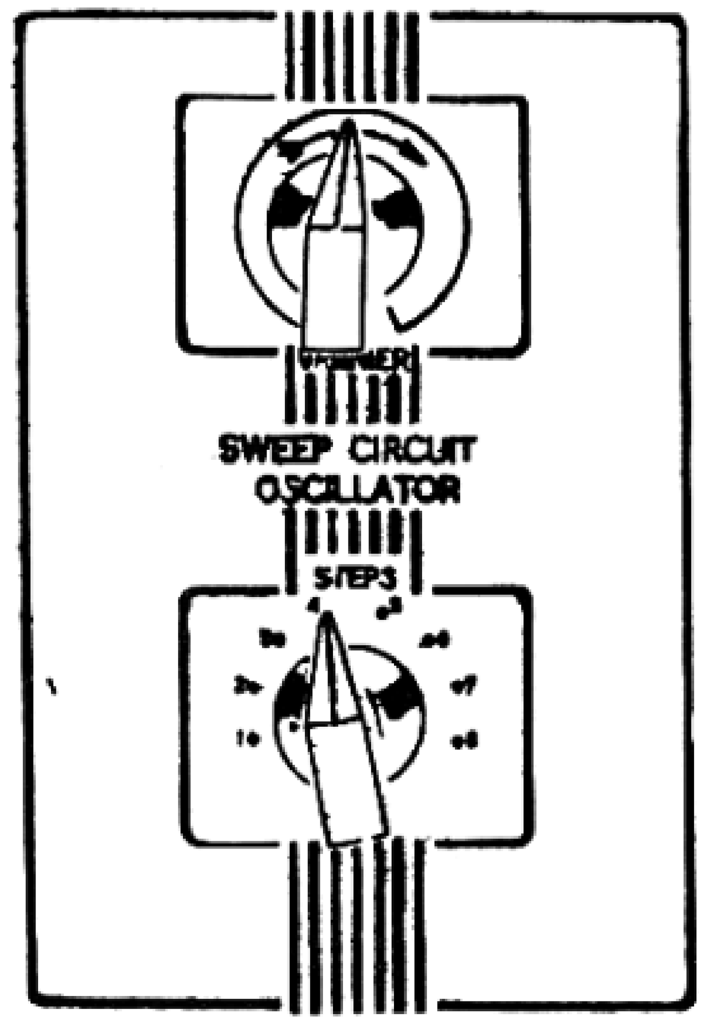


Figure 5

¶22 This section is interconnected to the Horizontal Control Panel. The Oscillator is so arranged that it builds up slowly to the crest of the positive polarily and returns to negative crest almost instantaneously. The explanation of this circuit will be given later.

¶23 The selector switch in the lower half of this section has eight positions or Steps. These are the rough adjustments for frequencies from 15 cycles to 15000 cycles. The Vernier is for fine adjustments between steps and has sufficient overlap to cover frequencies over each step.

¶24 A sweep circuit oscillator is commonly known as a "linear" or "sawtooth" oscillator. The names are derived from the fact that its function is to produce a linear or uniform motion of the beam across the screen so that voltages applied to the vertical plates may be spread out and viewed as voltage (plus or minus) vertically with respect to time horizontally. Since the frequency of the linear oscillator can be adjusted through wide limits, audio frequencies of almost any order can be studied and analysed.

6. Radio Frequency Panel.

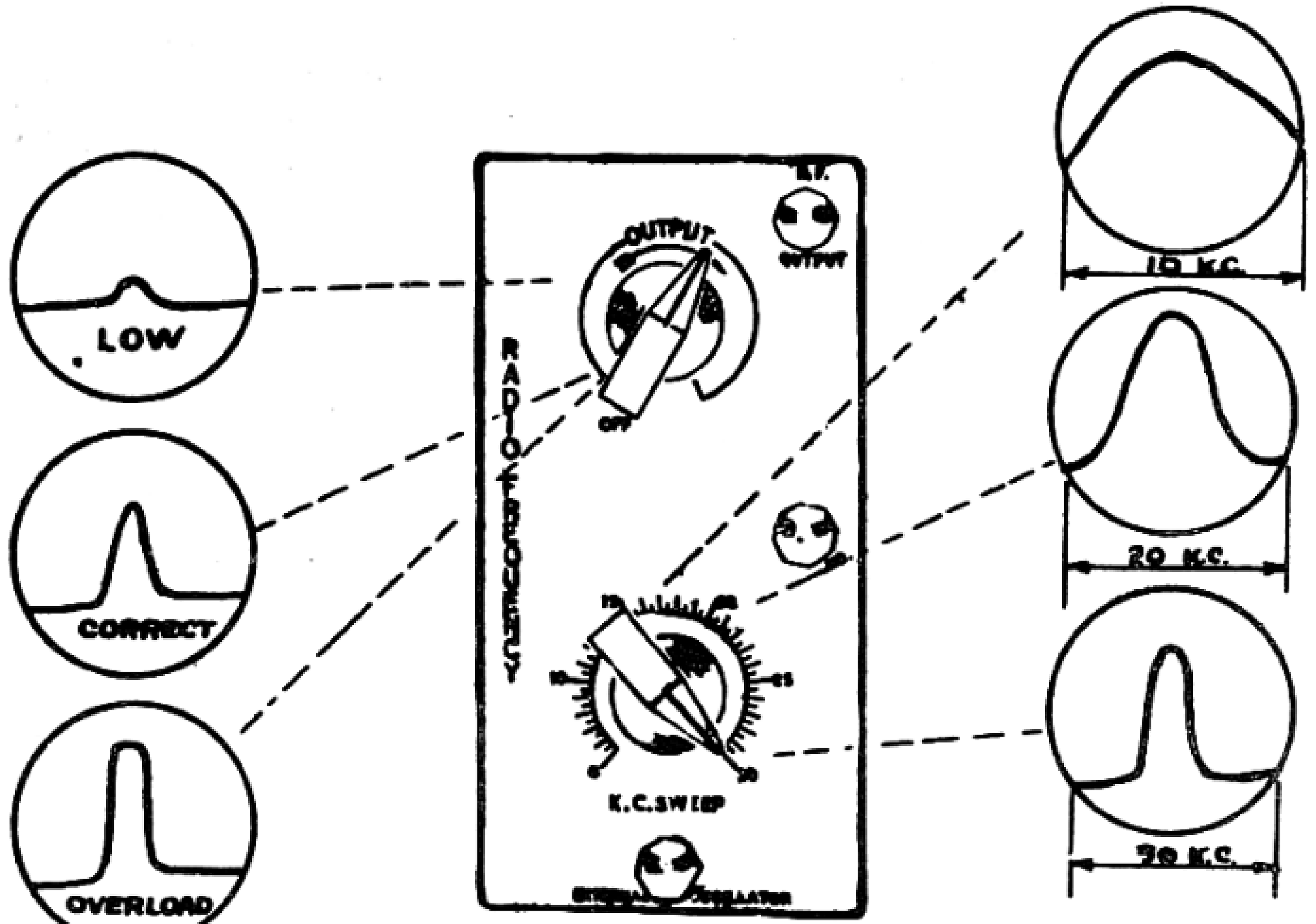


Figure 6

¶25 This section of the panel contains the controls for the frequency modulator. The circuit is an electronic controlled oscillator, frequency modulated from /0 to 30 kilocycles. This action is sometimes referred to as a "Wobbler".

¶26 The binding post R. F. Output is the oscillator output; the Ground being the customary chassis connection. The binding post in the bottom center of the panel is for connection to an external oscillator for beat-note or heterodyne purposes.

¶27 The control knob Output serves as an output attenuator and also combines an off-on switch for the Radio Frequency Section only.

¶28 The K.C.Sweep Control Knob is used to regulate the frequency modulation and can be varied from 0 to 30 kilocycles. When rotated completely counter clockwise until switch action is obtained, the rate of sweep changes from 60 to 120 cycles. In this position the width of sweep is fixed at 30 K.C.

¶29 This section is ordinarily used only for the alignment of Radio Frequency or Intermediate Stages or component parts, and may also be used for development of dynamic and static Audio Frequency outputs as will be explained later.

¶30 The operating frequency of this oscillator is 665 K.C. unless otherwise noted and may be used for visual alignment at this frequency or any harmonic thereof up to approximately 5 megacycles without the use of an external oscillator.

7. The Cathode Ray Tube.

¶31 The cathode ray tube may be compared with a galvanometer. The cathode ray can be moved vertically or horizontally, or vertical and horizontal movements can be combined to produce patterns on the tube screen. The ray is without weight and possesses very little inertia. Thus, it is faster and more flexible than a galvanometer. It requires a negligible amount of power for its operation, thus permitting accurate readings without loading of the circuit under test.

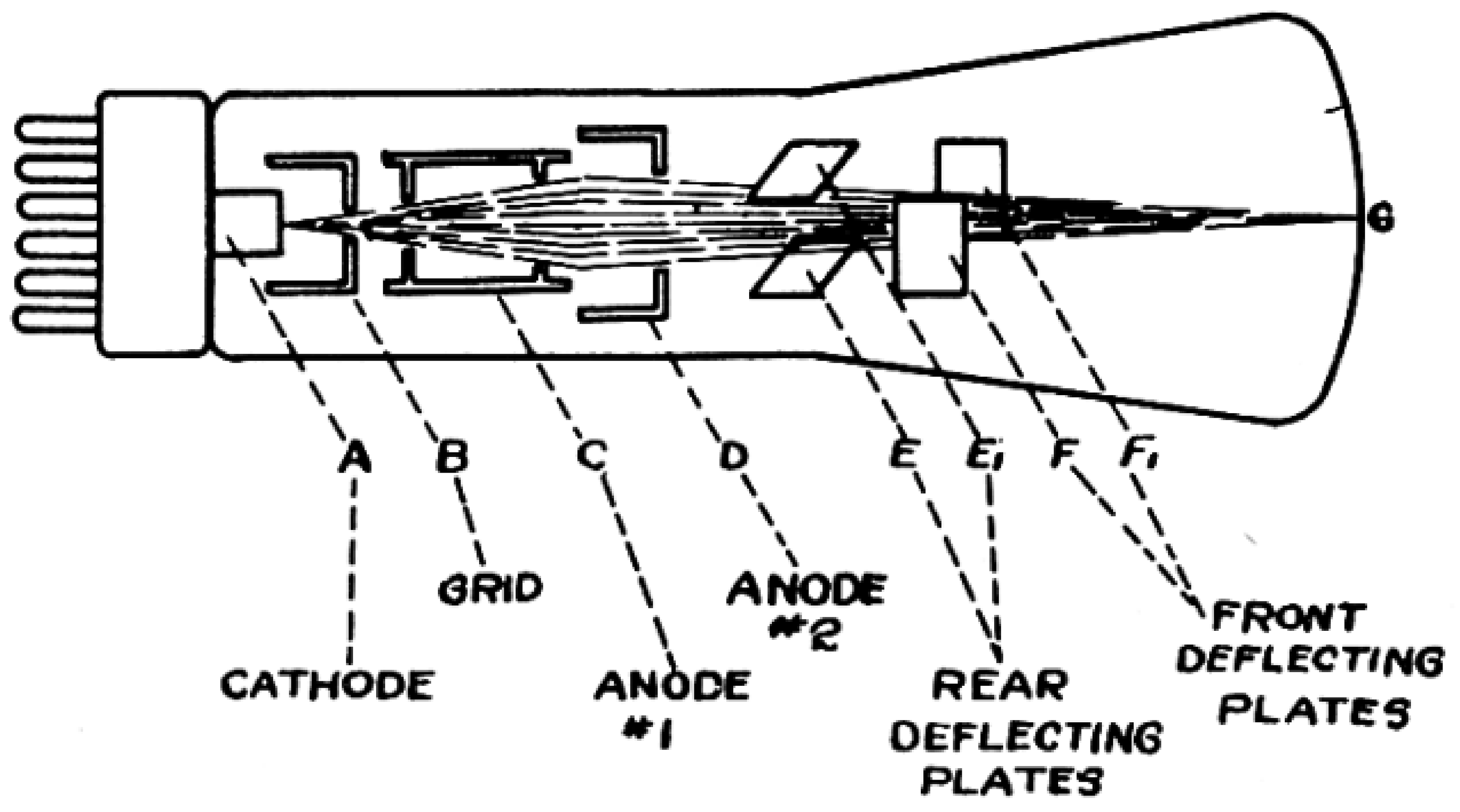


Figure 8

- How It Works:

¶32 Fig. 8 shows the details of the Cathode Ray Tube. Electrons emitted from the Cathode flow through the control grid toward Anodes (Plates) 1 and 2, due to the higher positive potentials on these Anodes. The stream continues through two sets of deflecting plates, horizontal and vertical, to the flourescent screen. One of each of the horizontal and vertical plates is at ground potential. With no potential applied to the deflecting plates the cathode ray will appear as a spot on the center of the tube screen. If a positive voltage is placed on one horizontal plate the ray or spot will move to the right in proportion to the potential applied; if negative, then the spot will travel to the left.

¶33 Thus an alternating voltage would cause the spot to move to its one extremity and then to the center and then to the other extremity and to center, which movement would be repeated until the voltage is removed.

- Persistence of Vision:

¶34 Any image reaching the retina of the eye registers and persists there for a period of time even though the image disappears. If the image is registered at the rate of 16 or more times per second the image appears continuous. As an example, "moving" pictures are really a series of "still" pictures projected progressively at the rate of 16 or more per second. As such the motion appears continuous.

¶35 Similarly, if a cathode ray spot is moved on the screen at the rate of 16 or more cycles per second, the movement or trace will appear to be continuous.

¶36 This is due to persistence of vision.

¶37 Vertical deflection is precisely the same with a voltage applied to the vertical plates.

¶38 Note: The Hickok RFO-4 Oscillograph is wired with a blocking condenser in the circuits to the deflecting plates as a safety measure.

- Setting up the Oscillograph.

¶39 The Hickok Oscillograph is shipped complete, but, to prevent damage to the tube, the Cathode Ray Tube is removed before shipping.

¶40 To install the Cathode Ray Tube, remove the top and side screws from the front and rear of the case cover, loosen the nuts holding the tube socket and insert the tube. Tighten the nuts sufficiently to hold the tube securely and then replace the cover.

¶41 Caution: Never turn on the Oscillograph with the cover removed. Very high and dangerous voltages are present in this apparatus.

¶42 Unless otherwise noted, the oscillograph is to operated from 110-120 volts, 50-60 cycle A.C. supply.

¶43 The power consumed is approximately 50 watts.

¶44 If the pilot light in the lower left corner does not light immediately, investigate the following:

(a) Be sure the supply line is A.C. Not D.C.
(b) Check the voltage.
(c) Check the fuse mounted on the resistor support beneath the chassis.
(d) Check the pilot lamp to be sure it has not become loosened in transit or is not burned out.

● Operating the Oscillograph.

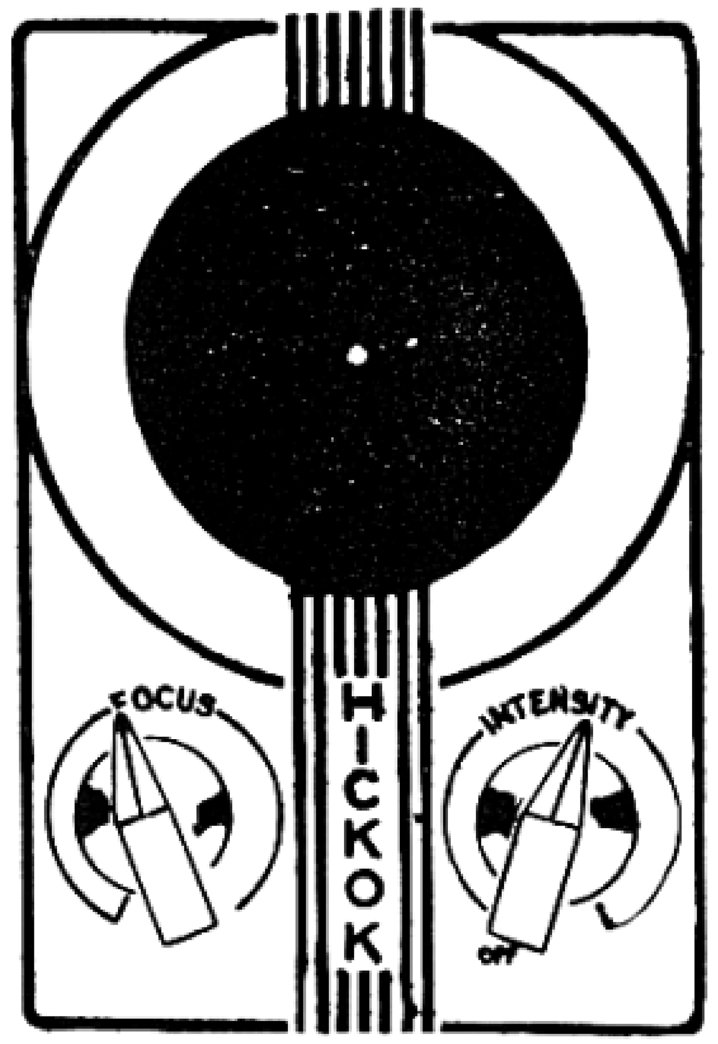


Figure 9

¶45 1. Turn Horizontal and Vertical Control Selector switch to OUT and the Synchronization Selector Switch to External.

¶46 2. Turn Intensity Control to slightly over half rotation. This action turns on the a.c. current and lights the pilot signal in the lower left corner. Wait for cathodes to heat.

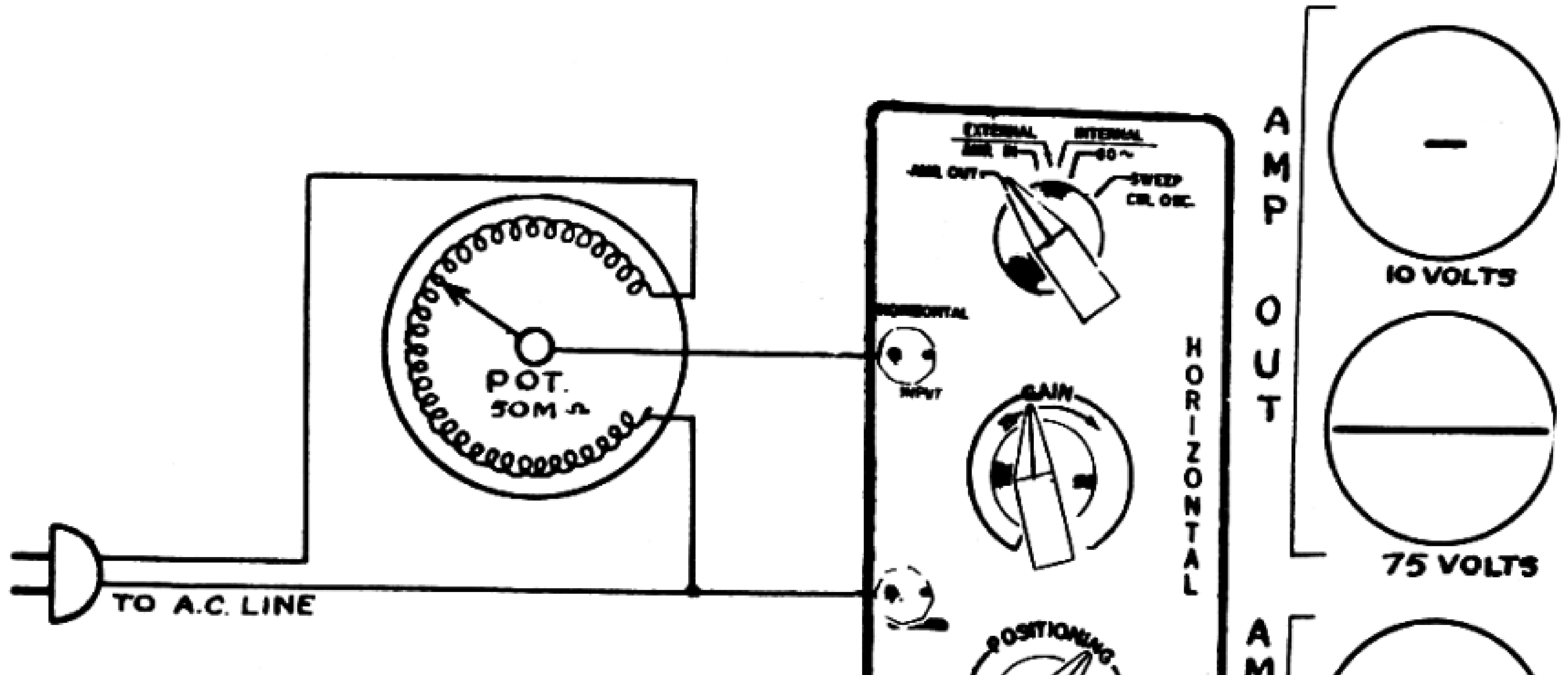
¶47 3. Adjust the spot on the screen. This is done by increasing or decreasing the Intensity Control until the minimum desired brilliance is obtained. Next, rotate the Focus control until the spot is brought down to a point.

¶48 4. During the foregoing, the spot might not be in the screen center. The spot may be positioned horizontally by rotating the horizontal Positioning Control, vertically by rotating the vertical Positioning Control.

Caution: Do not leave the spot in one place for a very long period of time. To do so will burn that part of the tube screen. (When the spot is once adjusted, you can turn the horizontal selector switch to 60 Cycles position, which action will sweep the spot across the screen and prevent damage) or the Intensity Control may be rotated counter clockwise until the spot disappears.

¶49 5. To test the Horizontal Deflection: Turn the horizontal selector switch to Amp. Out. Connect any low a.c. voltage source to Horizontal Input and Ground. This can well be done by using a potentiometer as illustrated. A voltage of 75 will sweep almost across the screen. A correspondingly lower sweep will be accomplished by applying a lower voltage. Next, turn the selector switch to Amp. In. This interposes a voltage

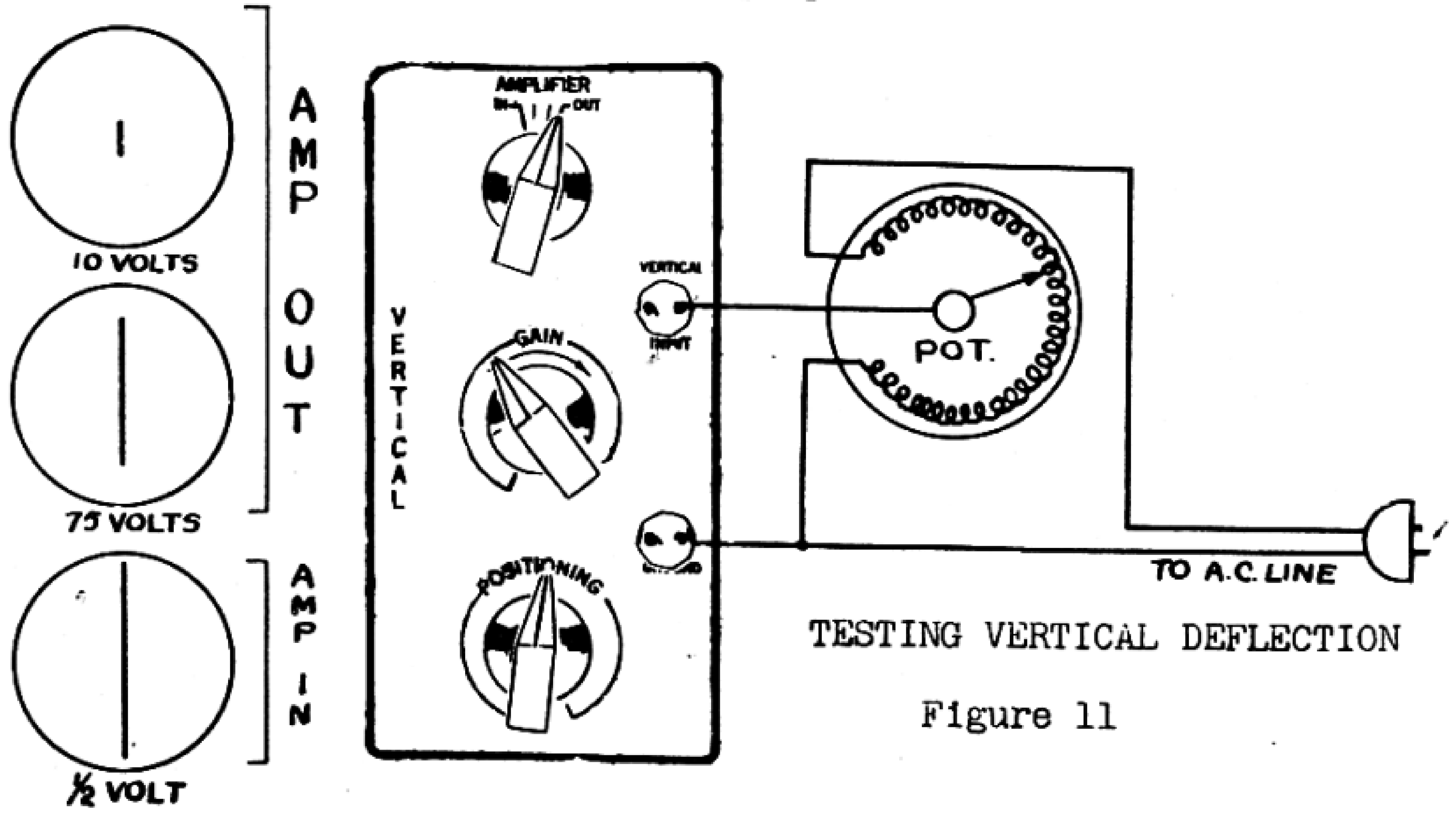
amplifier and, by means of the Gain control, the width of the sweep may be moved from a spot to a complete sweep. This explains the use of the amplifier which may be used when the voltage to be measured is too low to give ample sweep for your purpose.



TESTING HORIZONTAL DEFLECTION

Figure 10

¶50 6. To Test the Vertical Deflection: Turn the vertical selector switch to Amp. Out. Connect any low a.c. voltage source to Vertical Input and Ground. This can well be done as illustrated. A voltage of 75 will sweep almost across the screen. A correspondingly lower sweep will be accomplished by applying a lower voltage. Next, turn the selector switch to Amp. In. This interposes a voltage amplifier and, by means of the Gain control, the width of the sweep may be moved from a spot to a complete sweep. This explains the use of the amplifier which may be used when the voltage to be measured is too low to give ample sweep for your purpose.



TESTING VERTICAL DEFLECTION

Figure 11

6. The Sweep Circuit Oscillator.

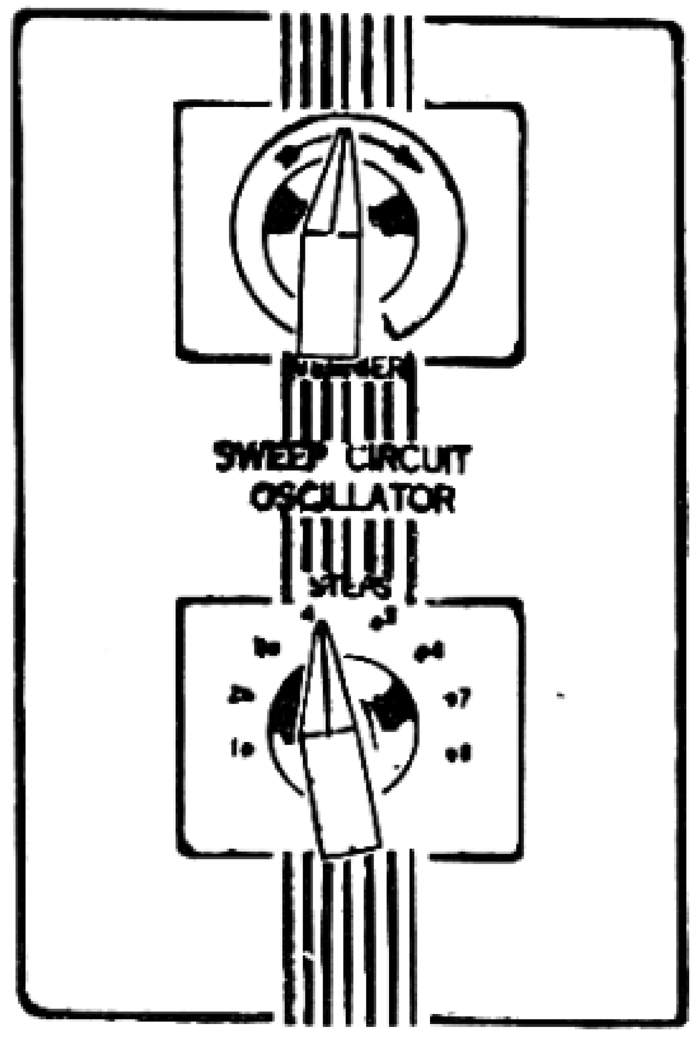


Figure 12

¶51 In studying various phenomena it is frequently desired to follow the trace with respect to time and to keep the traces running in one direction only. The sweep circuit oscillator makes this possible.

¶52 In a pure sine wave the voltage starts at zero, reaches maximum positive, returns to zero, reaches maximum negative, and then returns to zero potential at a regular rate of speed. If a sine wave were used to sweep both the horizontal and vertical axis the pattern would double back at the same rate and be difficult to study.

¶53 The desirable sweep for the horizontal plates is one that starts at maximum negative (left side of screen), approaches maximum positive (right side of screen), at an even rate and, just as it reaches maximum positive returns instantly to maximum negative. Such a wave form is practically all in one direction and repeatedly moves the trace from left to right across the screen.

¶54 This wave form is generated by a relaxation oscillator, Fig. 12A, in which a capacitance is charged until the charge is sufficiently great to reach the ionization point of the oscillator tube, then it discharges. Several such condensers are connected to the Steps Selector Switch on the panel. These steps roughly adjust the frequency of the oscillator. The resistance marked Vernier gives the finer regulation between the coarser steps. In this manner frequencies from 15 to 15000 may be generated. Thus the sweep can be adjusted in step with the frequency applied to the vertical plates.

¶55 Fig. 12 B. illustrates the potentials applied to the horizontal plates during two cycles operation of the sweep circuit oscillator. Figs. 12 C.- D.- E. illustrate the resulting pattern with 60 cycles applied to the vertical plates and with the horizontal sweep adjusted to 60, 30 and 15 cycles respectively.

¶56 In order to use the Sweep Circuit Oscillator for horizontal deflection, the Horizontal Selector Switch must be turned to Sweep Cir. Osc. The Gain Control is effective to regulate the width of the sweep.

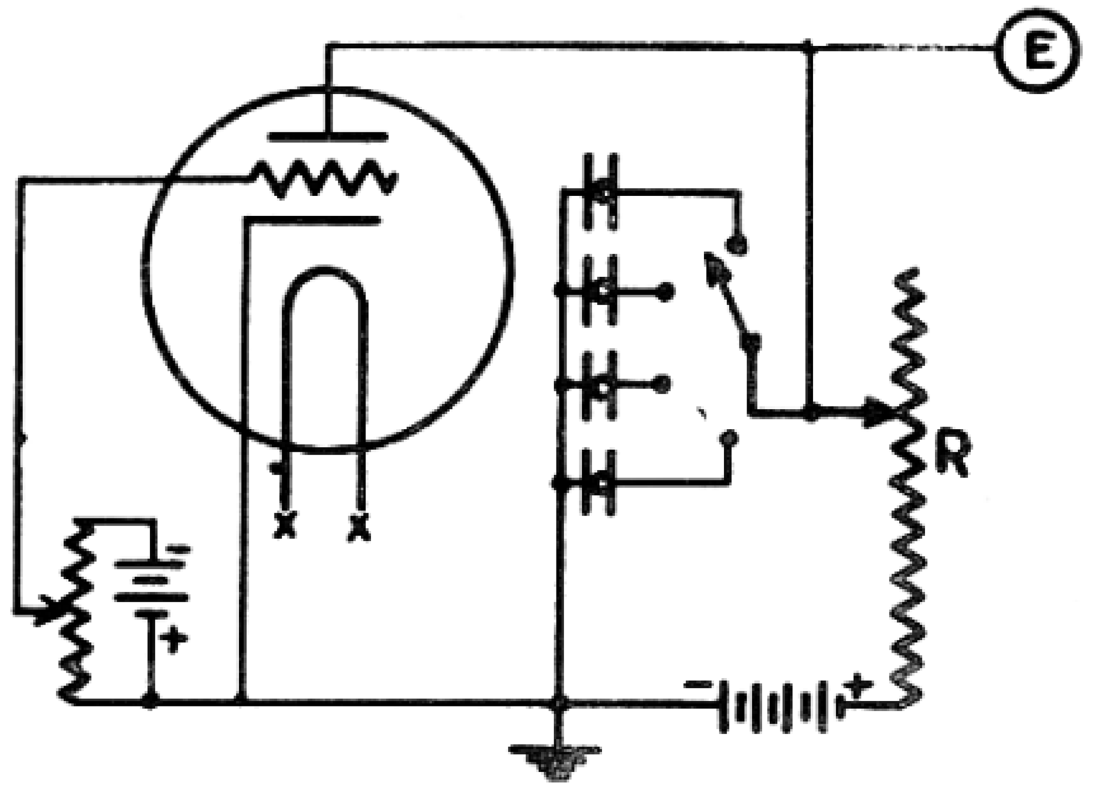


Figure 12A
SWEEP CIRCUIT OSCILLATOR

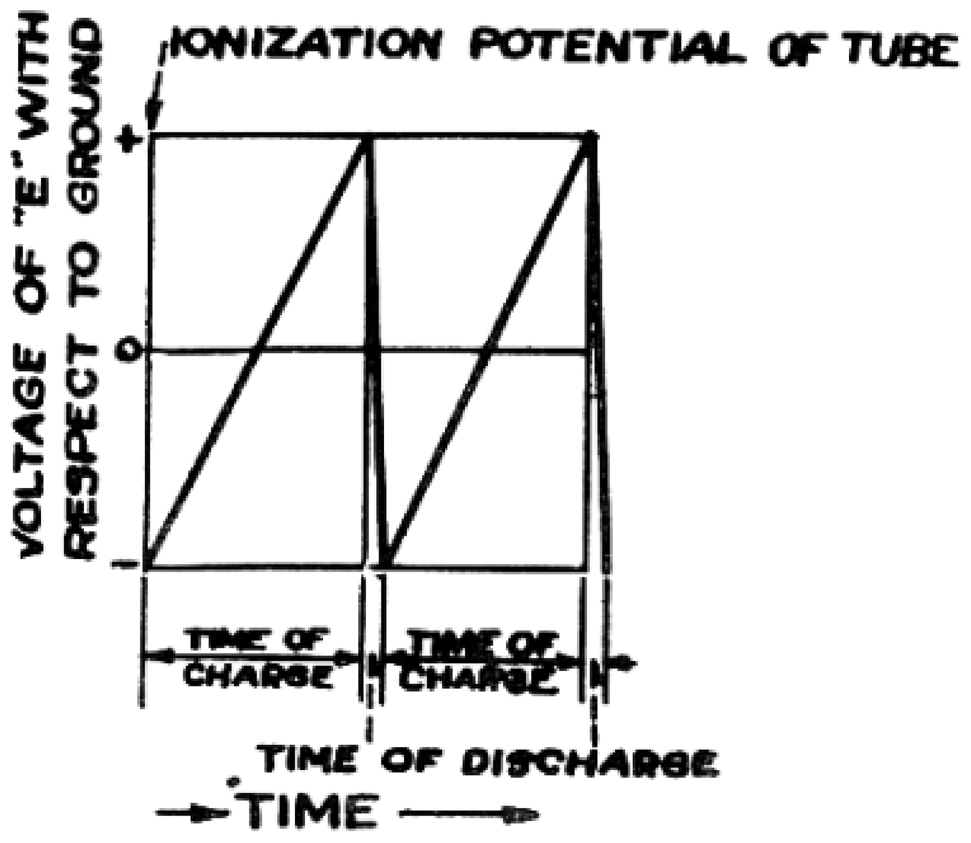


Figure 12B

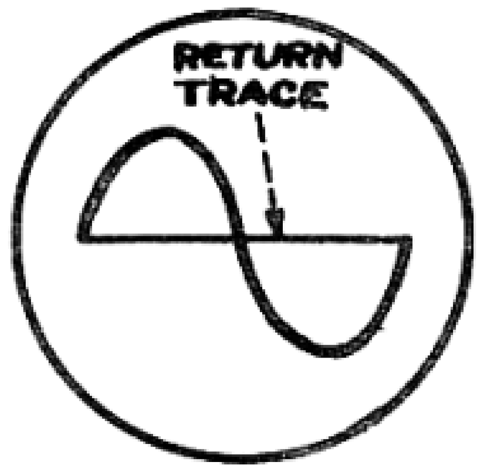


Figure 12C

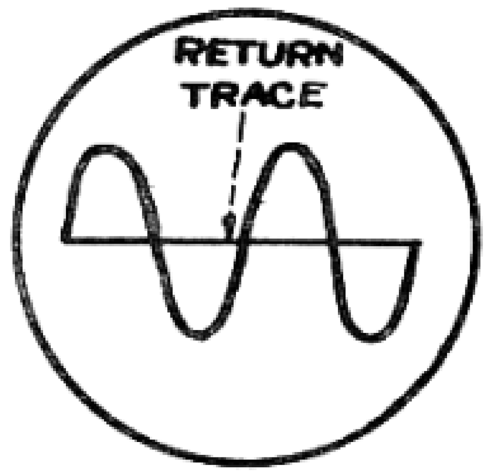


Figure 12D

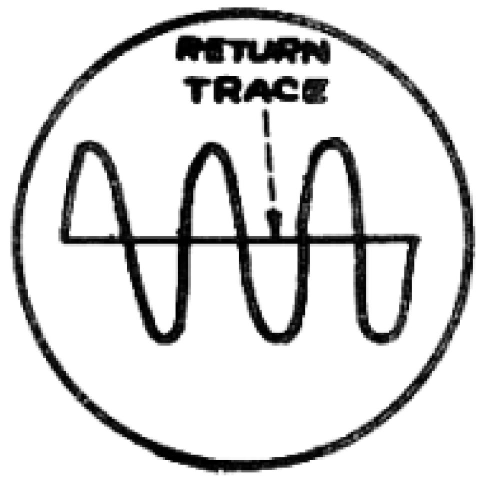


Figure 12E

Sweep Circuits.

¶57 As any one of the condensers "C" is charged through resistor "R", the potential of point "E" above ground is gradually increased to a value at which the gas in the tube ionizes, causing a rapid discharge of condenser "C" through the tube from cathode to plate. The voltage between "E" and ground will then be equal and opposite to the voltage that existed just prior to the discharge of "C". See figure 12 B. On the oscillograph panel, the "step control" connects in various values of condensers "C" and the Vernier "control" adjusts "R".

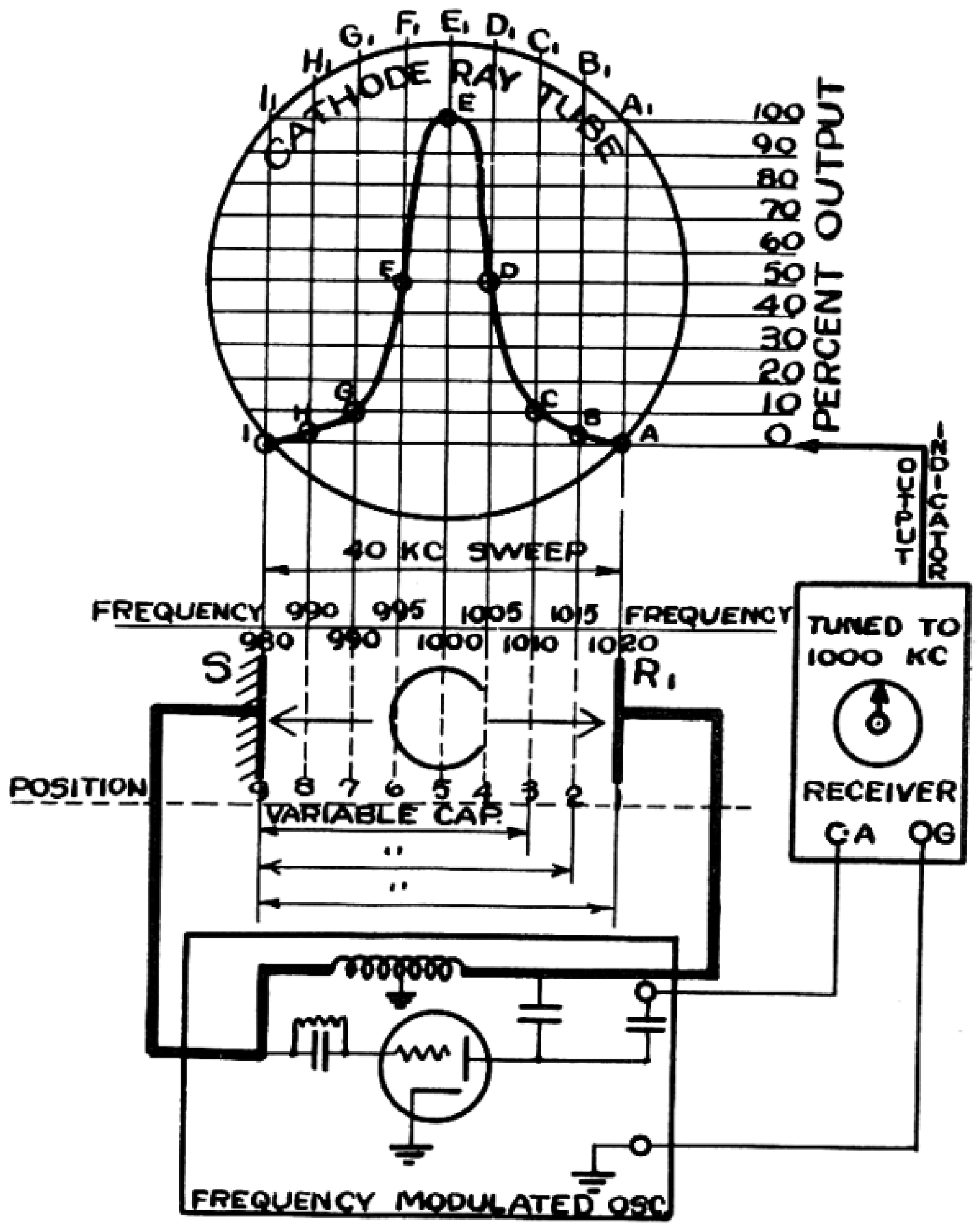
7. Synchronization.

¶58 If there were no means to synchronize the horizontal sweep with the vertical deflection, the pattern would "crawl" or travel across the screen. Therefore synchronization is made possible in two different ways: (See Fig. 4 - page 7).

a. External. With the switch in this position a small voltage from any source applied to the vertical plates may be connected to the External Binding Post and after a close adjustment on the Sweep Circuit Oscillator a sufficient locking voltage can be imposed on the sweep by advancing the locking control to retain the image or pattern stationary on the screen.

b. Internal. This switch position imposes a voltage from the vertical plates on the sweep circuit and synchronizes the horizontal sweep with the vertical deflection, thus making it possible to lock the horizontal sweep in step at any frequency being studied.

¶59 The Locking Control permits the adjustment of the proper locking voltage to the sweep circuit oscillator. Always operate with as little locking voltage as possible.



FREQUENCY MODULATION

Figure 13

8. Frequency Modulation.

¶60 In making R.F. and I.F. alignments, and for some other purposes, it is necessary to vary the carrier frequency a definite number of kilocycles each side of the fundamental. Frequency modulation has heretofore been accomplished by motor driven condensers or inductors. In the Hickok Oscillograph, the frequency modulation is accomplished electronically and without the use of any mechanical moving parts.

¶61 The modulated frequency may be connected to the antenna and ground posts of the Radio Receiver or to the Intermediate Frequency Stages as explained later in these instructions.

¶62 The second detector (load side) is connected to the Vertical Input Binding Post. As the carrier is frequency modulated the voltage from the second detector load is impressed on the vertical deflection plates. By sweeping the beam with a 60 cycles sinusoidal voltage in step with the rate of frequency modulation the output at various frequencies above and below fundamental is shown on the screen.

- Use of the Radio Frequency Section:

¶63 Figure 13 is a graphic representation of the principles involved in producing a radio frequency response. For convenience of explanation 1000 K.C. has been chosen as the Basic frequency rather than the R.F.O.4 Fundamental of /660 K.C. or any other frequency which could easily be generated. Also the width of sweep has been taken as 40 K.C. rather than 30 K.C. which is standard accepted practice. The frequency of the oscillator shown is determined by the effective capacity between stator plates and rotor plate "R". For convenience of explanation, rotor plate "R" is illustrated as moving directly toward "S" and always parallel to it, rather than rotating into mesh with the stator plate in accordance with conventional practice. The output from the oscillator is connected directly to the antenna and ground posts of a receiver which is tuned to 1000 k.c. An output indicator of the receiver is illustrated as moving vertically from 0 to 100 along the "per cent output" scale.

¶64 The movement of rotor plate "R" is conceived to move the electron stream horizontally across the face of the cathode ray tube in accordance with its position. The movement of the output indicator establishes control of the vertical displacement of the electron beam. Starting the cycle with the rotor plate in position 1, the frequency generated by the oscillator is established at 1020 k.c. by virtue of the low capacity existing between "S" and "R". The position of "R" establishes the horizontal displacement of the electron beam somewhere along the line "A-A1". Since the receiver is tuned to 1000 k.c. and the applied frequency is 1020, the output will be practically zero. This establishes the vertical displacement of the beam at point "A", opposite zero in the % output scale. As rotor plate "R" is moved to position 2, the capacity between "R" and "S" is increased. This results in a decrease in the frequency of the oscillator from 1020 to 1015. The horizontal displacement of the beam is then established somewhere along the line "B-B1". The receiver, being tuned to 1000 k.c., will show little if any output when the impressed frequency is 1015. Therefore, point "B" is established. A change of "R" to position 3 likewise results in the establishment of point "C". This is based on the assumption that the receiver will deliver 10% of its maximum output when the impressed frequency is 10 k.c. above the frequency to which it is turned.

¶65 By moving "R" step by step, over to position 9, the remaining positions "DEFGH & I" can be located. In actual practice, the path of the beam travels from "A" through this series to "I" so rapidly that persistance of vision makes it appear to the eye as a continuous line.

9. Radio Frequency Modulator.

¶66 This panel controls and provides connections to an R.F. Oscillator having a basic frequency of approximately 665 kilocycles. The exact frequency of your instrument is stamped on the plate for this purpose.

¶67 The Output Control attenuates the R.F. signal from approximately 1 volt to 2 microvolts. Care should be taken to keep this output below a.v.c. action when used as a driver for a radio receiver.

¶68 The K.C. Sweep Control modulates the basic frequency of the self-contained oscillator according to the setting. The numbers refer to the total modulation. When turned to 30 k.c. the signal is modulated to 15 k.c. each side of the basic frequency.

¶68A When this control is turned to a complete counter-clockwise rotation, a switch action will be obtained which will change the rate of sweep from 60 to 120 cycles per second. Either rate of sweep may be used and should be determined by the preference of the operator.

¶69 The screen supplied with the Oscillograph has five vertical lines each side of center. The screen is calibrated at 5 k.c. per line when the K.C. Sweep Control is set at 30. By positioning the horizontal sweep lower, it is possible, in some cases, to observe the pattern more accurately.

● The binding post marked External Oscillator is used to connect an unmodulated external oscillator to the internal oscillator to produce a "beat-note" equal to the difference of the internal oscillator and the external oscillator and to frequency modulate this beat frequency. For example, if it is desired to obtain an I.F.Signal of 262 kilocycles and your Oscillograph frequency is 665, then it would be necessary to set the external oscillator at 665 plus 262, or 927 kilocycles, or 665 minus 262, or 303 k.c. Beating this signal against 665 would produce 262 kilocycles. See Fig. 25, page 24.

● This same action may be used to produce a variable audio frequency by adjusting the K.C. sweep control to zero and adjusting the external oscillator to the desired audio frequency above or below the internal frequency of 665 K.C. For example: if 5 KC or 5000 cycles of audio frequency were desired, the external oscillator should be adjusted to 5 KC above or below the internal frequency of 665 KC which would result in an adjustment of 670 or 660 KC.

● Dynamic audio frequency response curves may be obtained by advancing the K.C. sweep control to the desired width of sweep after the foregoing connections for audio frequency output have been made.

● Uses of the Oscillograph.

¶71 The Oscillograph has so many uses that it would be impractical to attempt to explain them all in these instructions.

¶72 However, the description and instructions given above serve to give you the fundamental information and many uses will suggest themselves to you as you become more familiar with the instrument and its operation.

Visual Alignment

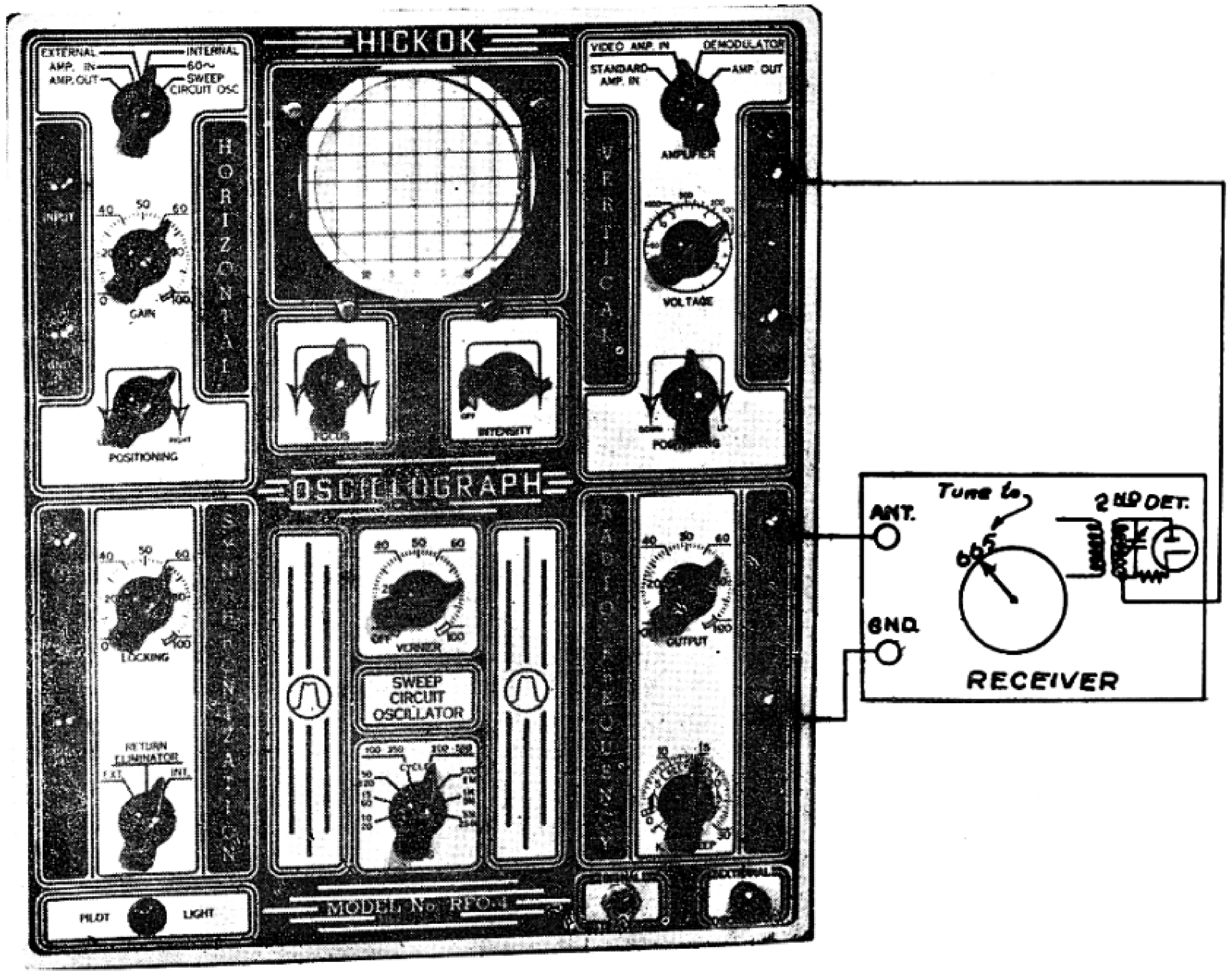


Figure 13B

¶73 This instrument at once becomes of great value in Intermediate Frequency Alignment. Patterns observed will permit improvement in sensitivity, selectivity, and quality of reproduction, so that the receiver will operate in accordance with the manufacturer's specifications. Detection of a.c. hum and many other irregularities may be found by observation and analysis of the oscillograph pattern.

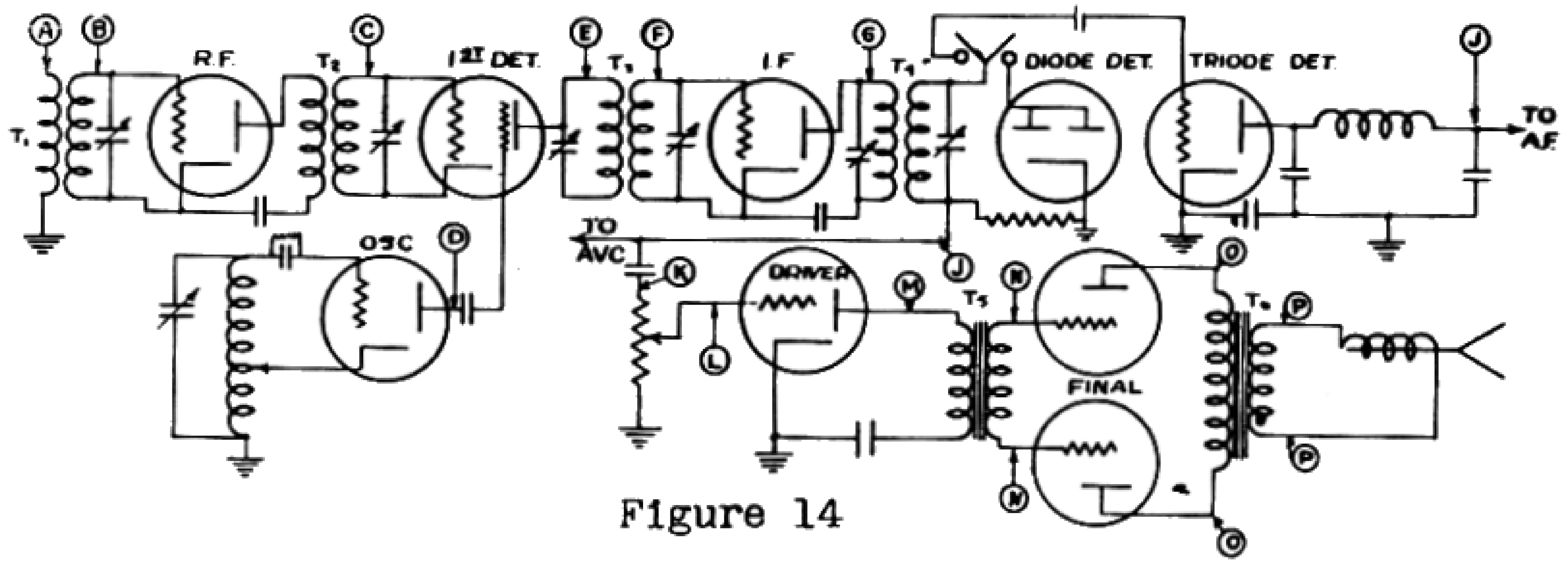


Figure 14

¶74 Fig. 14 shows a typical receiver circuit simplified to include only essential parts for this discussion.

¶75 Turn on the Oscillograph and the R.F. Oscillator. It is now set to produce the pattern resulting from frequency modulating a R.F. signal and impressing this signal on the antenna circuit of the receiver.

Setting on Oscillograph

Horizontal:	Selector Switch to 60 Cycles.
Vertical:	Selector Switch to Std. Amp. In. Gain Control half advanced.
Radio Frequency:	Output half advanced. K.C. Sweep at 30.

Connections:

Oscillograph	-	Receiver
R.F. Output	to	Antenna
Ground	to	Ground
Vertical Input	to	Second Detector Load (J)

¶76 Now turn the receiver tuning dial to the basic Oscillograph frequency (approximately 665) and observe the screen of the cathode ray tube.

¶77 Advance or retard the Vertical Gain Control so that image is of proper size or height. In all of this procedure the Radio Frequency Output must be kept as low as is possible.

¶78 Now let us check up on what we are doing. We are driving the Receiver with an R.F. Signal at approximately 665 K.C. with 30 K.C. modulation. We are picking up the output at the second detector load. We are placing this resulting voltage on the vertical cathode ray tube plates while the beam is being swept horizontally to right and then to left by an internal 60 cycle

voltage. There are actually two traces being made. If they are identical, they would appear as one. This is known as the "double trace" method. The resulting curve from a normal receiver operating properly should resemble Fig. 15A or 15B. Fig. 15A would result from a receiver of rather high selectivity whereas Fig. 15B would be that from a receiver of less selectivity. Fig. 15C is that obtained from flat topping a high fidelity receiver.

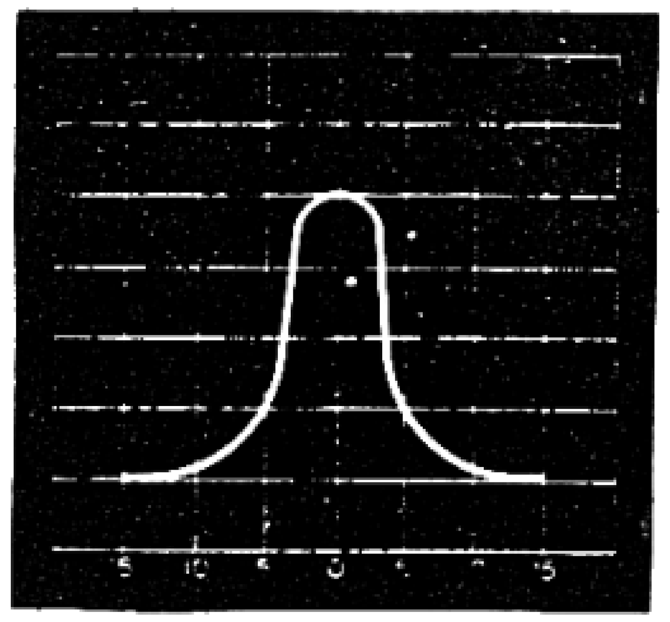


Figure 15A

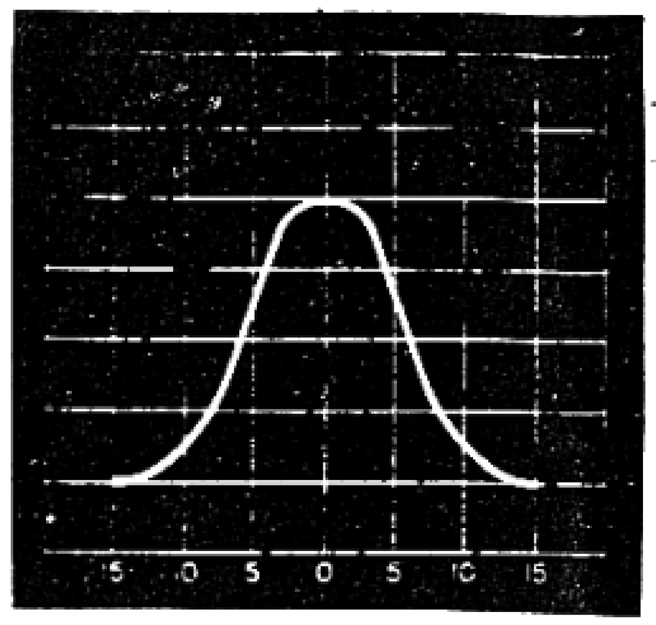


Figure 15B

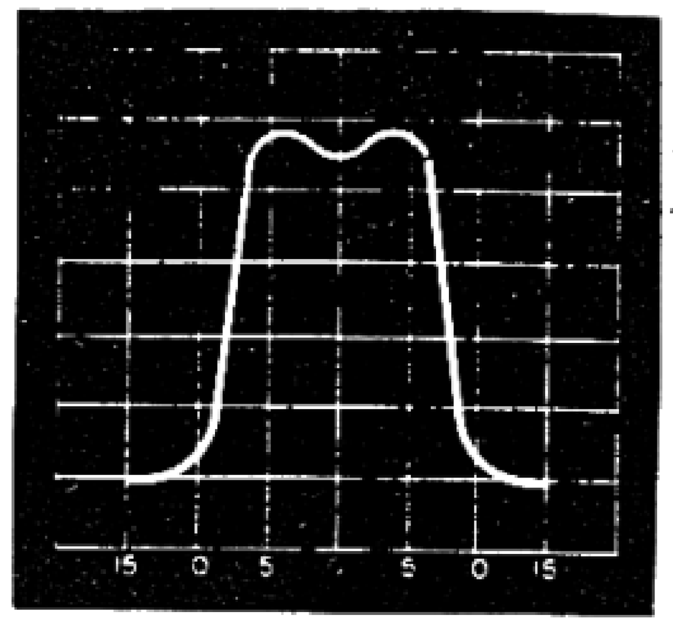


Figure 15C

Alignment at Wrong Frequency.

¶79 Fig. 16 shows a normal receiver with intermediate frequency stages tuned lower than the correct frequency. Fig. 17, the intermediate frequency stage is tuned higher than the proper frequency. Note that the response curve is symmetrical but that its peak has been displaced three kilocycles below (Fig. 16) and above (Fig. 17) proper resonance frequency.

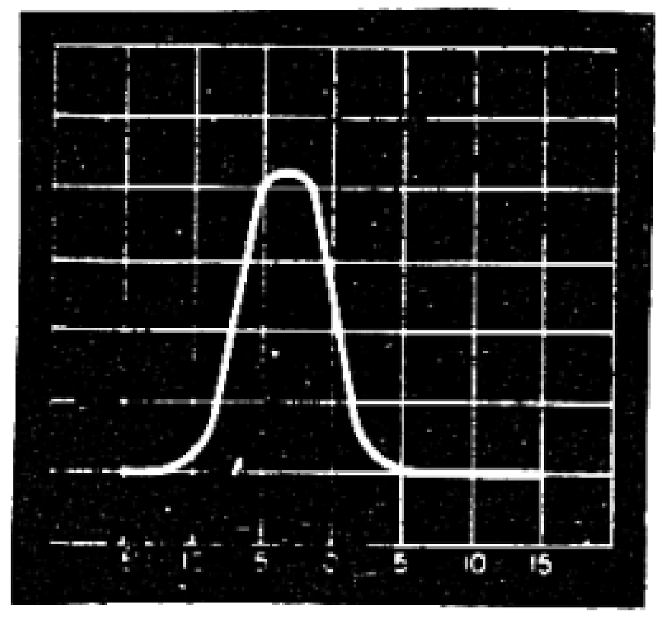


Figure 16

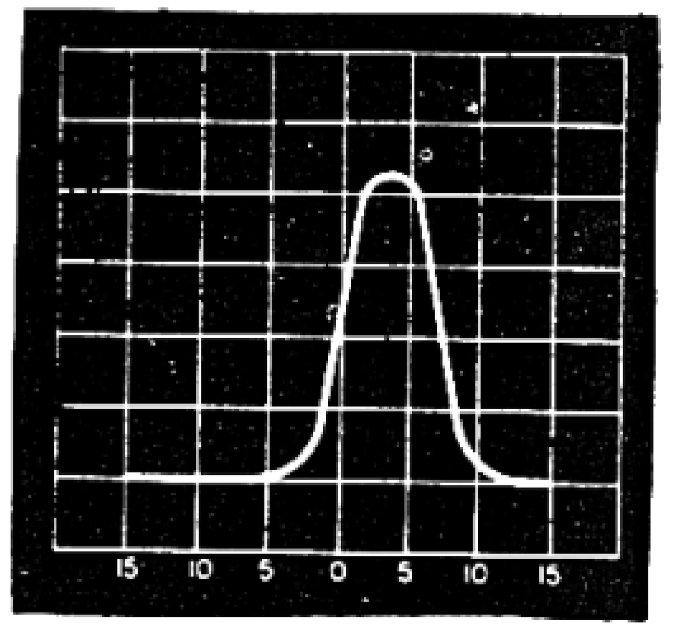


Figure 17

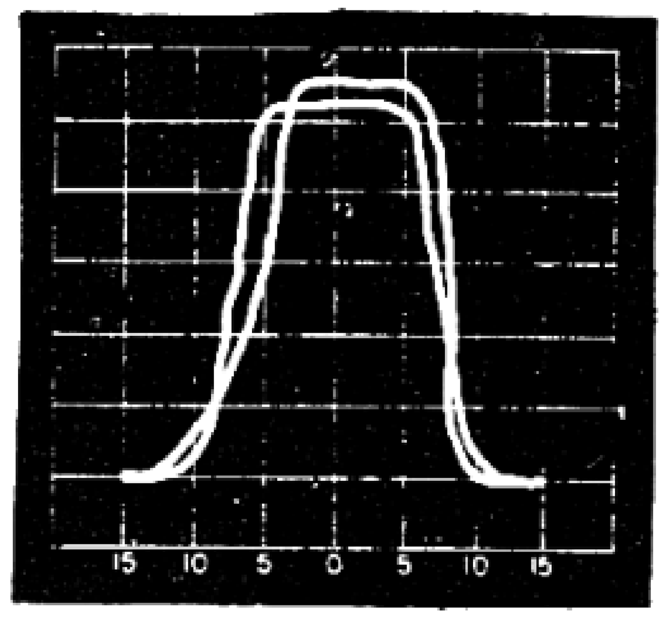


Figure 18

Overload.

¶80 Fig. 18 illustrates the condition in which the receiver had been overloaded. The remedy in this case is to reduce the input to the receiver.

Hum.

¶81 Hum, generally due to improper filtering will show up in one of two ways. Fig. 19 illustrates hum in a receiver using full wave rectification. Fig. 20 illustrates hum as it will show up in a receiver using half wave rectification.

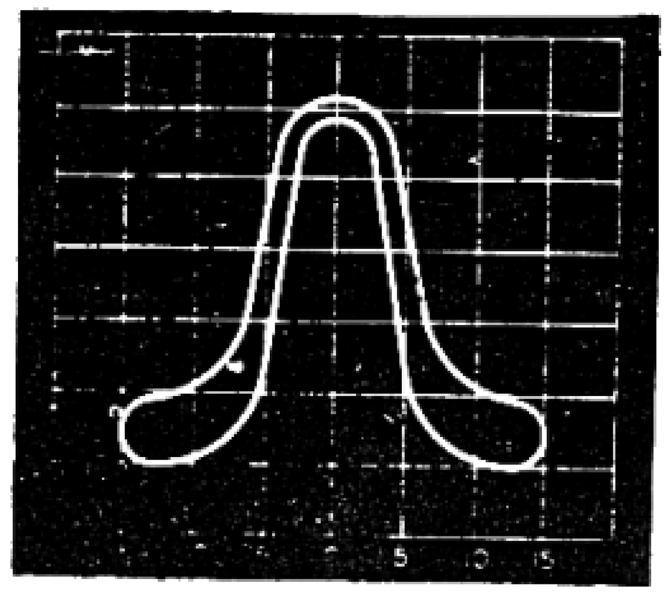


Figure 19

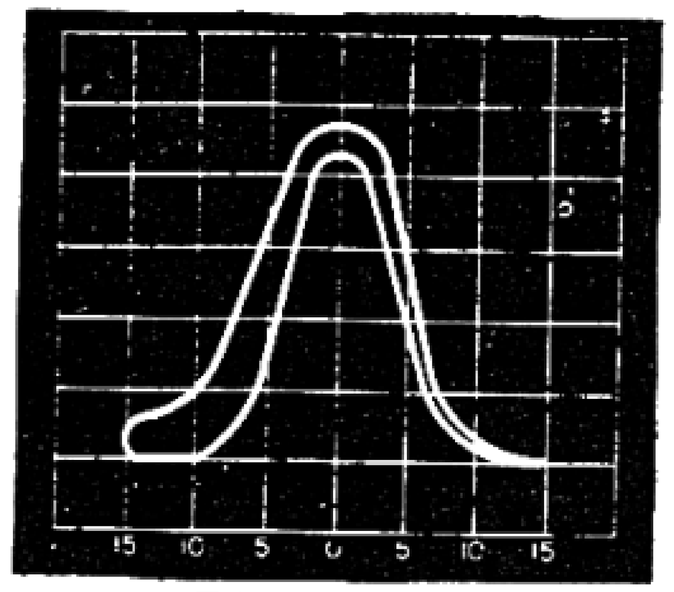


Figure 20

Misalignment.

¶82 Fig. 21 illustrates the case of misalignment of the I. F. Stages as it would appear when using a 30 cycle sweep. Fig. 22 illustrates the same condition when using a 120 cycle sweep. Note the almost vertical slope of the curve on one side of resonance while the other side has a gradual or lesser slope. This is due to the IF transformers being aligned at different frequencies.

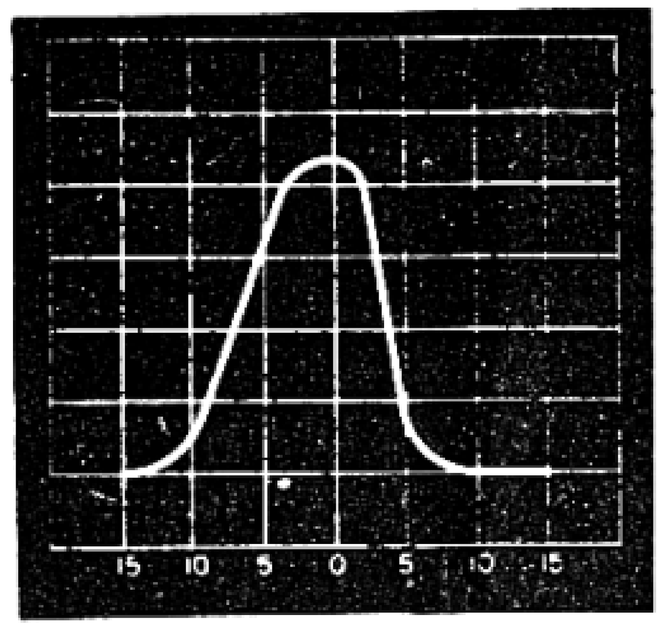


Figure 21

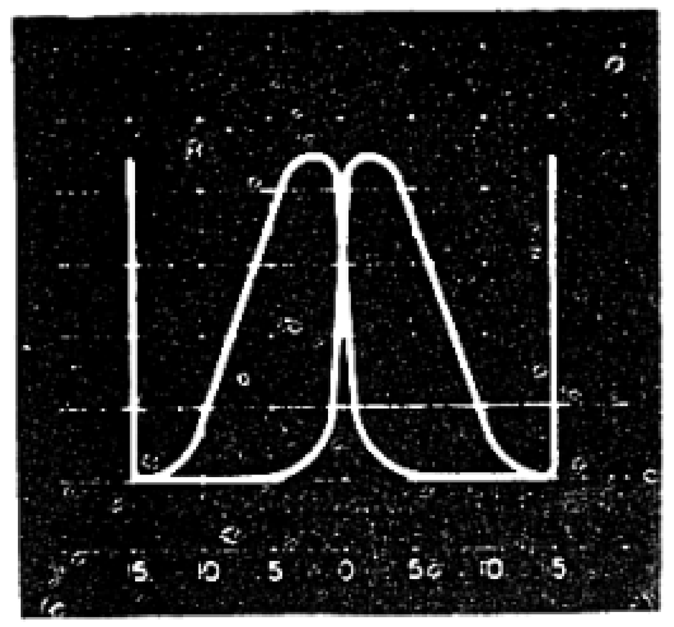


Figure 22

Regeneration.

¶83 Fig. 23A illustrates regeneration which is generally caused by open by-pass condensers, especially on the screen circuits in the intermediate frequency stages.

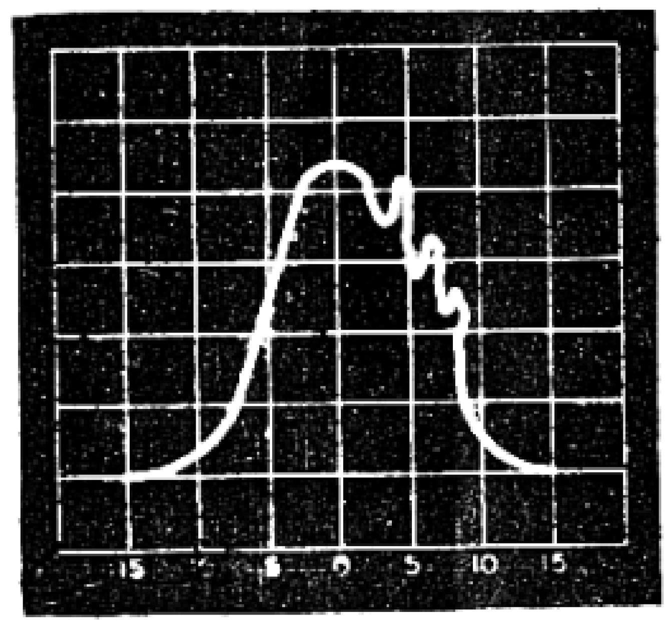


Figure 23A

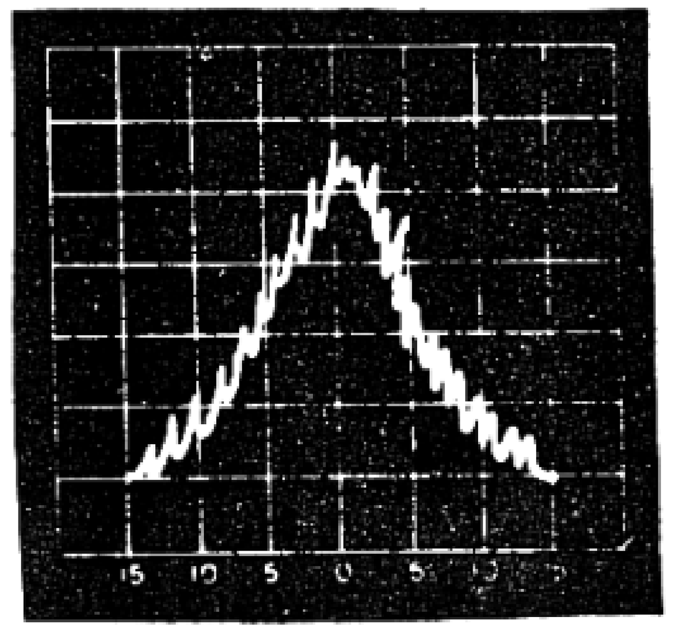


Figure 23B

Oscillation.

¶84 When regeneration becomes extensive oscillation as illustrated in Fig. 23B may result.

Using the 120 Cycle Sweep.

¶85 If the KC sweep control is retarded to the 120 cycle position correct alignment will be effected when the two curves overlap as illustrated in Fig. 24A. As the frequency is changed the two curves will separate as illustrated in Fig. 24B.

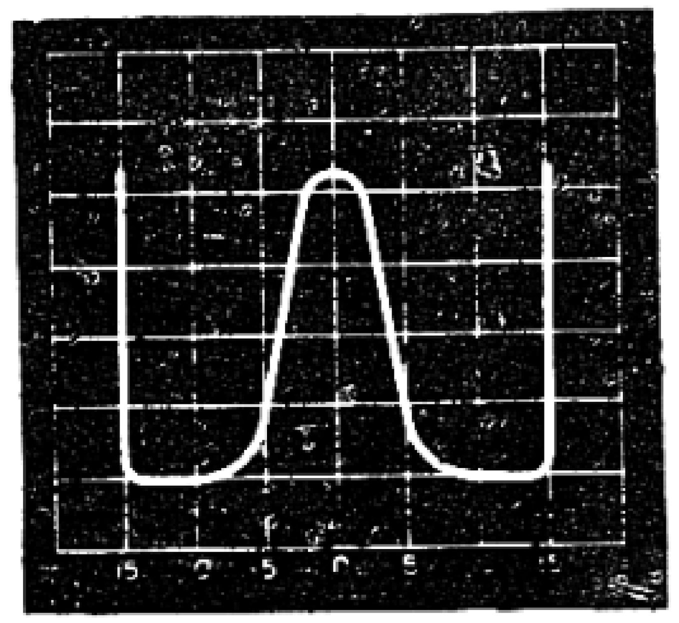


Figure 24A

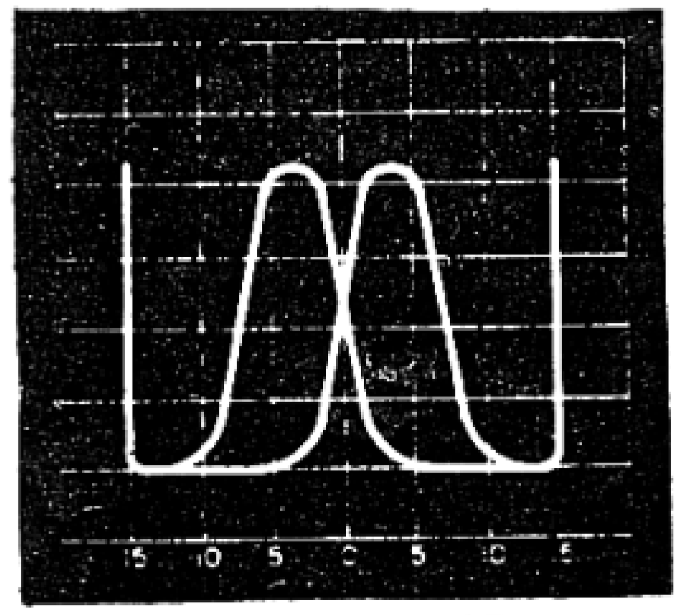


Figure 24B

Phase Distortion.

¶86 Fig. 24C illustrates the condition of phase distortion. A certain amount of this may be found in most receivers, however, excessive phase distortion may be traced to improper connection from the vertical plates to the second detector load or insufficient by-pass or coupling capacitors in the intermediate frequency circuits.

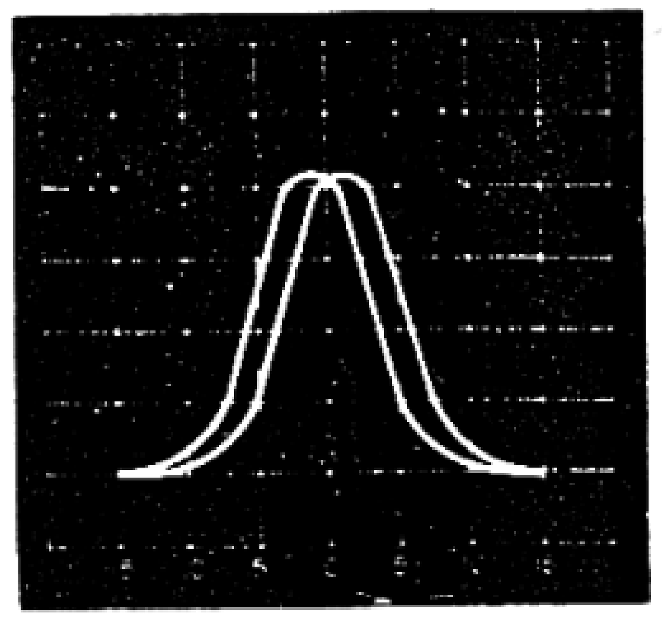


Figure 24C

Phasing Control.

¶87 Phasing control is incorporated in the oscillograph and properly adjusted at the factory. It is accessible for future adjustment, if desired, and will be found protruding upwards through the chassis directly underneath the center of the cathode ray tube.

Linear Sweep.

¶88 The internal sweep circuit oscillator may be used for horizontal deflection in lieu of the 60 cycle sweep. The use of this has no advantage and several disadvantages and therefore its use is not recommended for visual alignment of intermediate frequency stages.

Heterodyne Interference.

¶89 If alignment is attempted at the same frequency on which a strong local broadcast station is operating the interfering signal may give a response curve similar to Fig. 23B. The remedy in this case, of course, is to select a different frequency for alignment.

Return Eliminator.

¶90 The use of the return eliminator has little advantage in I.F. and R.F. alignment. It may, however, be used if desired and will serve to eliminate the sweep from the higher to the lower frequencies.

Demodulator.

¶91 It will be necessary to use the demodulator if the signal is to be picked up anywhere along the radio frequency or intermediate frequency stages ahead of the second detector.

I. F. Alignment With External Oscillator.

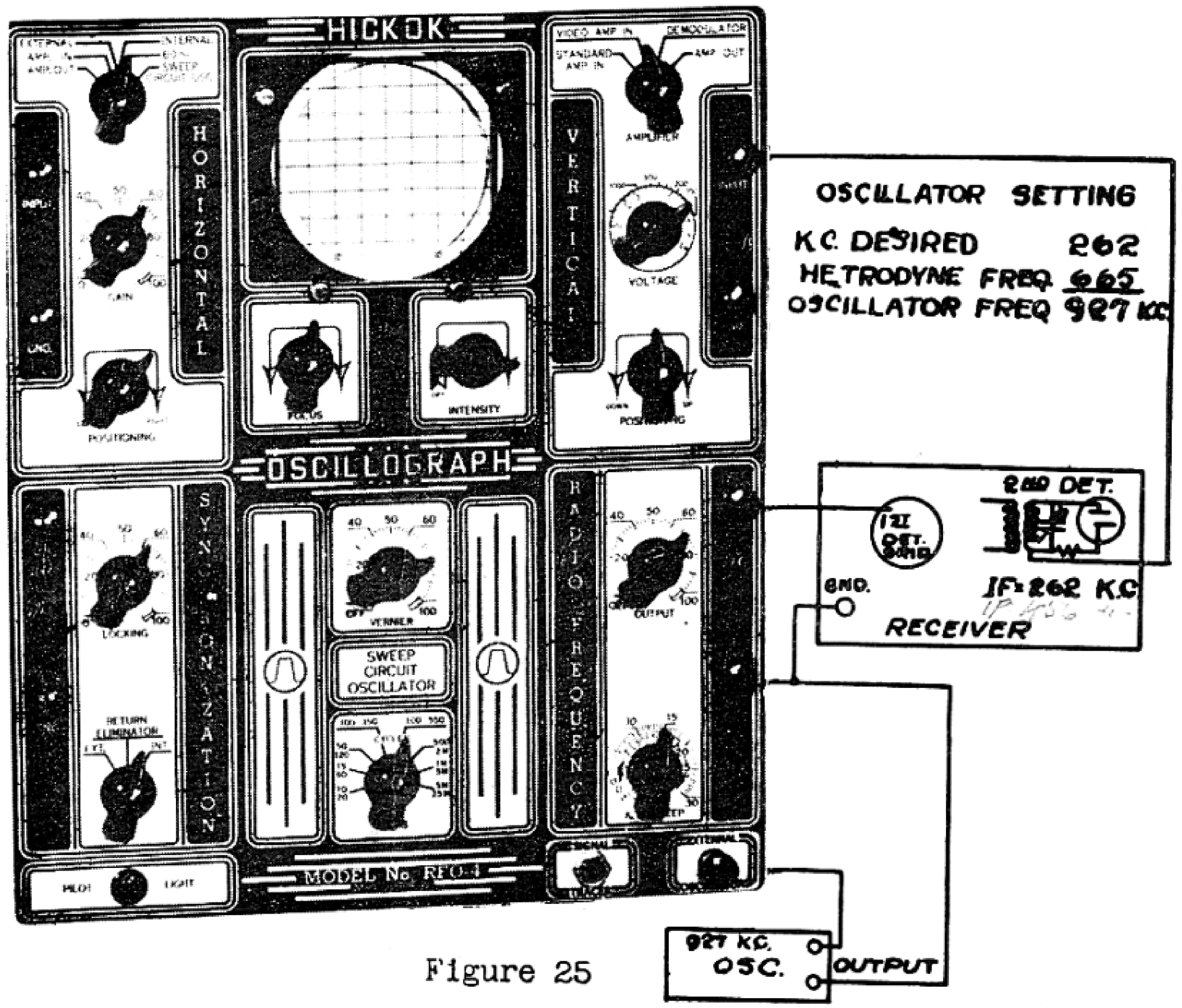


Figure 25

¶92 In the method outlined above, we showed alignment by feeding the R. F. Signal into the Receiver Antenna. Actually, you will have many cases of alignment where you will want to drive an I. F. Signal into the first detector. This signal should be frequency modulated, so you will use your external oscillator in connection with the Wobbler or R. F. Section of the Oscillograph.

¶93 When using this method, it is necessary to feed a signal from the external oscillator into the External Oscillator Binding Post of the Oscillograph. The frequency setting on the external oscillator should equal the sum of or the difference between the Oscillograph Oscillator Frequency of 665 k.c. and the I. F. Frequency of the Receiver. For example, if the desired I. F. is 262 k.c. and the Oscillograph Oscillator is 665, the setting on the external oscillator should be 665 plus 262, or 927 k.c. or 665 minus 262 or 303 k.c. The external oscillator is set at 927 k.c. or 303 k.c. (unmodulated) and the antenna connection made to the binding post, External Oscillator. The grounds are all common to the Receiver Chassis and the R.F. Output Binding Post used to connect the I. F. Signal to the First Detector Control Grid. The Vertical Input Binding Post takes the connection from the Second Detector load circuit of the Receiver. From this point alignment is made in the usual manner, Fig. 25 shows these connections

Lissajous Figures

¶94 This name has been applied to certain figures in which the same frequencies at various angles are reproduced. The name comes from a French Musician who attempted to demonstrate complexities in sound with various patterns.

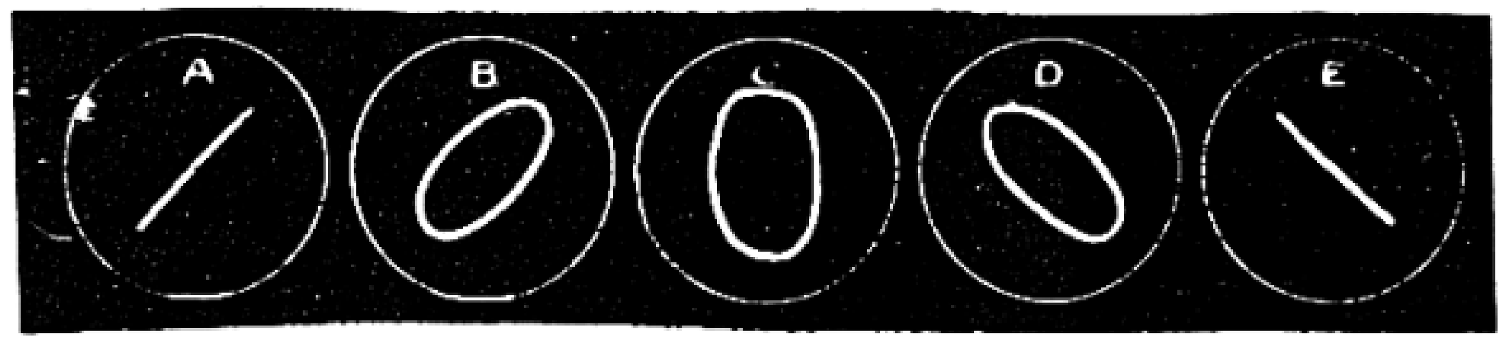


Figure 26

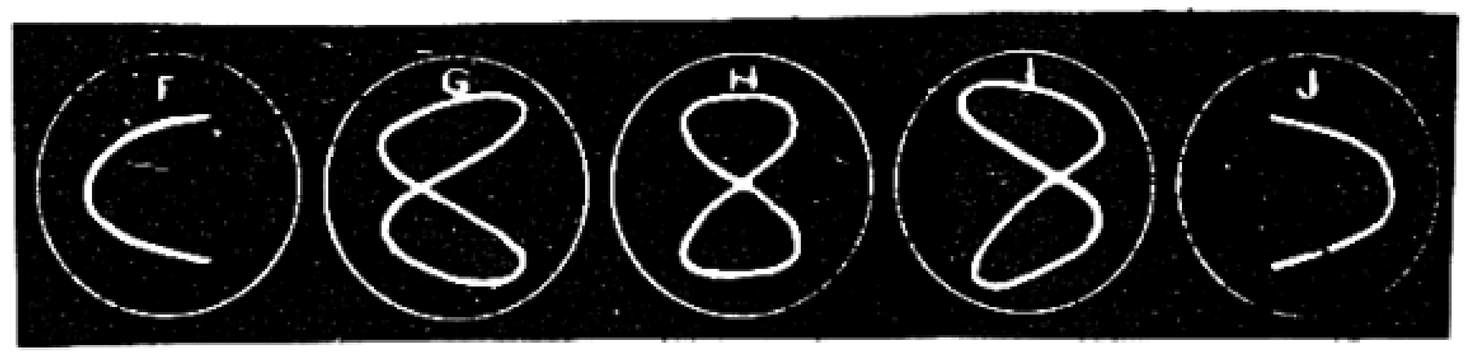


Figure 27

¶95 Figs. 26 and 27 represent such figures. Let us analyze A in which the phase relations between two voltages are 180 degrees apart. Maximum positive horizontally occurs at the right and vertically at the bottom. At the instant that the horizontal voltage is maximum positive, the horizontal trace would be at the extreme right of the screen. But the vertical voltage is maximum negative and the vertical trace is at the top. Now bring them into phase E and the maxima positives occur at the same time. In both cases zero occurs at the same time so the line crosses at the center. At 90 or 270 degreen C the vertical maxima in each direction occur at zero on the horizontal and vice versa, hence we get a rear circular figure.

¶96 In the lower figures, the horizontal frequency is 60 and the vertical is 30. It will be helpful to you to picture in your mind certain results and then to try and duplicate them on the screen.

¶97 The main point in this entire description and instruction is to familiarize you with the theory of operation and acquaint you with the internal circuits, so that you will be able to use the Oscillograph for many profitable purposes.

Checking Audio Amplifiers

¶98 Using an oscillograph for radio frequency alignment is just one of the many valuable services which can be rendered by an oscillograph. A very valuable service may be rendered in the checking of audio frequency amplifiers and associated circuits. In this case it is necessary to have a suitable audio frequency oscillator which has inherently a pure sine wave output. It is also advisable to have a variable audio frequency oscillator as distortion may occur at some frequencies not covered by a fixed frequency oscillator.

¶99 The Model OS-10, OS-11 and OS-12 Oscillators, have a self-contained fixed audio oscillator at 400 cycles and in addition to this a variable audio frequency oscillator from 0-10000 cycles.

¶100 If there is any question about the oscillator which is going to be used to test audio amplifiers not being of such a design that it will produce a pure sine wave, it is advisable to first check the output from the oscillator by applying it to the vertical plates of the oscillograph while sweeping the horizontal plates with the sweep circuit oscillator at whatever frequency is necessary to get three or four sine waves on the screen.

¶101 Assuming that the audio oscillator is suitable, the next step would be to connect the output from the amplifier which, in the case of receivers, would be the voice coil to the vertical plates of the oscillograph. By connecting the output of the audio oscillator to the grid of the final amplifier tube, a sine wave should appear on the screen similar to figures 12C to 12E. If there is distortion of this sine wave it is evidence of a defect in the amplifier. By starting at the end of an amplifying system as outlined, and proceeding back towards the input it is possible to locate and isolate any trouble which might exist. It is advisable to feed in various frequencies such as 100, 500, 1000 and 5000 cycles to make sure that the amplifier is not distorting at any of the frequencies which would normally be used through this amplifier.

¶102 Demodulator:- With switch in demodulator position the electrical action of the demodulator is similar to the second detector action in conventional receiver design in that it rectifies and filters the RF carrier, leaving only the audio component. As a result of this action, the RF wave may be used anywhere along the RF or IF stages. When either an amplitude modulated or frequency modulated signal is being supplied to the receiver from the signal generator, connections would be as follows: with either frequency modulated or amplitude modulated at the antenna post "A" (see Fig. 14) and with the vertical control switch at the demodulator position, the vertical plate connection may be made at point "B" for the check of transformer 1, labeled T-1, or at the plate of the first RF tube for a check of transformer 1 and RF tube. If the connection is taken off at point "C" the response curve will give a check on the combination of T1 T2, and the RF tube. With the connection remaining at point "C", if the input from the signal generator were to be applied at point "B" rather than at point "A" the check would then be made on the RF tube and T-2 alone. Likewise, the vertical input can be advanced to point "E", to point "F", to point "G" and to point "J" giving a continuously progressive test of the various stages and tubes in the radio frequency and intermediate frequency section. If sufficient output is available from the signal generator, any signal transformer may be tested independently, for example, T-3 in the intermediate frequency stages may be tested by feeding the output from the signal generator in at point "E" and measuring the demodulated output at point "F". It is generally advisable

to connect a rather low capacity coupling condenser between the point "F" for example and the vertical input plate to avoid any possibility of the connection to the oscillograph upsetting the tuning of the internal circuit in the receiver.

Visual Audio Frequency Response Curve.

¶103 To obtain a visual audio frequency response curve similar to figure applying, the type of precedure would be as follows:- connect an external oscillator in at the proper plates on the oscillograph and determine first the width of the dynamic audio frequency response curve desired. If it is desired to have the width of a curve 10 KC or 10,000 cycles, then the KC sweep control should be advanced to 10. With the output from the radio frequency section connected to the input of the audio frequency amplifier under test and with the output of the audio frequency amplifier connected to the vertical input binding post, with the amplifier in, if the amplifier is necessary for producing sufficient height on the response curve, or with the amplifier out, if the amplifier under test has sufficient voltage to swing the beam vertically without the necessity of using the built-in vertical amplifier on the oscillograph. The horizontal control could be set to the 60 cycle position and the synchronization control turned to the return eliminator position. By adjusting the external oscillator until the entire zero beat is on the extreme left side of the screen, as illustrated in figure , the response curve obtained will be a dynamic response curve of the audio frequency amplifier under test.

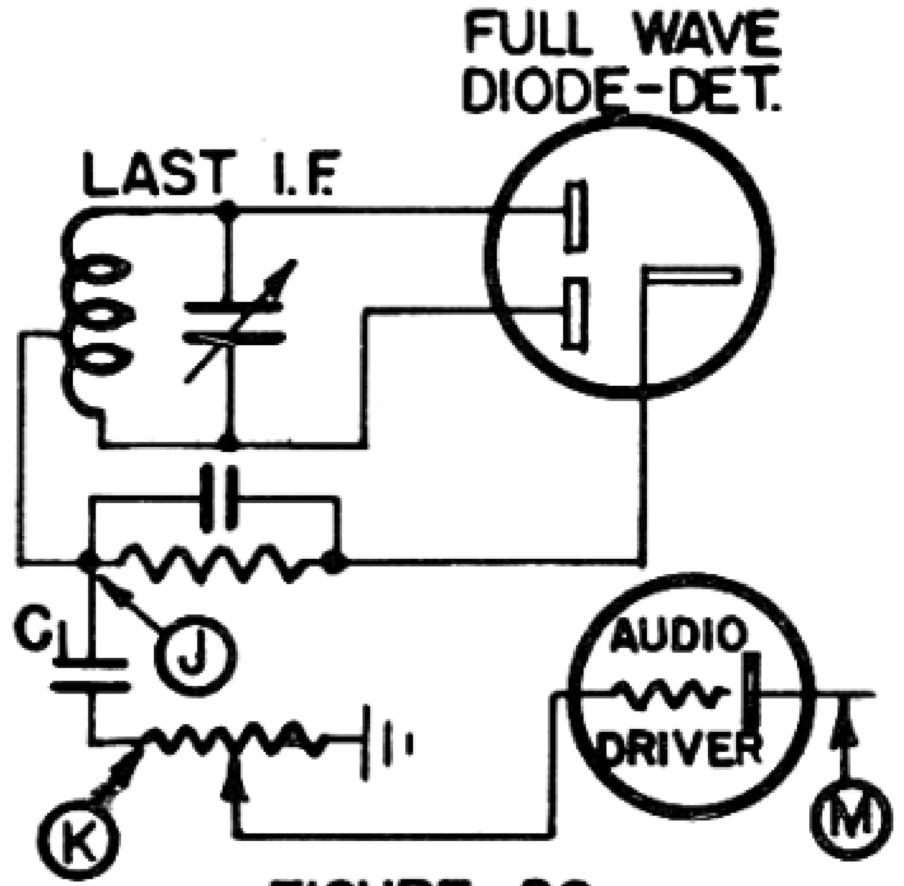


FIGURE 28

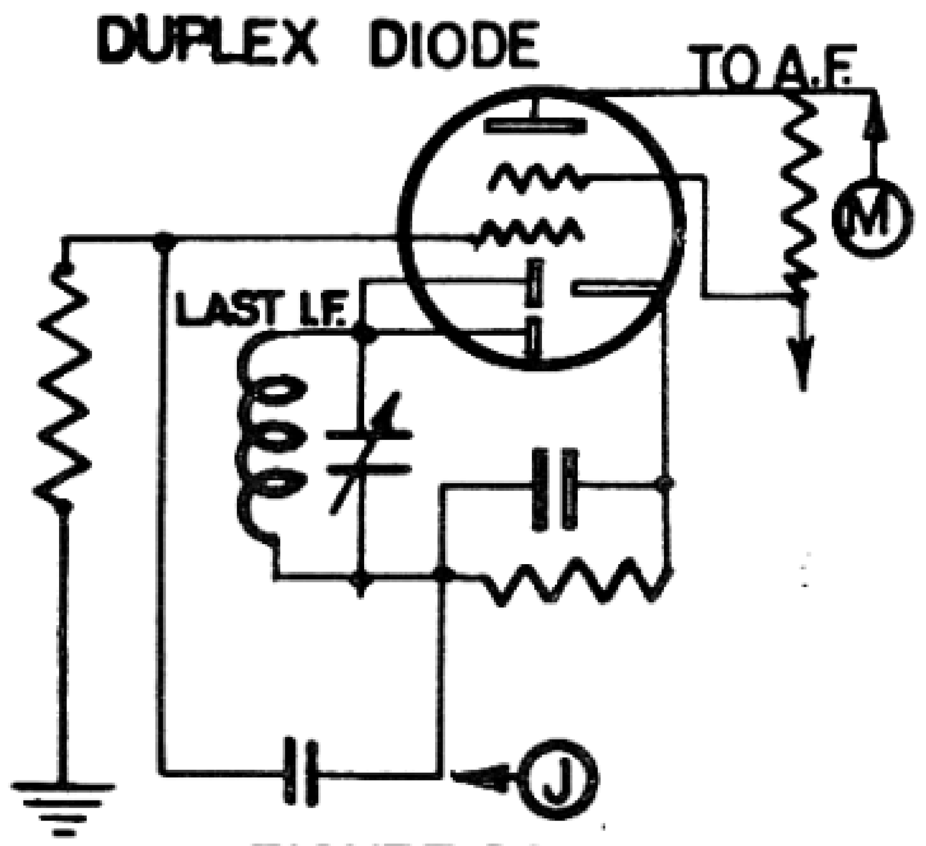


FIGURE 29

¶105 Figure 14, Page 20, illustrates 2 types of second detectors. The conventional halfwave diode and the triode. Two other types are now in general use and are illustrated by Fig. 28 and Fig. 29.

¶106 In the case of the full wave diode detection the proper connection to the vertical plate of the oscillograph should be at point "J" which is the high end of the second detector load resistance. In some cases, however, it is possible to connect to the high end of the volume control at point "K" which is generally somewhat more accessible than point "J"; however, capacity C1 should be of a fairly high value in order to minimize phase distortion, otherwise if this capacity is too small phase distortion as shown in Fig. 21 might appear, or as in Fig. 22 in case of phase distortion together with excessive hum.

¶107 In the case of the duplex diode series of tubes as mentioned in Fig. 29, the proper connection is point "J" which is the high end of the load resistance. Do not make the mistake of connecting at point "M" which is the plate of this tube as a curve similar to Fig. 21 or 22 might be obtained due to the inherent phase displacement in the tube. Also there is always a certain amount of A.C. ripple in the power supply of a receiver which would show up at the plate of this tube at point "M" and tend to open up the lower loops of the curve as illustrated in Fig. 22.

¶108 In general, it is safe to connect to the high side of the volume control first and see if the proper pattern cannot be obtained with this connection. This is always quite easy to find in a receiver and does not as a rule entail any search for the load resistor. However, it must be kept in mind that if the traces do not coincide, it will be necessary to go back and make the connection as outlined in this and the foregoing text.

Output Circuit of Model RFO 4 Oscillograph

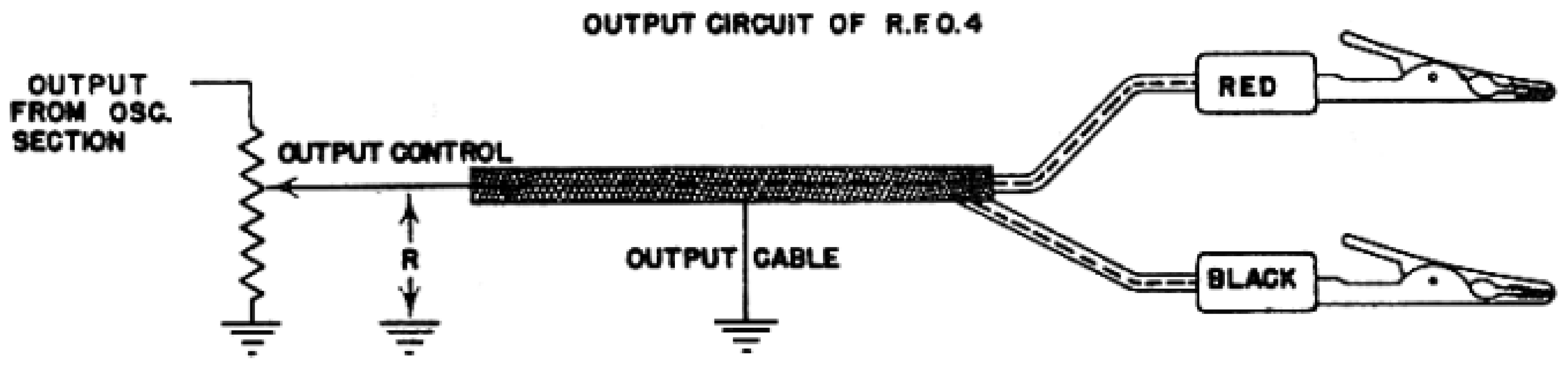


Figure 30

¶109 With reference to the above drawing, it will be noted that the output impedance of the model 10 and 12 signal generator and RFO 4 Oscillograph, as measured between the black ground lead and the red high output lead will vary from zero to 3500 ohms as the output control is advanced in a clockwise direction.

¶110 If the black lead is connected to the chassis of the receiver under test and the red lead connected to any voltage with reference to the black lead, this voltage will dissipate itself thru the output control potentiometer. Take a typical case in which by accident or otherwise, the red output lead were connected to the plate prong of the tube, which it may be assumed to be at 200 volts above ground, then the voltage appearing across the output control would be 200 volts, and if the output control were advanced half-way so that the resistance were approximately 1500 ohms the wattage dissipated in the output control would be given by the formula $\frac{E^2}{R}$ is equal to watts.

¶111 If the voltage applied were 200 and the resistance were 1500 ohms, the wattage appearing across the output control would be $(200)^2$ divided by 1500, or 40,000 divided by 1500, or something over 20 watts. The output control is the standard control and is capable of dissipating approximately 1 or 2 watts, but will immediately burn out if such a connection is made, which would apply a power of 20 watts on this control.

¶112 If it is ever necessary to connect the red lead to the plate pin of a tube or any high voltage source in the receiver, it is always desirable to connect a blocking condenser in series with this red lead.

¶113 In normal use, the control cannot be burned out. Therefore, this defect cannot be covered by the guarantee.

Alignment of A.F.C. Circuit with Hickok Model RFO-1 or RFO-4 Oscillograph

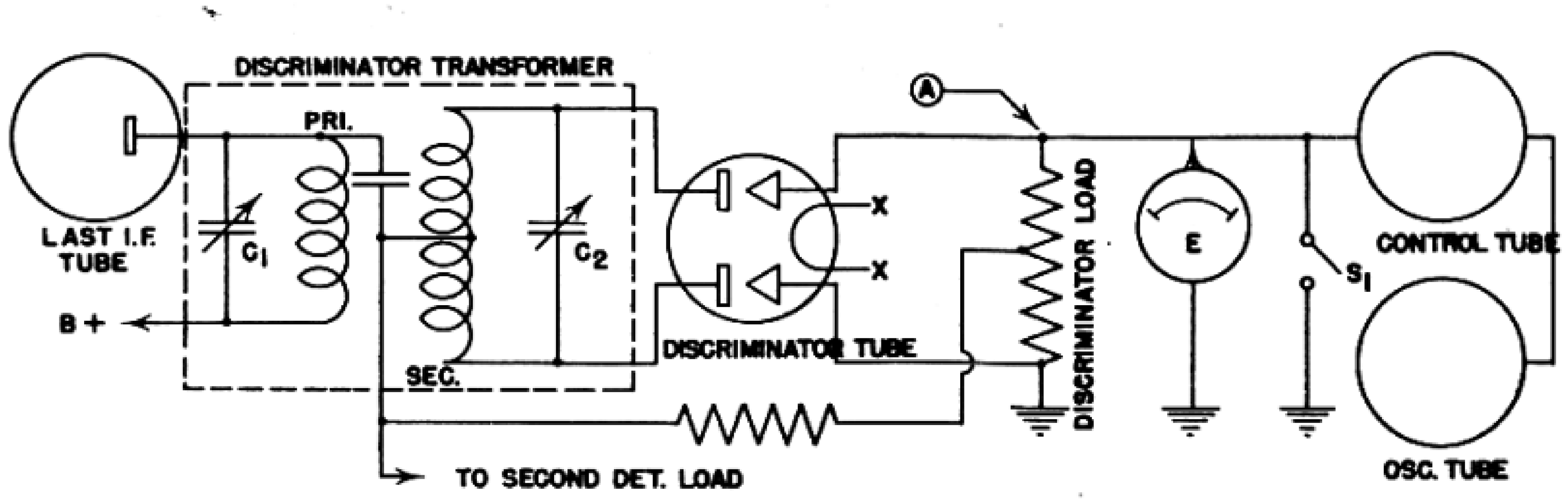


Figure 31

¶114 The operation of automatic frequency control circuit may be briefly explained by a reference to the above A.F.C. circuit schematic. Automatic frequency control systems may be broken down into four fundamental parts. Namely, discriminator transformer which replaces the last intermediate frequency transformer in the conventional superheterodyne receiver, the discriminator tube which is usually the type 6H6 or equivalent, the control tube and the oscillator tube which is the regular oscillator tube in the receiver.

¶115 The discriminator transformer and the discriminator tube operate in the following manner. It is assumed that the intermediate frequency of this transformer is designed to be 450 kilocycles, then with a 450 KC signal being fed from the last intermediate frequency tube to the primary of the discriminator transformer and C1 properly tuned, this frequency will be transferred to the secondary of the discriminator transformer and when C2 is properly adjusted to resonate the secondary at 450 KC the discriminator tube will act to produce a voltage E from point A to ground which will be exactly zero across the discriminator load resistance.

¶116 If the frequency being supplied from the last I.F. .tube changes either above or below the designed frequency, that is, the frequency for which the discriminator transformer is tuned the voltage "E" from point A to ground will vary either positive or negative in accordance with the increase or decrease above or below 450 KC of the applied frequency. This change in voltage is then applied to the grid of the control tube which in turn varies the frequency of the oscillator section.

¶117 It is quite obvious that if a given frequency is fed in at the antenna post of a receiver and the receiver properly tuned to this frequency, that the frequency supplied to the intermediate frequency stages will be a frequency equal to the difference between the oscillator tube frequency and the incoming frequency, and this frequency should be exactly equal to the intermediate frequency of the receiver under test. If we take the case of a received signal of 1000 KC and assume that the dial on the receiver is tuned to exactly 1000 KC then the oscillator tube would be operating in this case, at 1450 KC giving us a difference of 450 KC which would be fed thru the intermediate frequency stages. Since the discriminator transformer is tuned to exactly 450 KC the voltage appearing across E will be zero and the control tube will have no effect on the oscillator tube frequency. However, if the receiver were mistuned, say 5 KC high, or in other words, while the oncoming signal was still 1000 KC the actual tuning of the receiver were at 1005 KC the oscillator tube frequency would then be 1455 KC rather than 1450 and the frequency appearing thru the intermediate frequency stage would then no longer be 450 KC but would be 455 KC. This would result in a voltage "E" being applied across the discriminator load resistance which would react on the control tube causing it to shift the oscillator frequency down towards 1450 KC which would result in the intermediate frequency being reduced towards its proper frequency of 450 KC. Conversely, of course, if the receiver were mistuned to 995 KC the same result would be obtained with the exception that the voltage appearing across E would be of opposite polarity thereby causing the control tube to shift the oscillator tube frequency up rather than down tending to being the intermediate frequency back to its proper value of 450 KC.

¶118 In most cases where automatic frequency control is employed there is a method of disconnecting the automatic frequency control feature so that standard tuning may be obtained. This is generally accomplished by a switch on the main panel of the receiver which enables the operator to select automatic frequency control or not at will, and is generally accomplished by a switch in a position similar to that shown at S1 which shorts out the discriminator load resistance back to ground thereby always applying a zero voltage on the control tube which results in this tube having no effect on controlling the oscillator tube frequency.

¶119 In many cases the discriminator circuit is also used as a second detector and the audio frequency stages fed directly from this circuit as indicated in the drawing, however, in some cases a tap is taken off the discriminator transformer or a capacity coupling from this over to a separate detector and this used for demodulation and the demodulated signal applied to the audio frequency stages. In all cases, however, the connections of the oscillograph vertical plate to the receiver under test should be made to the second detector load, whether this load is incorporated into the discriminator circuit or whether it is separate as previously mentioned.

¶120 The proper alignment procedure should be as follows:

First: Connect the frequency modulated signal adjusted to the proper intermediate frequency direct into the first detector tube grid through a blocking condenser. This connection is illustrated in Figure 5, page 24 of this booklet.

Second: Close S1 back to ground, thereby eliminating any discriminator action.

Third: Align the intermediate frequency stages in the conventional manner, getting the maximum possible amplitude from the response curve consistent with symmetrical sides as outlined in this operating instruction book. In this alignment it is not necessary that the secondary of the discriminator transformer tuned by C2 be adjusted. However, C1 should always be adjusted in the same manner as the other trimmer condensers on the intermediate frequency transformers.

After this alignment has been completed, disconnect the frequency modulated output which was being fed in at the first detector and connect to the antenna post of the receiver. In this connection it is suggested that no external oscillator be used, but the radio frequency output of 665 KC be taken from the radio frequency of the oscillograph and connected to the antenna post of the receiver under test. With all other connections the same, tune the receiver at approximately 665 KC until the response curve is centered in the cathode ray tube screen, use the 60 cycle sinusoidal sweep for horizontal voltage.

Fourth: Open S1 and when this switch is open it will be found that the response curve will travel rapidly either to the right or left on the screen. Merely readjust C2 the secondary discriminator condenser until the curve is returned to the center of the screen and the alignment of the discriminator circuit will then be complete. A check on this alignment may be made by opening and closing S1 and making sure that the curve does not move when this switch is either opened or closed.

¶121 An alternative method is somewhat faster and can be used if you are reasonably sure that the intermediate frequency stages are tuned quite close to their proper frequency is as follows:

First: Sort out S1 and feed the output of the oscillograph directly to the antenna and ground post of a receiver which is tuned for 665 KC.

Second: Adjust all intermediate frequency trimmers together with C1 on the Discriminator transformer for a proper response curve as previously outlined. Open S1 and readjust C2 to re-center the curve on the screen.

Signal Tracer Feature.

● The present model RFO-4 incorporates what is commonly known as a signal tracer. This feature enables the operator to actually hear the signal as it is any place along the radio frequency or intermediate frequency stages.

Fundamentally,this picking off the signal with the demodulator and demodulating the R.F. carrier leaving the audio component, and this audio component is amplified and fed to phones or speaker by the vertical amplifier stage. Normally, the output from the vertical amplifier is fed to the vertical plates of the cathode ray tubes so that the signal can actually be seen on the screen of the tube. You will find a jack on the front of the panel labeled signal tracer and when a pair of phones or speaker is connected into this jack the signal which is being fed to the vertical plates of the oscillograph can be heard on the phones or speaker.

In some cases the operator may desire to build a small audio amplifier consisting of a single stage, the output of which is connected to a speaker and by feeding the input to the amplifier from the signal tracer jack a relatively intense audio signal can be obtained.

Model RFO-4 Visual Vacuum Tube Voltmeter.

● The calibrated control for vertical amplifier of model RFO-4 has two calibrated ranges. First range is from .2 of 1 volt to 100 volts to be used with the vertical switch in the amplifier in position. The second range from 100 to 1000 volts to be used with the vertical switch in the amplifier out position.

In measuring voltages with this calibrated control procedure should be as follows:

Connect the source of voltage to be measured between the vertical input binding post and ground binding post. Turn the vertical control switch to the amplifier in position. Adjust the vertical gain control until the vertical displacement of the beam on the cathode ray tube screen is equal to the distance between the two double horizontal reference lines on the screen. The voltage being measured with then numerically be equal to the reading on the inner scale of the calibrated gain control. If the voltage is less than .2 of 1 volt or over 100 volts it will be impossible to make adjustment of the vertical gain control to bring the vertical displacement of the beam equal to the distance between the horizontal reference lines. If the voltage is less than .2 of 1 volt no measurement on the voltage can be made, however, if the voltage is over 100 volts turn the vertical selector switch to amplifier out position and adjust the gain control until the vertical displacement is equal to the distance between the two horizontal reference lines. The value of the voltage being measured will then be indicated by the position of the gain control on the outer calibrated scale from 100 volts to 1000 volts.

Maintenance.

- With good care the Cathode Ray Tube should have a long life. It is a standard 3" tube and may be replaced with any reputable make.

- The tubes used in the Hickok Cathode Ray Oscillograph are:

  1 Type 6C6 used in Horizontal Amplifier.

  1 Type 6J7 used in Standard Vertical Amplifier.

  1 Type 1852 used in Video Vertical Amplifier.

  1 Type 884 used in Sweep Circuit Oscillator.

  2 Type 80 used in Power Supply Circuit.

  1 Type 6A7)
  1 Type 6C6) used in Radio Frequency Modulator Circuit.

  1 Type 6H6 used in Demodulator Circuit.

- The instrument has a line fuse in the rear and underneath the chassis shelf. Replacements should be made with 2.0 amp. size.

- If, for any reason, you require further information, write us.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
10514 Dupont Avenue,
Cleveland, Ohio

OTHER HICKOK PRODUCTS

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  - Panel Mounting
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- Dynamic Mutual Conductance Tube Testers
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- Traceometers
- Appliance Testers
- Zero Current Voltmeters
- Vacuum Tube Voltmeters