SERVICE APPLICATIONS

OF

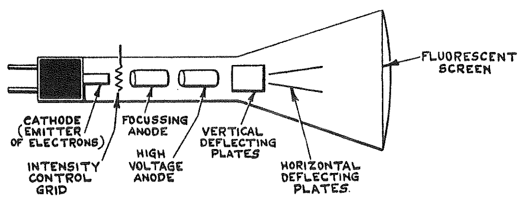
CATHODE RAY OSCILLOGRAPH

TYPE TMV 122-B

OPERATION OF THE CATHODE-RAY OSCILLOGRAPH

THE RCA CATHODE-RAY TUBE

The heart of the Cathode-Ray Oscillograph is the Cathode-Ray Tube, a development of RCA Engineers to its present practical form. The Cathode-Ray tube has often been called the "Electron Gun," as this describes its functions. The illustration shows an elementary diagram of the tube.

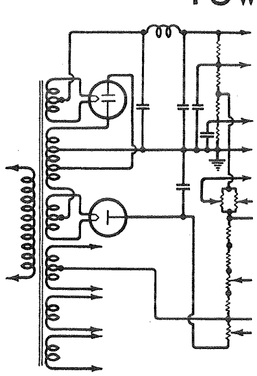


For the purpose of understanding the action of the "electron gun," one may consider the cathode as emitting electrons, which are accelerated by the high voltage anodes and which strike the fluorescent screen at the end of the tube, thereby creating light. The course of the electrons is controlled by the two sets of deflecting plates, one for horizontal deflection and one for vertical deflection. The amount of deflection, which controls the location of the light-spot on the screen, is a direct function of the voltage at any particular instant on the deflecting plates.

From the foregoing it is seen that a pattern of light may be traced on the screen by the simultaneous application of voltages to the horizontal and vertical deflecting plates. If this action is repeated twenty or more times per second, the retentive power of the eye is such that the tracing will not be discernible and the entire pattern will be seen.

Focusing of the light beam on the fluorescent screen is accomplished by adjusting the voltage on the anode nearest the cathode. The intensity of light is controlled by the negative voltage applied to the grid.

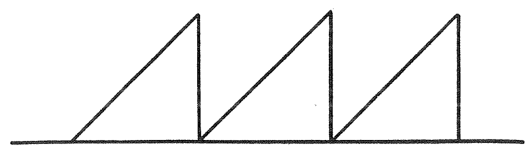
POWER SUPPLY



The high voltage anode of the Cathode-Ray Tube requires 1000 volts DC for proper operation. Also, DC voltages are required for the amplifier. The RCA-879 rectifier is used in a half-wave rectifying circuit for providing the necessary anode voltage for the RCA-906. The RCA-80, connected in a full-wave rectifying circuit, provides plate and grid voltages for the two RCA-57 amplifiers. While a single transformer is used for both rectifiers, individual filter circuits are provided. The transformer is oversize to prevent stray magnetic leakage that would otherwise affect the operation of the Cathode-Ray Tube.

THE SAW-TOOTH OSCILLATOR

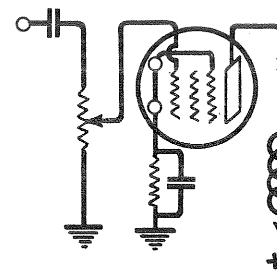
The external voltage under test is always connected to the vertical deflecting plates. However, unless some means is provided for moving the beam simultaneously in a horizontal direction, a beam rising and falling vertically will be obtained. As this would merely give an indication of the



maximum voltage available, a means must be provided for simultaneously deflecting the beam horizontally. For this, the so-called variable frequency "saw-tooth" oscillator is necessary. The "saw-tooth" refers to the wave shape of the oscillator and is required because of the necessity for having the horizontal deflection increase in a linear manner and then abruptly return to zero and again shift across the screen. The frequency of the oscillator must have a definite relationship to the frequency of the voltage under test. For example, to examine one cycle, the saw-tooth oscillator must be the exact frequency of the voltage under test. If the saw-tooth oscillator is one-half of the frequency of the voltage under test, then two cycles will be shown on the screen at one time.

With the saw-tooth oscillator provided in the TMV-122-B, the minimum number of cycles for the highest frequency is six, being obtained when a 90,000-cycle voltage is observed with the saw-tooth oscillator at 15,000 cycles. Higher frequencies may be examined by connecting directly to the vertical plates and using an external timing oscillator.

AMPLIFIERS



The sensitivity of the Cathode-Ray Tube is such that a voltage of 75 is required for either a vertical or horizontal deflection of one inch. Because many voltages used in radio circuits are very small, an amplifier has been provided for each set of deflecting plates. Both amplifiers use an RCA-57 tube and have a high gain and wide frequency range. The gain is approximately 40 and the frequency range is 20 to 90,000 cycles $\pm 10\%$.

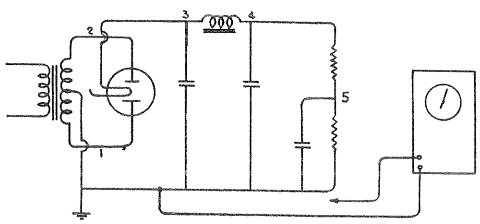
Designing an amplifier circuit of such wide frequency range is a difficult engineering problem. Its solution greatly increases the flexibility of the equipment.

APPLICATIONS OF THE CATHODE-RAY OSCILLOGRAPH

VOLTMETER AND AMMETER

In all of its applications, the oscillograph receives the voltage to be studied from an external source on its vertical deflecting plates and a voltage which may be either external or internal on its horizontal plates. The deflection in either direction is proportional to the voltage impressed on the plates. If voltage is impressed on the vertical plates only, the instrument can be considered as an a-c meter. It may be used as a voltmeter without the amplifier; it may be used as a voltmeter with the amplifier; or it may be used

APPLICATION OF MODEL 122B AS A VOLT METER
MEASURING RECTIFIER RIPPLE



DEFLECTION IS PROPORTIONAL TO A.C. COMPONENT
FREQUENCY OF RIPPLE EASILY ESTABLISHED.

Figure 1—Oscillograph as a Voltmeter

as an a-c ammeter. The specifications for voltmeter and ammeter use may be briefly summarized as follows:

A—A-C voltmeter without amplifier
- (1)—Impedance: 400,000 ohms below 100 KC (80,000 ohms at 1,000 KC)
- (2)—Frequency range: at 20-100,000 cycles (higher at low impedances)
- (3)—Voltage range: 150 volts (higher with external attenuator)
- (4)—No needle to bend
- (5)—No delicate coils to burn out
- (6)—Calibration: 75 peak volts per inch (approx.)

B—A-C voltmeter with amplifier
- (1)—Impedance: 500,000 ohms below 100 KC (160,000 ohms at 1,000 KC)
- (2)—Frequency range: 20 to 90,000 cycles
- (3)—Voltage range: 700 volts (higher with external attenuator)
- (4)—No needle to bend
- (5)—No delicate coils to burn out
- (6)—Calibration: 2 peak volts per inch (maximum)

C—A-C ammeter with the amplifier
- (1)—Use as voltmeter across external shunt
- (2)—Range, with 1 megohm shunt: 0.6-2100 micro-amperes
- (3)—Range, with 1000 ohm shunt: 0.2-700 milli-amperes

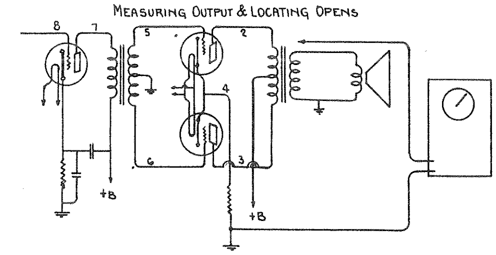
The diagram, Figure 1, shows an application of the oscillograph for checking power supply units. The oscillograph shown on the right has one terminal connected to the common lead of the filter circuit and the other lead is placed in turn at "1" and "2" to measure the magnitude of the a-c supply; at "3" to measure the a-c ripple across the first condenser; at "4" to measure the ripple on the low side of the choke coil; and at "5" to measure the ripple across that section of the voltage divider circuit. Putting the leads across terminals "3" and "4" very readily checks for shorted turns in the filter choke. The particular value of this instrument over a voltmeter in this application is the fact that, unlike a voltmeter, it has no delicate coils to burn out, no delicate mechanical moving element, no pointer to slap up against the stop pins and, for small voltages, an extraordinary high impedance.

In Figure 2 the application of the cathode-ray instrument as an audio frequency voltmeter is illustrated. One side of the "vertical" input is shown connected to ground and the other side is placed alternately across "1", "2", "3", "4", "5", "6", "7" and "8", in order to find the cause for loss of sound. By applying the sweep circuit on the horizontal plate, one can observe the character of the wave. This helps greatly in locating intermittent troubles.

OBSERVATION OF AUDIO WAVE SHAPES

In the diagram of Figure 3 is shown a general scheme of measurement using cathode-ray equipment which cannot be accomplished by the means of a voltmeter. The problem here is in discovering the audio quality of a receiver, and perhaps in locating the cause for audio distortion. In the upper part of the diagram is shown an audio oscillator or frequency record, which feeds into the second detector of the receiver. The character of the output is observed on the oscillograph. The saw-tooth sweep circuit is interlocked with the signal on the vertical plate. In this way the audio wave stands still and distortion is readily discernible. Normally one should observe the quality of the input as well

APPLICATION OF MODEL 122B AS A VOLTMETER
MEASURING OUTPUT & LOCATING OPENS



DEFLECTION PROPORTIONAL TO A.C. COMPONENT
WAVE FORM CAN BE OBSERVED TO ASSIST IN
LOCATING INTERMITTANT TROUBLES

Figure 2—Audio Frequency Voltmeter

as that of the output to make certain that the distortion is not being fed into the receiver.

In order to check the overall audio performance of the receiver, a modulated r-f oscillator can be used. The output of the oscillator should be observed and this compared with the output of the receiver.

MEASUREMENT OF MODULATION

The application of the cathode-ray tube as a modulation indicator or the modulation meter is of interest, especially to "hams". It should not be inferred that only "hams" have troubles maintaining the proper percentage of modulation. Sometimes commercial stations are lax in this respect and a knowledge of modulation is often very helpful in servicing receivers. In Figure 4 is shown method "A", in which the modulated r-f output of a transmitter is fed into the vertical plates of the oscillograph and the audio signal is fed into the synchronous circuit. The saw-tooth oscillator should be adjusted so that for normal audio frequencies, several modulation envelopes appear on the screen and the wave can be observed quite readily, although it is

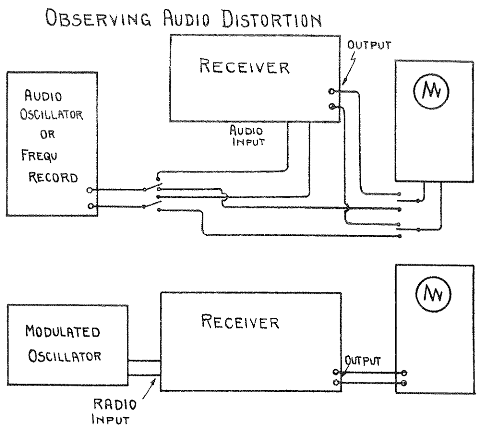


Figure 3—Audio Quality Measurement

not stationary. There is no way of synchronizing this signal with the speech or music which would ordinarily be used for transmission because of the great variation in frequency, but one can nevertheless get an excellent idea of the amount of modulation. In checking the transmitter, a constant frequency input can be used and the horizontal timing-axis interlocked with this frequency so that the wave stands still and the amount of modulation is very clearly defined.

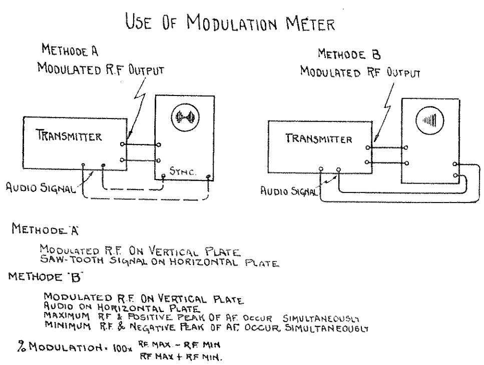


Figure 4—Measurement of Modulation

Method "B" on the right of Figure 4 shows the instrument used in a somewhat different manner as a modulation meter. The modulated output is put on the vertical plates and the audio signal on the horizontal plates of the oscillograph. Since the r-f amplitude is maximum when the audio voltage is maximum in the positive direction; since the r-f voltage is minimum when the audio is maximum in the negative direction; and since the audio and the envelope of the r-f both are sinusoidal voltages, the resultant figure is a trapezoid if the modulation lies between zero and 100%.

The figure becomes a triangle if the modulation is 100%, and a vertical line if the modulation is zero. The percent modulation equals 100 times the difference between the maximum and minimum vertical sides of the trapezoid, divided by the sum of these two sides. This is shown somewhat clearer by Figure 5.

On the left of figure 5 appears the oscillogram for 100% modulated wave; immediately below it the corresponding audio voltage which causes the horizontal swing, and below that, the 100% modulated r-f voltage which causes the vertical swing. If it is remembered that, when the vertical amplitude increases in direct proportion to the horizontal deflections, the result is a straight line, it will be understood why this triangle results.

Below the trapezoid which represents 50% modulation, is shown the decreased audio frequency voltage which does not bring the r-f amplitude down to zero on the negative voltage wave and does not cause such a high value of r-f when the audio voltage is at a positive maximum. This diagram serves well to develop the formula for percent modulation. Under normal operating conditions, the un-

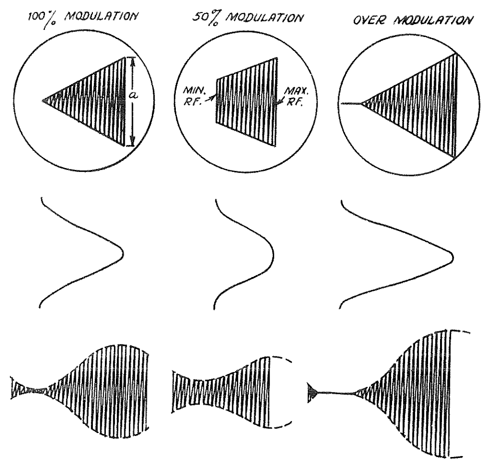


Figure 5—Indication of Percent Modulation

modulated r-f will have an amplitude which is the average between the maximum r.f. and minimum r.f. shown in the diagram. This follows because the wave increases as far on the positive audio loop as it decreases on the negative audio loop. This average will equal maximum r.f. plus the minimum r.f. divided by two. The difference between the maximum r.f. and minimum r.f. represents twice the audio voltage. Therefore, the percent modulation which is equal to the audio voltage divided by the unmodulated carrier voltage, will equal r-f maximum minus r-f minimum divided by the quantity r-f maximum plus r-f minimum.

On the right of the diagram is the figure which results when the modulation is over 100%. Below it is the cause for such a figure. The audio voltage is much larger than it was before and on the right-hand side the positive loop causes the r-f energy to increase to a very large amplitude. When the audio voltage swings negative, however, it reduces the carrier to zero and the carrier stays zero until the audio voltage swings through its negative peak and back to a sufficiently low negative voltage to again permit r-f output.

I-F ALIGNMENT

Alignment of i-f stages with the oscillograph is a subject in which there is much interest. Figure 6 shows the necessary apparatus and general connections. On the lower left is a sweep condenser which causes the frequency generated in the r-f oscillator to sweep up and down about the frequency for which the oscillator is set. For example, if the

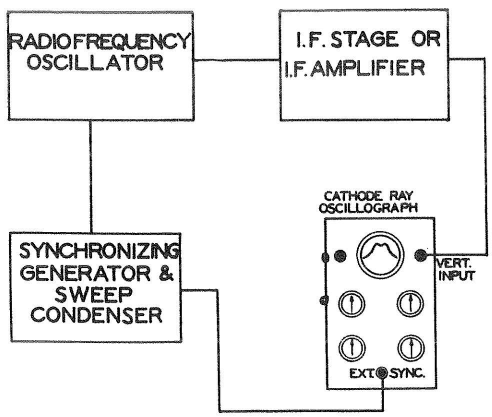


Figure 6—Scheme for I-F Alignment

oscillator is set at 460 kc, then the sweep condenser will cause this frequency to vary from, say, 445 to 475 kc. This varying frequency of constant amplitude is fed into the i-f amplifier, the output of which is impressed on the vertical plates of the oscillograph. A synchronizing (or impulse) generator which rotates in synchronism with the sweep condenser, is connected to the synchronizing terminals of the oscillograph so as to synchronize the saw-tooth generator with the frequency variation of the input into the i-f amplifier. The oscillator should not be modulated by audio frequency for this adjustment.

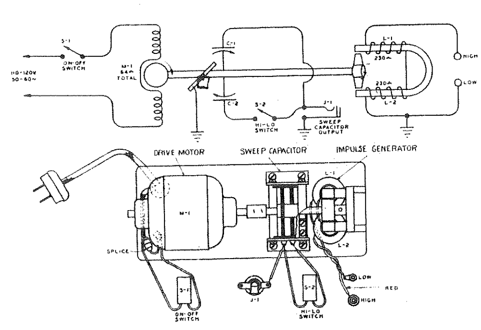


Figure 7—Frequency Modulator

An illustration of the sweep condensers, the synchronizing generator and the motor which drives them is reproduced in Figure 7. The sweep condenser is connected across the condenser of the r-f oscillator and in rotating causes the capacity of that circuit to vary above and below the normal fixed frequency. Provision is made so that the capacity of the sweep condenser can be varied, thus controlling the frequency range of the sweep.

The synchronizing generator consists of a permanent magnet with an air gap in which is rotated an armature with two poles. Twice each revolution these poles are across the air gap and produce an increase in magnetic flux so that the field coils which are mounted on the magnet have two pulses of voltage induced in them for each revolution of the condenser. The relative position of the armature of the synchronizing generator with respect to the plates of the sweep condenser can be varied so that these pulses occur at the point of maximum and of minimum capacity, to the end that the horizontal movement of the ray of the oscillograph starts when the frequency is just beginning to increase and starts again when the frequency is just beginning to decrease.

At the top of Figure 8 is depicted the frequency-modulated signal which is fed into the i-f amplifier. Because the i-f amplifier is tuned to a particular frequency the output of the amplifier will look somewhat as shown on the second line. If this i-f amplifier output is passed into a rectifier, and the high frequency component by-passed, a rectified current as shown on the third line will be produced. It is possible to feed either the output of the i-f amplifier or the rectified current onto the vertical plates of the oscillograph in order to make the alignment; the latter, however, is preferred because of the difficulty of connecting into the i-f amplifier without changing the tuning of its circuit and the

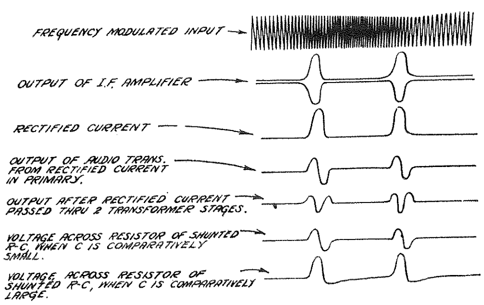


Figure 8—Frequency Modulation and Rectification Waves

fact that the intermediate frequency of most present day receivers is far above the range of the amplifier in the oscillograph, so that the i-f output would have to be large enough to be fed directly to the plates of the cathode-ray tube without amplification.

In utilizing the rectified current, the fact that it is not an audio frequency current but instead a pulsating direct current, requires certain considerations as to its use. If the pulsating direct current passes through the primary of an audio transformer, the voltage produced on the secondary will appear as shown in the fourth line, having a positive maximum when the current is increasing at the maximum rate, a negative maximum when the current is decreasing at a maximum rate and being zero whenever the current is not changing.

If such a current is fed through a second transformer stage, the curve shown on line 5 is produced. In Calculas terminology, curve 4 is the derivative of curve 3 and curve 5 is the derivative of curve 4. Obviously, it is better to establish the standard shape of curve desired, as that of rectified current rather than that which has passed through one or two audio transformers.

If the oscillograph is coupled to the rectifier circuit, by putting a resistor in series with a condenser across a resistor which is in the rectifier circuit, it is necessary to be careful of the relative size of the resistor and condenser. If the ohmage of the resistor is comparatively large with respect to the capacity reactance of the condenser, a curve as shown in the seventh line will appear, which is almost identical with that of the rectified current and which can be made near enough for all practical purposes by making the condenser sufficiently large.

If a small condenser, having a high capacity reactance and a low ohmage resistor is used, the resultant curve of voltage across the resistor will be as shown in line 6, which, of course, is not desirable as a standard.

In Figure 9 there are three diagrams indicating the preferred method of connecting the oscillograph into the detector circuit. On the left is shown a modern set using a diode for detector. It is possible to connect the vertical plates across the volume control, or across the volume control and AVC resistor both, if it is convenient to make this connection. The capacitor and gain control of the vertical amplifier in the oscillograph are properly proportioned so as to cause no distortion of the curve.

In the center diagram a second detector is shown, which may be either a triode, a tetrode or a pentode, and which is resistance coupled to the first audio stage. Here the vertical amplifier of the oscillograph is connected to the plate of the detector and the other side connected to ground. The voltage used is that across the coupling resistor. The condenser in the amplifier input circuit serves to block out the d-c plate potential.

In the figure on the right, there is a triode, tetrode or pentode, which is coupled to the first audio amplifier by a transformer, or by an inductor. Here, a resistor is connected between the plate and the coil to by-pass the signal around the coil by a one mfd. or larger capacitor. The impedance in the plate circuit is changed to a resistance rather

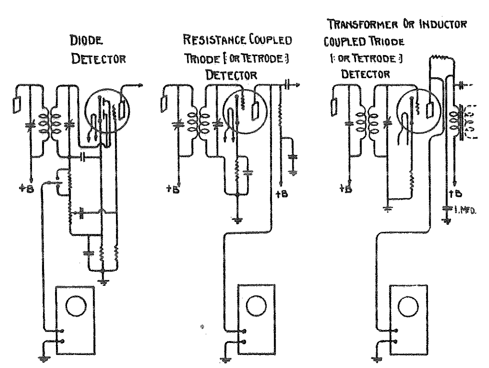


Figure 9—Connections of Oscillograph to Receiver

than an inductance. The vertical amplifier is connected between the plate and ground so as to take the voltage off this resistor.

In the factory, when using the resistor in series with the plate, the alignment operators are provided with a detector tube which is normal in every respect except that a hole has been drilled through the base. The lead from the plate to the prong is brought out and the connections are made to these leads. This special tube can be substituted for the regular second detector tube and the connections can be made rapidly, and without undue loss of time.

Use of an adapter between the socket and the tube might be considered in order to get at the plate lead but the use of such an adapter will increase the length of the grid lead and change the tuning of the i-f transformer. Of course, the i-f transformer can be retuned if the adapter is to be left in permanently, but an adapter cannot be properly used to align the i-f coils and then remove the adapter and the coil expected to remain aligned.

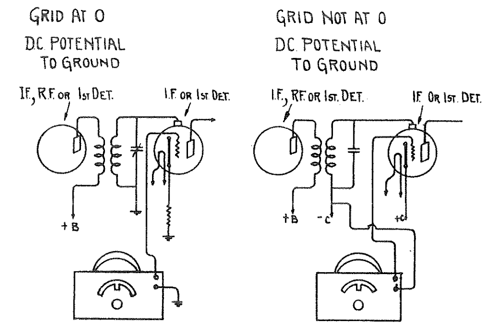


Figure 10—Oscillator Connections

Figure 10 is for the purpose of showing how the r-f oscillator can be connected so as to feed the signal into the i-f amplifier.

The connection from the r-f oscillator should be made to the grid of the tube preceding the coil to be adjusted. For example, if adjusting the last i-f transformer (between the last i-f tube and the second detector), feed the signal into the grid of the last i-f tube. If adjusting the first i-f transformer, feed the signal into the grid circuit of the first detector.

If the grid of the tube into which the connection is made is at zero d-c potential with respect to ground, the oscillator should be connected to the grid of the tube and the lead ordinarily connected to the grid should be removed.

If the grid is not at d-c potential with respect to ground, it is necessary that the bias be maintained unchanged and the proper connection, as shown on the right of this diagram, is to connect one terminal of the oscillator to the grid (removing the wires that were previously connected to it) and connecting the other wire to "—C".

It will be noted that in both of these cases, the tuned circuit which was connected to the grid has been disconnected so that it cannot interfere with the operation of the r-f oscillator. In making the connection into the grid circuit there will be no difficulty, of course, if the grid is brought out through a cap in the top of the tube. By drilling a hole in the base of a tube and bringing out the connections from the grid and the grid prong, considerable time can be saved in making these connections when the tube has no grid cap.

One might consider using a "socket selector" or analyzer which permits access to the elements of the tube by a plug and cable arrangement. In doing so, be very careful that oscillation is not set up by virtue of the change in capacity which has taken place between the plate and grid lead, The general process which is followed in aligning intermediate frequency amplifiers with the cathode-ray equipment follows:

(1)—Feed the sweeping input of proper frequency into the grid of the last i-f tube shown at point 1 on the Figure 11 and align the last i-f transformer. The detailed method of alignment follows in connection with another diagram.

(2)—Shift the receiver tuning condenser to see that the curve is not affected by signals generated or picked up in the r-f or oscillator part of the receiver. (This is sometimes caused by strong local signals or harmonics of the signal generator, which get to the grid of the first detector tube and beat with the oscillator, or with harmonics of the oscillator frequency.) An alternative method is to stop the oscillator of the receiver from oscillating by short-circuiting its grid coil or plate coil, or other obvious means.

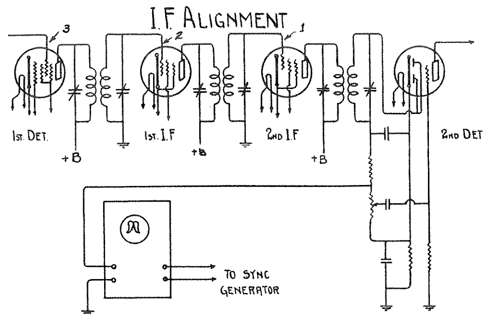


Figure 11—Connections of Oscillograph

(3)—Change the external input to the grid of the next previous tube and align the second from the last i-f transformer.

(4)—Change the input to the grid of the next previous tube (if there are three i-f transformers) and align the first i-f transformer.

(5)—AVC circuits may be made ineffective if desired, but in general, the sweeping of the input frequency takes place so fast (26 revolutions per second) that AVC action does not affect alignment.

Refer to Figure 12, the uppermost diagram. The capacity of the sweep condenser changes from minimum to maximum and back to minimum again in one revolution of the condenser shaft, and of course the impressed frequency would likewise change from minimum to maximum and back to minimum. (When the capacity is minimum, the frequency is maximum so that the variation of the frequency is in the reverse order to the variation in capacity of the sweep condenser. This is immaterial in the following discussion.)

On the next line is seen the voltage which will be impressed on the vertical plates of the cathode-ray tube, which is recognized as the rectified current output of the i-f amplifier, discussed in a previous diagram. If the i-f coils are to be aligned in the center of the sweep, then they are in alignment at the center of the increasing sweep and again in the center of the decreasing sweep which operation gives two waves for each revolution of the sweep condenser.

Of course, it is possible to show these two waves on the oscillograph screen, but as a rule, better results are obtained by using but one loop and enlarging the other so as to better study its configuration.

On the third line of the diagram there is shown the saw-tooth voltage which causes the horizontal swing of the beam. The frequency of the saw-tooth is twice that of the frequency of revolution of the sweep condenser. In most methods of i-f alignment, the ray of the cathode-ray tube is cut off every other cycle by biasing the control grid of the cathode-ray tube during this period (or by other means) so that for the first half-revolution, a wave is generated as shown on the left of the fourth line of the diagram; for the second half-revolution the screen is blank; for the third half-revolution the curve is again identical with the first and so on. The curve re-appearing every half-revolution will, of course, appear on the screen as a stationary curve and by its shape one can tell whether or not the alignment is correct.

The vertical line seen on the screen can be drawn by the operator in preparation for alignment to make sure that when the coils are finally adjusted they are aligned to the proper frequency. This should be done by disconnecting the sweep condenser, adjusting the oscillator to the proper i-f frequency and peaking the i-f coils for maximum output. Then the sweep condenser should be reconnected and the setting of the input frequency adjusted so that the highest peak lies on a vertical line drawn approximately in the center of the sweep. The receiver should then be trimmed so the curve is centered on this line and is exactly alike on the two sides.

The method just described, which is "usual method", is not the method recommended for use with this equipment and no provision has been made for using same.

The method used in the RCA Victor factory and for which this equipment is designed, may properly be called the reverse sweep method.

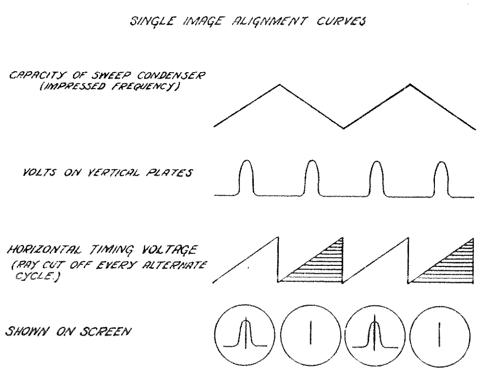


Figure 12—Alignment Curves (Single Image)

At the top of the Figure 13 is shown the curve which represents the capacity of the sweep condenser and at the same time the frequency of the input signal.

On the next line, is represented the output of the detector which is impressed on the vertical plates of the cathode-ray oscillograph as an asymmetrical wave. That is, a wave in which the leading side differs from the trailing side. Wave "A" will be produced when the frequency is increasing; wave "B" will be formed when the input frequency is decreasing and the next revolution of the sweep condensers these two waves are repeated, etc. Wave "B" is dotted so that it can be more clearly distinguished from wave "A" in the lower diagrams. On the third line is illustrated the saw-tooth voltage which produces a horizontal swing for each half-revolution of the sweep.

In the reverse sweep method the ray is not extinguished, as in the "usual method", but the increasing and decreasing curves are thrown on the screen one on top of the other.

In aligning a receiver by the reverse image method, the r f unmodulated oscillator must be adjusted so that the frequency is correct at the middle of the sweep. The trimmers

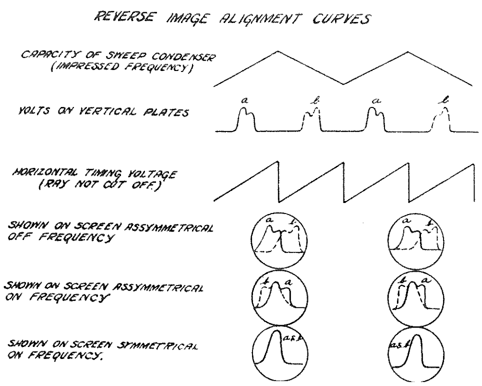


Figure 13—Alignment Curves (Reversed Image)

are then to be turned until the two curves exactly coincide throughout. The fact that the two curves have their centers coincident indicates that the transformer is tuned to the middle of the sweep (and are therefore on frequency) and the fact that the sides coincide shows that the transformer curve is the same on both sides of this point.

The fourth line of Figure 13 shows typical curves when the coil is neither properly tuned nor adjusted to the right frequency. The fifth line shows the curves when they are peaked at the right frequency but are not properly adjusted to accept both side-bands equally, i.e., they are asymmetrical.

The lowest line shows the curves "A" and "B" exactly coinciding and therefore symmetrical and on frequency.

In preparing for alignment using the reverse sweep method, the same procedure is to be followed as in preparing for the single sweep or "usual method".

(1)—Pull the plug extending from the sweep condenser to the r-f oscillator. Set the oscillator on the proper i-f frequency and arrange it for audio modulation.

(2)—Adjust the i-f amplifier for maximum output; i.e., peak it as much as possible.

(3)—Readjust the r-f oscillator to remove the audio modulation. Impress the sweep frequency. Adjust the frequency of the r-f oscillator until the forward and reverse waves show on the screen of the oscillograph. The highest point of wave "A" will be at the frequency for which alignment is to be made and will occur on the point of the increasing sweep at which the sweep frequency is exactly that for which the i-f is to be aligned. The highest point on wave "B" will be at the i-f frequency for which the coil is to be aligned and occurs when the downward sweeping frequency comes at the right point.

(4)—Adjust the frequency of the external r-f oscillator (raise the frequency) until the highest point of these two waves coincide. The highest point of wave "A" will then lie exactly in the middle of the upward sweep and the highest point of wave "B" will lie exactly in the middle of the downward sweep. (Perhaps the best way of showing this is to consider that the position of minimum capacity is the zero degree position; the position of average capacity, the ninety degree position; the position of maximum capacity, the 180 degree position; the position of average capacity in the decreasing side as the 270 position and the return to minimum capacity as the 360 or zero degree position. If the sweeping frequency passes through the alignment frequency at the 80 degree position, it will of necessity pass through the same point in the 280 degree position, hence peak "A" will lie a little to the left of the center of the horizontal beam movement and point "B" will lie a little to the right of the center of the horizontal beam movement. Only when the peaks come at the 90 and 270 degree positions can each peak lie on the center of the horizontal movement and only then can they coincide.) The adjustment of the r-f oscillator, to make the highest point of wave "A" and wave "B" coincide, corrects the oscillator setting to compensate for the added capacity of the cable and half of the sweep condenser capacity. This new position of the r-f oscillator dial can be read and recorded for future use so as to make unnecessary this calibration when future alignment is to be made using this same higher frequency. After the highest point of the two waves has been made to coincide, adjust the primary and secondary trimmers on the i-f coils until the two curves coincide

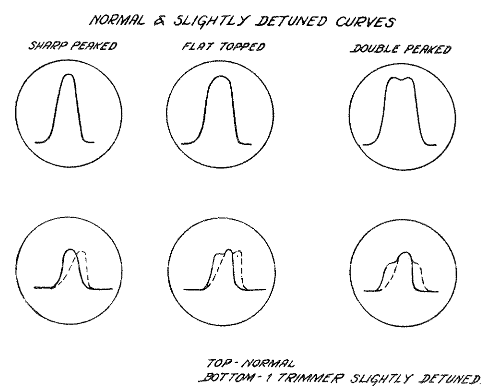


Figure 14—Typical I-F Curves

throughout their entire length. When this occurs, the coil is symmetrical with respect to the i.f. so that it does not favor one side band nor part of one side band more than it does the corresponding part of the other, and it is adjusted to the proper frequency.

The advantages of the reverse sweep method over the "usual method" are:

(1)—Avoids the necessity for extinguishing the ray on alternate half cycles.

(2)—Avoids the necessity of marking a line on the screen for vertical reference.

(3)—The possibility of error in aligning on frequency is reduced by more than one-half, since the separation between the two waves will be twice the displacement of one of the waves.

(4)—Distortion following detection (because of passing the signal through a transformer or condenser) does not cause error, since this distortion will occur on the right, or on the left, of both waves and proper alignment will be had, following the normal procedure of making the two curves coincide throughout.

(5)—The superposition of the right and left sides makes symmetrical adjustments easy and accurate.

In Figure 14 is shown three curves used in i-f transformers when properly aligned. The shape of these curves is very closely interconnected with the audio frequency characteristic of the audio end of the receiver and any change in the shape of the curve will change the audio frequency response. For example, in the sharply peaked curve at the left, a considerable cutting of side bands occurs with corresponding reduction in high frequency response, which would be compensated by a corresponding rise in the audio response of the amplifier.

Correspondingly, the flat-top wave shown in the center requires a different audio frequency characteristic and the double peak curve which results from overcoupling has a still different audio frequency response curve.

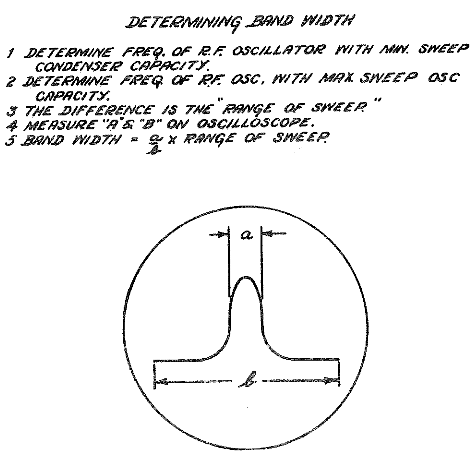


Figure 15—Typical Wave Shape

Below these three normal curves, there is a curve which obtains if one of the trimmers on the transformer was turned slightly. These indicate the necessity for great care, not only in getting the i-f transformer onto the proper frequency, but also in getting it to have the proper wave shape.

The determining of the width of the band which will be passed by an intermediate frequency amplifier is somewhat complicated until the constants of the apparatus are determined for the particular frequency in question, after which the determination of band width is comparatively easy. In outlining the procedure to be followed it is assumed that the particular intermediate frequency amplifier in question is aligned at 460 kc. and that the r-f oscillator is adjusted so that this frequency is in the middle of the sweep.

First determine the frequency of the r-f oscillator when the sweep condenser is in the minimum capacity position. This is done by setting the capacity of the sweep condenser at its minimum and adjusting the r-f oscillator so as to have it audio-modulated and feeding this signal into a receiver which is in reasonably good calibration. Tune the receiver to the fundamental, or to a harmonic of the modulated r-f signal and from the dial setting, record the frequency of

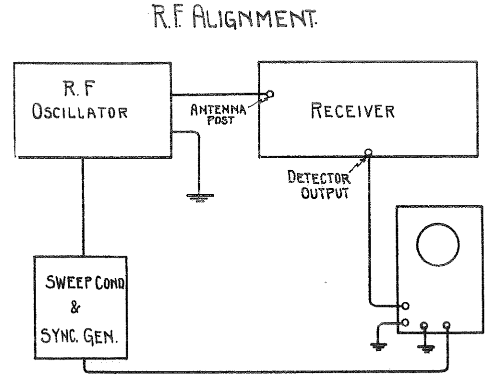


Figure 16—Connection for R-F Alignment

the input signal and calculate the fundamental frequency. Next, determine the frequency with the sweep condenser in the maximum capacity position. To do this tune the receiver harmonics of the r-f signal and calculate the fundamental frequency. Then subtract the minimum from the maximum capacity to obtain the total "range of sweep" in kilocycles.

This "range of sweep" is a constant for the particular r-f oscillator and sweep condenser at the r-f oscillator dial setting used. When this is known, the calculation of band width is very simple.

Figure 15 illustrates the wave as it will appear when symmetrical and on frequency, the length of line "B" is proportional to the range of sweep and if this range of sweep is 60 kc, band "A" will be 10 kc wide if the distance "A" were 1/6 as long as distance "B". The formula as shown on the diagram is: "band width" equals "A" divided by "B" times the "range of sweep".

R-F ALIGNMENT

The equipment and connections for making an r-f alignment using cathode-ray equipment is almost identical with that for making an i-f alignment, except, of course, in this case the r-f oscillator is fed into the antenna rather than onto the grid of the i-f amplifier tube. The output is again taken off the second detector. Figure 16 shows the necessary connections.

The procedure to be followed is:

(1)—Adjust the r-f oscillator so that the frequency in the middle of the sweep is exactly that to which the r-f is to be aligned and calibrated.

(2)—Set the dial at the proper point.

(3)—Feed the sweeping signal into the antenna.

(4)—Adjust the receiver oscillator trimmer until the forward and reverse curves coincide as well as possible.

(5)—Adjust the r-f trimmers until the curves coincide throughout. (It may be necessary to slightly re-adjust the receiver oscillator and again adjust the r-f trimmers to get maximum coincidence.)

In order to determine the proper setting of the dial of the r-f oscillator to give the proper frequency when the sweep capacity is exactly in the middle of its range proceed as follows:

(1)—Set the dial on the receiver to the point at which it is to be aligned.

(2)—Feed an audio-modulated signal of the single proper frequency (not sweeping) into the receiver and adjust the oscillator and the r-f coils to maximum possible output.

(3)—Then feed an unmodulated r-f frequency into the receiver and adjust the external oscillator until two curves show on the screen and until they coincide at their highest points. Record the setting of the r-f oscillator so that this (the above) procedure will not have to be repeated the next time an r-f amplifier is to be aligned at this frequency.

CONCLUSION

No mention is made in this discussion of the application of model TMV-122B oscillograph, which is perhaps the most valuable use it can have. By the use of cathode-ray equipment, knowledge of electrical apparatus and electrical circuits can be made much more real and conclusive. Whenever there is something which is not understood thoroughly, one will find that the oscillograph, by giving the picture of the otherwise invisible electric current, is an invaluable aid. There is no place where one can invest his money with a greater security or a greater percentage of profit than in increasing his own knowledge and ability. From this angle, a flexible cathode-ray equipment opens advantages which previously have been denied to any but the greatest of our laboratories.