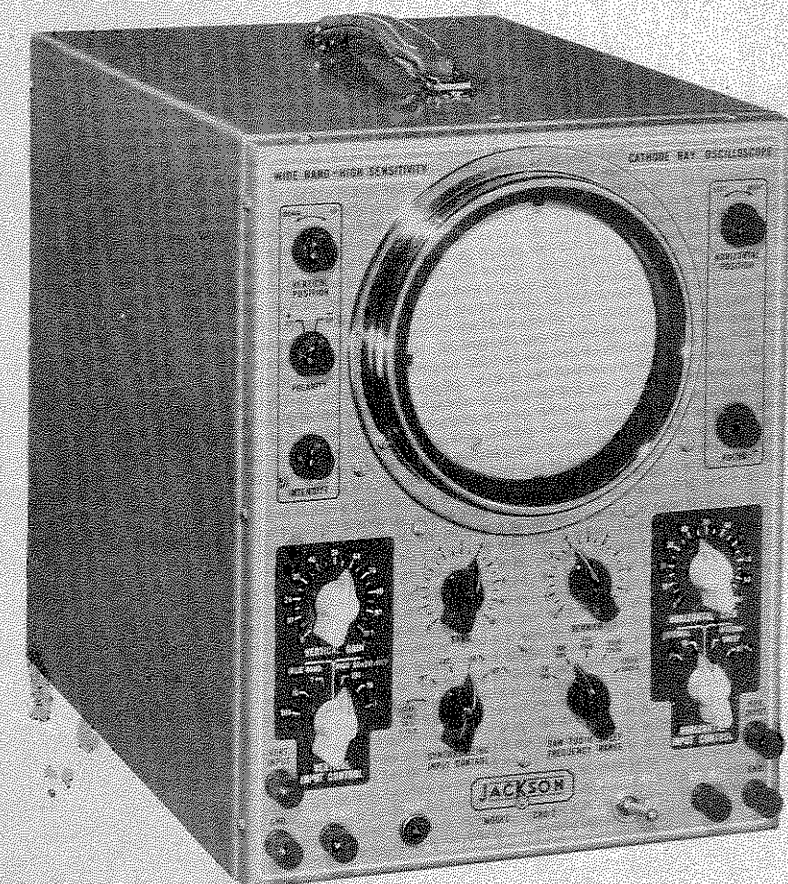
JACKSON *Radio Testing Equipment*

WIDE BAND - HIGH SENSITIVITY

CATHODE-RAY OSCILLOSCOPE

MODEL CRO-2



INSTRUCTION MANUAL

THE JACKSON ELECTRICAL INSTRUMENT COMPANY, DAYTON, OHIO

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I TECHNICAL DATA

A. POWER SUPPLY SOURCE

Rating - 110-120 volts, 50-60 cycle
Power consumption - (60) watts
Fuse protection - 1 ½ amperes

B. PHYSICAL DIMENSIONS

Height (Including handle) - - - - - - - - - - - - - - 13 1/8 inches
Width - 10 1/4 inches
Depth - 15 1/8 inches
Weight - 26 lbs.

C. TUBE COMPLEMENT

1 - Type 6C4 - - - - - - - - - - - - - - - - - - Vertical input Cathode follower
2 - Type 6J6 - - - - - - - - - - - - - - - - - - Vertical push-pull amplifiers
1 - Type 6C4 - - - - - - - - - - - - - - - - - - Horizontal input Cathode follower
1 - Type 6J6 - - - - - - - - - - - - - - - - - - Horizontal push-pull amplifier
1 - Type 6J6 - - - - - - - - - - - - - - - - - - Saw-tooth sweep oscillator
1 - Type 6C4 - - - - - - - - - - - - - - - - - - Retrace Blanking Amplifier
1 - Type 5UP1 - - - - - - - - - - - - - - - - - Cathode Ray Tube
1 - Type 5Y3GT - - - - - - - - - - - - - - - - Low Voltage rectifier
1 - Type 5Y3GT - - - - - - - - - - - - - - - - High voltage rectifier

D. AMPLIFIER FREQUENCY RESPONSE

Vertical - Amplifier set for Wide Band operation. Sine wave response uniform within 10% from 20 cycles to 4.5 megacycles, down not more than 25% at 5.0 megacycles.

Vertical - Amplifier set for High Sensitivity, sine wave response uniform within 10% to 100 kc., down not more than 25% to 200 kc., down not more than 50% at 300 kc.

Horizontal amplifier - Sine wave response uniform within 25% from 20 cycles to 100 kc, down not more than 50% at 200 kc.

E. INPUT IMPEDANCE

Vertical amplifier - 1.5 megohms, shunted by 25 mmf.
Horizontal amplifier - 1.1 megohms

F. DEFLECTION FACTOR

Vertical amplifier, High sensitivity - .018 volt R.M.S. for 1 inch peak to peak deflection.

Vertical amplifier, Wide band - 0.25 volt R.M.S. for 1 inch peak to peak. Attenuation factors of 10 and 100 available for both High Sensitivity and Wide Band

Horizontal Amplifier - 0.40 volt R.M.S. for 1 inch peak to peak deflection. Attenuation factor of 1 & 10 available.

G. HORIZONTAL SWEEP

Frequency range 20 cycles to 50 kilocycles.

Synchronizing signal sources
- Internal (vertical signal)
- External
- 60 cycle
- 120 cycle

H. MAXIMUM SIGNAL INPUTS

AMPLIFIER
- Peak AC-plus DC 600 volts
- Peak AC 200 volts R.M.S.

DEFLECTION PLATES DIRECT
- Peak AC plus DC 400 volts
- Peak AC 200 volts R.M.S.

EXTERNAL SYNC.
- Peak AC plus DC 400 volts
- Intensity modulation
  (See Operation)

OPERATING INSTRUCTIONS

II. GENERAL DESCRIPTION

The oscilloscope Model CRO-2 is an instrument designed specifically for Television and radio service work.

To enable the radio service technician to perform a complete visual analysis of the complex electronic circuits now used in Television FM and AM radio and audio design, an oscilloscope must meet several important basic requirements and perform many varied functions.

The vertical amplifiers must be capable of reproducing at the deflection plates of the cathode ray tube the EXACT waveform introduced into the input circuit. This is particularly important in television where waveforms of square and triangular shapes must be inspected and compared with standard photographs.

The video amplifier circuits in television are among the most critical. Much care and expense is put into the design of these circuits by the manufacturer to assure adequate band width of at least 4 megacycles to provide the picture quality necessary for good reproduction. Visual inspection of these video signals will allow quick and accurate diagnosis of difficulties if the waveform is correctly reproduced on the oscilloscope screen. It follows then that any instrument designed to service such amplifiers by inspection of voltages and waveforms should cover at least the minimum band width demanded in the set design. This was a basic consideration in designing the vertical amplifier in the CRO-2. The band width extends with very little loss up to 5 megacycles.

In square wave testing of audio amplifier circuits, it is also absolutely essential that the waveforms be reproduced accurately for checking performance and locating possible difficulties.

The CRO-2 has the band width necessary to service television and audio circuits using square and triangular wave shapes.

The second consideration is adequate sensitivity to properly inspect the waveforms of low voltages. One of the most useful functions of an oscilloscope is as a signal tracer in the video IF circuits of a television receiver. By use of a demodulation probe and an oscilloscope of high sensitivity, it is possible to trace the characteristic pattern of the modulated picture signal from the plate of the converter tube, stage by stage, through to the video detector. This allows fast isolation of a defective stage, such as might be caused by a leaky bypass or coupling condenser. The CRO-2 is designed so that 18 millivolts at the input will give 1" deflection on the screen. This is more than adequate for detecting and inspecting all these voltages that are so very important in modern service work.

Other considerations such as the high impedance inputs, the horizontal sweep (sawtooth) waveform linearity, stability of the horizontal sweep oscillator frequency, provision for intensity modulation of the cathode ray tube grid, the addition of 120 cycle synchronizing voltage, switch reversal of vertical polarity, and the availability of a standard reference voltage all go to make the CRO-2 the most modern, complete oscilloscope "designed with the service man in mind."

III. THEORY OF OPERATION

A. Incorporated in the CRO-2 Cathode Ray Oscilloscope are a dual function (high sensitivity or wide band) vertical amplifier, horizontal amplifier, linear time base (sawtooth) oscillator, intensity modulation input, and power supply. These are shown in the block diagram (Fig. 2), and the various circuits will be analyzed individually so that you may better understand their many uses in this highly adaptable service instrument.

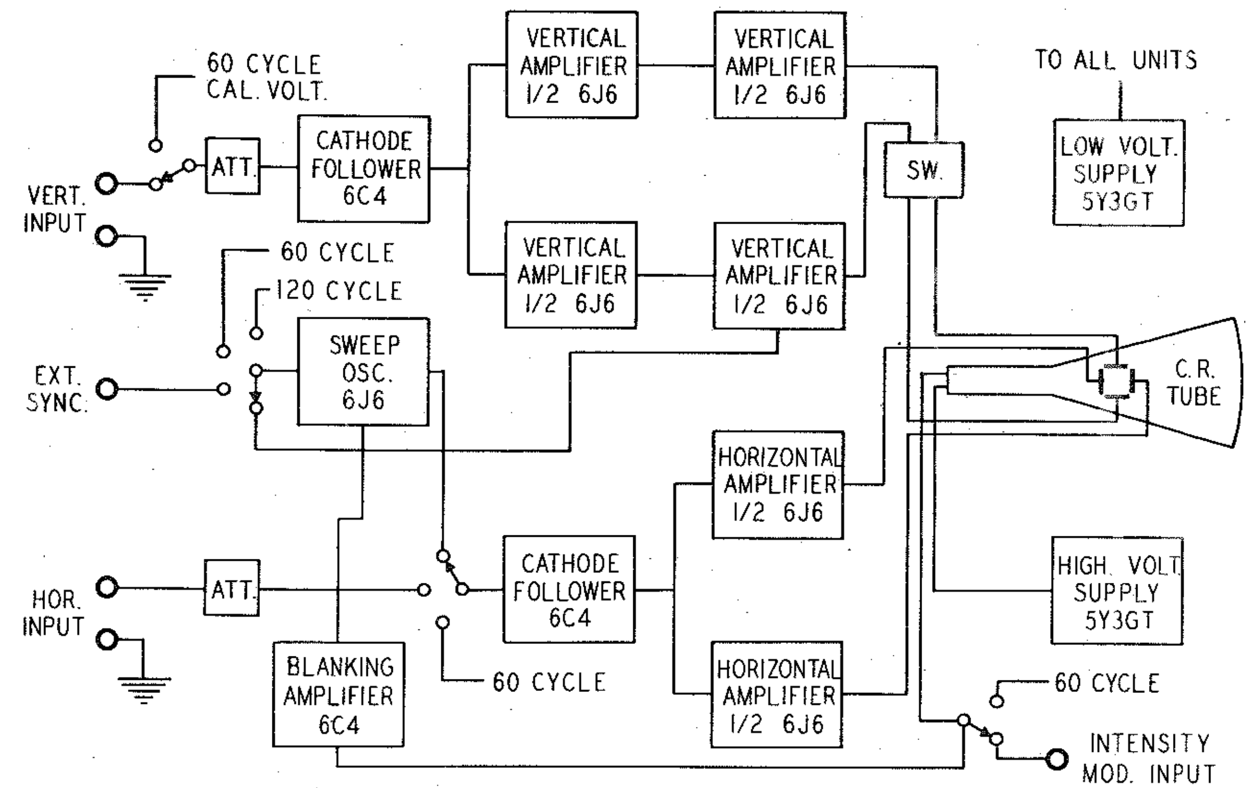

Figure 2

Block Diagram - Model CRO-2 Oscilloscope

B. CATHODE RAY TUBE

The "picture screen" for "seeing" electrical waveforms, from simple sine to the most complex, is the cathode ray tube. This tube is the heart of the cathode ray oscilloscope.

Although extremely sensitive to rapidly changing quantities with negligible inertia, this tube is not damaged by the application of too great a deflection voltage, therefore not delicate, and it uses such small amounts of power that it imposes a minimum load on any signal to be studied.

There are a great many types of cathode ray tubes available to the instrument engineer. They offer a variety of screen size, length, screen persistence, screen color and many other variables. Because the CRO-2 is a T.V. and radio service instrument, the type 5UP1 was chosen as offering the most in the things considered important for this oscilloscope. Large enough to use without being too bulky, brilliance and sensitivity with nominal accelerating potentials and size of spot make this tube the logical choice.

The cathode ray tube and associated circuits are shown in Fig. 3. Also shown are the four controls affecting operation of the tube and control of the beam.

The intensity control is a potentiometer (R61) in the high voltage bleeder. Its position controls the voltage on the cathode more or less positive with respect to the grid of the cathode ray tube which is operated at full negative voltage. This determines the flow of electrons from the "gun", thus controlling the spot brightness.

The focus control potentiometer (R59) also in the high voltage bleeder controls the first anode potential which accelerates and forms the electrons into the beam. It is necessary to vary this control to maintain sharpness when the intensity is varied as there is inherent interaction in all electrostatically focused cathode ray tubes.

Vertical centering and horizontal centering controls govern the position of the spot on the tube screen. These potentiometer controls (R62 & R63) are shunted across a portion of the low voltage bleeder so that varying amounts of d-c potentional are applied to each respective pair of deflecting plates, thereby allowing adjustment of the position of the spot or image.

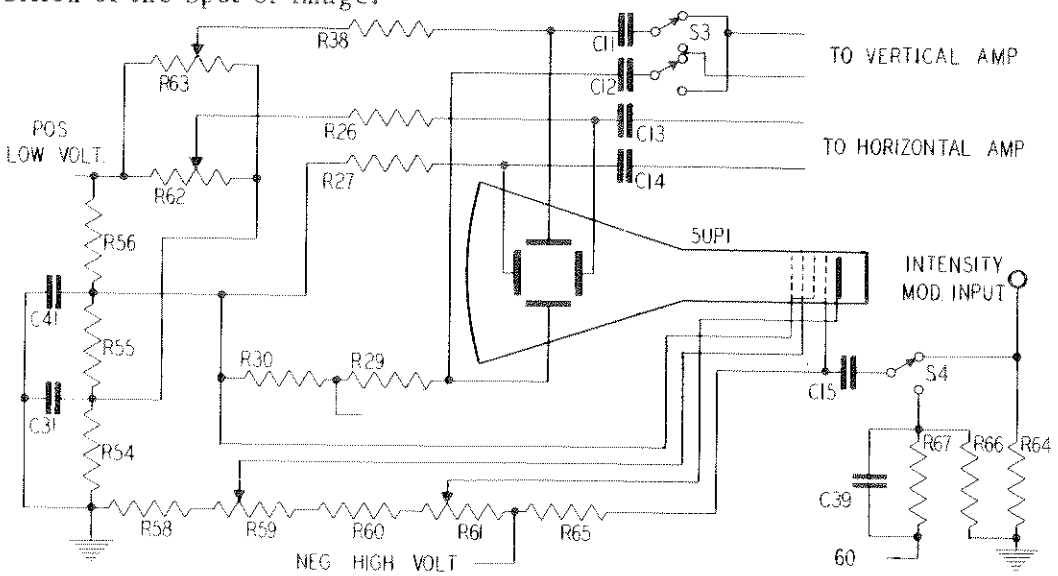

Figure 3

Schematic - Cathode Ray Tube Circuits

C. VERTICAL AMPLIFIER

As the vertical amplifier is used to amplify the signal to be inspected, much work has been done to provide the performance necessary for modern T.V. service laboratories.

Because in T.V. service work both wide band width and high gain are not usually needed together, it has been possible to incorporate both features in a compact and portable instrument. By means of a combination attenuation, selector switch (S1), either the wide band width or the extremely high gain are available to the user.

The entire input circuit (Fig. 4), compensated step attenuator and cathode follower permits a wide range of input signal level with minimum circuit loading and little or no frequency discrimination.

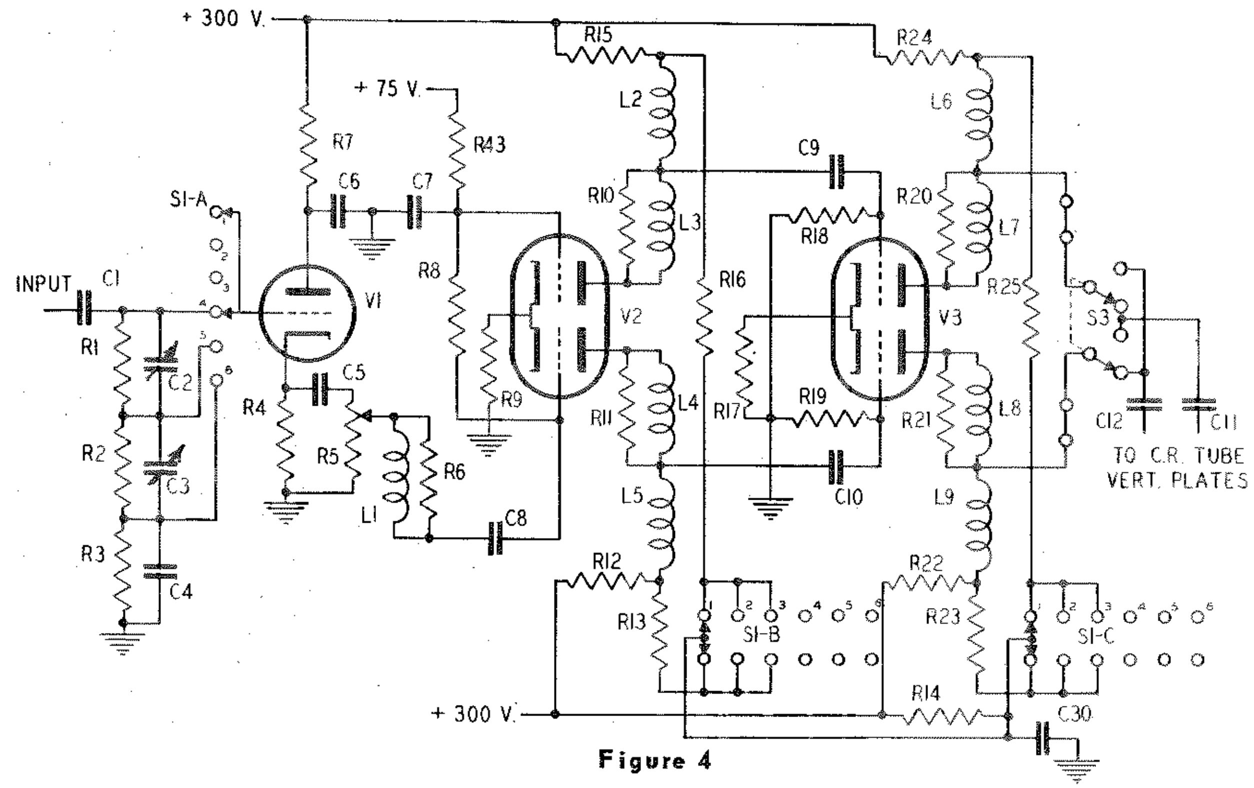

Figure 4

Schematic - Vertical Amplifier Circuits

The incoming signal is applied to terminals marked "Vertical" and "GND" on the front panel. A blocking capacitor (C1) is used so that only the A.C. component to be inspected appears at the step attenuator.

However care must be taken that the input stage is not overloaded by improper selection of the input step attenuator control. This attenuator step control is so designed that maximum voltages of 6, 60, and 600 volts R.M.S. respectively will not block the input stage in the 1:1, 10:1, and 100:1 ratio steps.

Compensation for distributed capacity in the step attenuator is accomplished by means of C2, C3, and C4. C2 and C3 are variable capacitors and are factory adjusted to balance out strays to maintain the wide frequency response characteristics of the amplifier at any attenuator setting.

A cathode follower input stage is used to isolate the input from the rest of the amplifier stages and due to the low impedance output the gain control R5 can be shunted across the cathode load resistor R10 to give a continuous fine adjustment of the input level with little effect on the frequency response up to 5 megacycles which the following amplifiers stages are designed to pass.

It must be remembered that the vertical amplifier extends the voltage sensitivity of the instrument, and in usual designs high gain is achieved at the sacrifice of frequency response. In the CRO-2, however, the compromises of frequency and gain have been eliminated by providing a choice of performance dependent upon the immediate need.

Compensation for high frequency must be made even in the high sensitivity operation and much more in the wide band. This is accomplished by use of combination series and shunt peaking. By the choice of proper values, the most gain and band width can be accomplished by this method.

The switching from high sensitivity to wide band width is done by the shunting resistor method. By switching a resistive load across the peaking coils, their response curves are widened, and by the proper choice of components, the desired response curves are achieved.

Balanced amplifiers are employed, because when a signal is applied to both plates of a "deflection pair" it makes possible proper focusing of the resultant trace across the entire screen and eliminates much of the instability caused by line voltage fluctuations.

The first stage (V2-type 6J6) employs a cathode coupled circuit to provide balanced output from an unbalanced input push-pull deflection amplifier (V3-type 6J6) feeding the vertical deflection plates of the cathode ray tube.

The signal from the gain control is fed to the first grid of V2 through a series peaking coil (L1). Due to the unbypassed condition of the resistor (R9) common to both sections, the signal appears at the cathodes. This resistor value has been chosen so that this voltage is equal to the input. Because the second grid is electrically at cathode potential, this input voltage will again appear at both plates amplified equally but 180 degrees out of phase, the condition for a balanced amplifier.

Further amplification is supplied by V3 and the output fed through jumpers on the terminal board at the rear of the cabinet to a reverse switch (S3).

This Vertical Position Polarity switch has been incorporated to provide simple means of reversing the pattern so that it will be either up or down for direct comparison with illustrations such as may be found in television alignment instructions.

D. HORIZONTAL AMPLIFIER

The horizontal amplifier (Fig. 5) provides for amplification of the signal it is desired to impress on the horizontal deflection plates of the cathode ray tube. This signal source normally will be a time base obtained from within or from an associated test instrument such as a television sweep generator. In any case the vol-

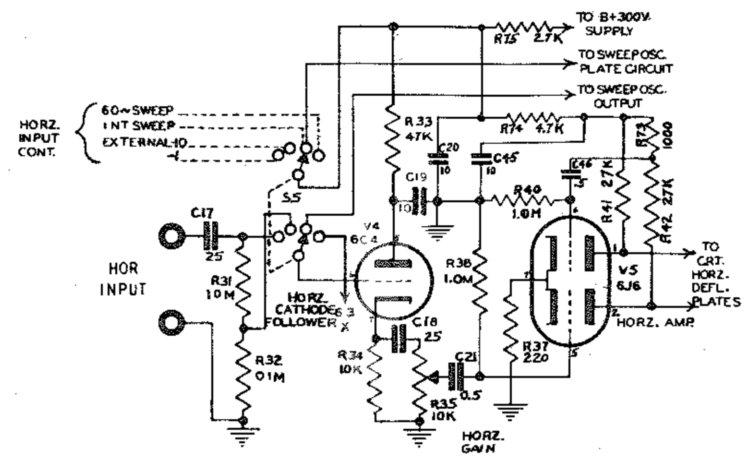

Figure 5

Schematic - Horizontal Amplifier Circuits

tage source is usually known and under the user's control so that the horizontal amplifier requirements as to gain and band width are not necessarily the same as those of the vertical.

The attenuator and switch provide 2 steps, 1:1 and 10:1 ratios, for external signal and selection of either an internal source of 60 cycle sweep and the internal sawtooth oscillator source. No compensation is necessary on the attenuator because of the comparatively limited range of frequencies applied to the horizontal plates. A cathode follower input isolation stage is provided (V4-type 6C4) and is identical to that used and described in the vertical Amp. input. A push pull stage of amplification, a twin triod (V5-type 6J6) tube is used, the first section is used to drive one deflection plate of the C.R. tube, also a portion of this voltage is fed to the grid of the second section which is used as a phase inverter amplifier, and the output from this section drives the other deflection plate of the C.R. tube.

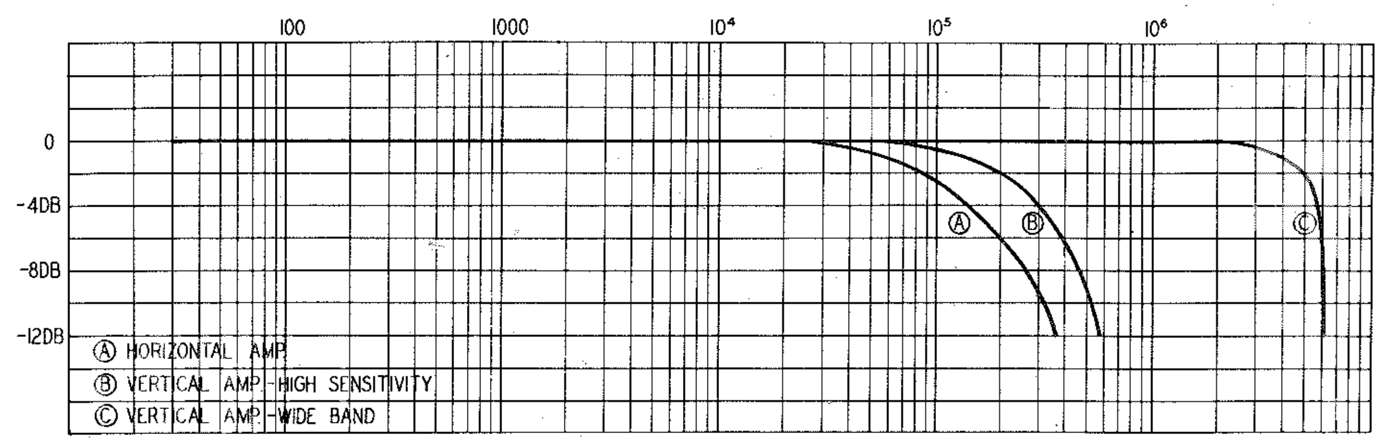

Figure 6

Typical Amplifier Response Curves

E. INTENSITY MODULATION

Intensity modulation is provided on the front panel with selection by switch (S4-Fig. 3) of a 60 cycle voltage or the external binding post.

This feature is useful for "blanking out" unwanted portions of the trace or to time the length of a waveform by means of "timing dots". (Timing of the beam by a means of narrow pulses)

The cathode ray tube grid is connected to the switch by a capacitor (C15) which blocks the negative high voltage. When selected by switch, a 60 cycle voltage from the transformer is divided by resistors R64 and R67 and applied to the grid to cut off the beam during a negative portion of the signal. This offers blanking of the retrace when using the instrument with 60 cycle sweep.

F. TIME BASE (Saw-tooth) GENERATOR

The saw-tooth generator uses a twin triode (V6-type 6J6) as an unsymmetrical multivibrator in a circuit very similar to that used in several television receivers as deflection generators.

This circuit was chosen because of its stability and linearity of waveform. The saw-tooth generator action in this unsymmetrical multivibrator is much the same as in a blocking oscillator and discharge tube circuit with one tube corresponding to the blocking oscillator and the other to the discharge tube. While negative signal from the first tube holds the second tube cut-off for a relatively long time, a discharge condenser (C24, Fig. 7) charges to the "B" supply voltage through a resistor (R51 & R53) for the linear rise on the saw-tooth voltage output. When the grid of the discharge tube is driven positive, the condenser discharges through the low resistance of the plate cathode circuit and the cathode resistor.

The frequency of the oscillator is variable by means of selectively connected capacitor (C25 to C29) and a potentiometer (one section R51). This varies the time constant, thus varying the period of cut-off for the second tube.

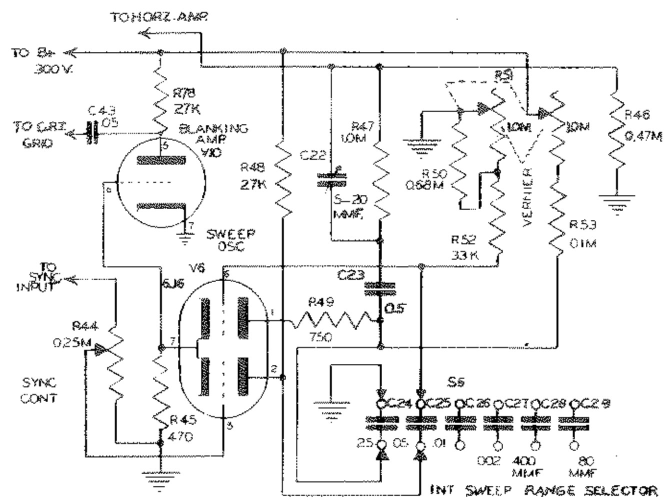

Figure 7

Schematic - Saw-tooth (Sweep) Oscillator & Blanking Amp.

To maintain constant amplitude and linearity, the discharge capacitor (C24) is also switched simultaneously with the frequency range, and the time constant varied simultaneously with a vernier adjustment. (1 section R51)

This multivibrator type of circuit is easily synchronized by introducing a voltage to the grid of the first tube and adjusting the voltage so that the peaks are large enough to raise the grid voltage above the cut-off. This adjustment is made by a potentiometer (R44). Provision is made for switching (S2) in three internal synchronizing signals, from the vertical amplifier, 60 cycle, and 120 cycle from an external source.

RETURN TRACE BLANKING

It is desirable to view only the forward trace of the sweep and to blank out the return trace. This can be accomplished by applying a negative pulse to the CR tube grid to cut off the beam during the retrace period. This can only be satisfactorily done by shaping the pulse and amplifying it so that blanking signal is uniform both as to size and shape over the entire sweep range.

In the CRO-2 this is accomplished by obtaining a positive pulse from the cathode of the sweep oscillator and directly coupled to the grid of the blanking amp. (V 10). The plate resistor R78 has been chosen so that the input signal blocks the grid of (V 10) and provides a negative square pulse which is capacity coupled to the grid of the C.R. tube to cut off the beam during retrace time.

G. POWER SUPPLIES

The power supply as shown in the schematic (Fig. 8) is made up of two separate sections. A low voltage, positive supply providing power for operating all amplifier stages, sweep oscillator as well as the positioning potentials for the cathode ray tube; and a high voltage, negative supply which furnishes the accelerating and focusing potentials for the cathode ray tube.

The low voltage power supply employs a 5Y3GT (V8) as a full wave rectifier. For the low hum level necessary, the output is filtered by a combination RC and choke condenser type filter.

The high voltage power supply consists of a 5Y3GT (V7) connected as a half wave rectifier to supply approximately 1300 volts, negative with respect to ground to the voltage divider network.

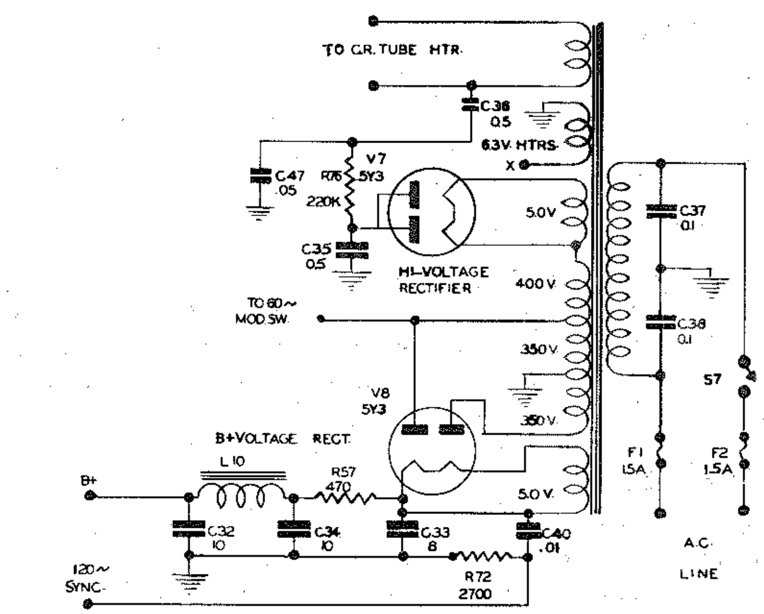

Figure 8

Schematic - Power Supply Circuits

IV. OPERATING CONTROLS

For the operator who is well acquainted with the cathode ray oscilloscope, the following brief description of the operating controls will probably give sufficient information for operation of the CRO-2.

A. BEAM CONTROLS

WARNING: DO NOT ALLOW A SMALL SPOT OF HIGH BRILLIANCY TO REMAIN STATIONARY ON THE SCREEN FOR ANY LENGTH OF TIME AS BURNING OR DISCOLORATION OF THE INTERIOR SCREEN WILL RESULT.

1. INTENSITY CONTROL

Increases the brilliancy of the image on the tube screen with clockwise rotation. The AC control switch is also on this control, and the unit is off with the control in the extreme counter-clockwise position.

2. FOCUS CONTROL

Adjusts the sharpness of the image on the tube screen.

3. VERTICAL POSITION

Governs the UP or DOWN position of the image on the screen.

4. POLARITY

In ≁UP position the spot moves up on the screen with positive voltage.

In - UP position the spot moves up with negative voltage applied.

5. HORIZONTAL POSITION

Governs the LEFT or RIGHT position of the spot or image on the tube screen.

B. INPUTS

1. Vertical Amplifier

Input terminals marked VERT. INPUT and GND are located at the lower left of the front panel. The VERTICAL INPUT CONTROL chooses either Wide Band or High Sensitivity with 3-step attenuator on each of the two modes of operation. The VERTICAL GAIN control gives continuous control of input for each attenutor setting, thus controlling the vertical deflection.

2. Horizontal Amplifier

Input terminals marked HOR. INPUT and GND are located at the lower right corner of the panel. To these terminals is connected any desired external horizontal sweep voltage. HORIZONTAL INPUT CONTROL selects the External Input with a 2-position attenuator, the internal sweep from the saw-tooth sweep oscillator or 60 cycle line frequency sweep. The HORIZONTAL GAIN adjusts the input voltage to the horizontal amplifier, thus controlling the horizontal deflection.

C. SWEEP CIRCUITS

1. SAW-TOOTH SWEEP FREQUENCY RANGE

Switches to various capacitors to obtain the 5-step variations in sweep frequency from 20 cycles to 50 KC.

2. VERNIER

This control provides the fine adjustment of sweep frequency within each of the 5 ranges of the sweep oscillator.

3. SYNCHRONIZING INPUT CONTROL

A dual purpose control which selects the various synchronizing signals and provides a calibration voltage of 10 volts, peak to peak, for the vertical amplifier. Four synchronizing voltages are provided, internal from the vertical signal, external, 60 cycle line frequency and 120 cycle.

4. SYNC.

Enables the operator to "lock-in" the sweep frequency by varying the amplitude of the synchronizing voltage. NOTE: The synchronizing voltage should be kept at minimum for best operation.

5. EXT. SYNC.

Provides a terminal connection for an external synchronizing signal.

D. INTENSITY MODULATION

1. INTENSITY MOD.

A 2-position selector switch providing the means for connection of either external signal or 60 cycle line frequency voltage to the cathode ray tube grid.

2. EXT. INT.

Provides a terminal for connection of an external intensity modulation signal.

E. DIRECT DEFLECTION (See Fig. 9)

A terminal board is provided on the rear of the cabinet for connection (through blocking capacitors) of signals direct to the cathode ray tube deflection plates. To make these connections to either set of plates, remove the jumpers and connect to the inside pair of terminals. The terminals for the vertical plates are on the right hand side and those for the horizontal on the left.

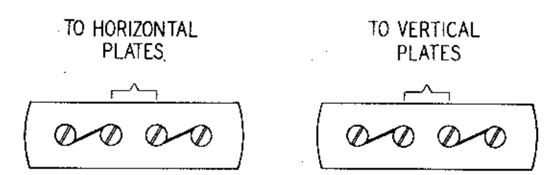

Figure 9

Rear Terminal Board

V. OPERATION OF THE CRO-2 OSCILLOSCOPE

A. OBTAINING THE TRACE

1. The oscilloscope should be placed on the bench so the screen of the cathode ray tube is in full view of the operator with a minimum amount of light on the face of the tube.

2. Set the controls as follows:

   INTENSITY to AC Off, ie., fully counter-clockwise

   FOCUS, HORIZONTAL POSITION, and VERTICAL POSITION to center of range

   POLARITY to ≠ UP

   VERTICAL INPUT CONTROL to Wide Band, ratio 10

   VERTICAL GAIN set to zero, extreme counter-clockwise

   SYNCHRONIZING INPUT CONTROL to INT.

   SYNC. to zero

   SAW-TOOTH SWEEP FREQUENCY RANGE to 20-100

   VERNIER at 5

   HORIZONTAL INPUT CONTROL to INTERNAL SWEEP

   HORIZONTAL GAIN set to 50

   INTENSITY MOD. to OFF position

3. Turn the Intensity control clockwise until the "click" is heard indicating that the AC line switch is "on" and allow 30 seconds for the instrument to warm up. Then, turn the Intensity control further clockwise until the horizontal line becomes visible on the screen. (If the line does not appear, rotate the Vertical Position control until it is centered.)

4. By adjusting the Focus control, clear up the trace by making it as sharp and clear as possible. If it is desired to brighten the trace for better observation, turn the Intensity control more clockwise. Then, readjust the Focus control for best clarity. It should be noted that the Intensity and Focus controls are dependent on each other, and it is usually necessary to adjust both controls.

5. By rotation of the Vertical Position control, the trace may be moved up or down, clockwise for up and counter-clockwise for down.

6. Rotation of the Horizontal Position control moves the trace right or left, clockwise for right and counter-clockwise for left.

7. The trace line that has now been obtained is in reality a single spot which is repeatedly moved from left to right across the screen by the sweep oscillator. This may be shown by turning the Horizontal Input control to either of the "external" positions. When this is done only a spot will appear, and if the positioning controls are correctly set, this spot will be in the center of the cathode ray tube.

WARNING: THE SPOT SHOULD NOT BE ALLOWED TO STAY ON THE SCREEN LONGER THAN NECESSARY FOR MOMENTARY OBSERVATION. THERE IS DANGER OF ANY STATIONARY SPOT BURNING THE SCREEN OF THE CATHODE RAY TUBE.

8. By returning the Horizontal Input control to the internal sweep position, the operator can now proceed to set up a test signal for observation on the screen.

9. By turning the Synchronizing Input Control to the "vertical calibrate 10 V, peak to peak" position, this voltage is fed to the input attenuator of the vertical amplifier. With the Vertical Input Control set at wide band attenuator ratio 10, rotate the Vertical Gain control to produce vertical deflection. With the Saw-Tooth Sweep Frequency Range set at 20 to 100 position, rotate the Vernier control until a sine wave of one or more cycles appears on the screen. As the Vernier control is turned toward the "zero" end of the scale, more cycles will appear.

10. The pattern will have a tendency to drift across the screen regardless of setting of the Vernier. With the Synchronizing Input control set to Internal, turn the SYNC. control clockwise, increasing the amplitude of the Synchronizing Voltage injected into the sweep oscillator. The pattern will "lock-in" at some given point beyond which the control should not be advanced. Too much synchronizing voltage has a tendency to make the oscillator unstable.

B. CALIBRATION

A calibrating voltage of 10 volts, peak to peak, is incorporated in the Model CRO-2 to standardize the sensitivity of the vertical amplifier to permit direct peak to peak voltage measurements.

To calibrate the amplifiers, set the SYNCHRONIZING INPUT CONTROL to the VERT. CAL. position. This applies 10 volts, peak to peak, to the vertical input circuit. With the VERTICAL INPUT CONTROL set to "High Sensitivity" and a ratio of 10; adjust the VERTICAL GAIN CONTROL to produce 1" which is 10 lines deflection. This sets up the calibration gain so the sensitivity is 10 volts per inch or 1 volt for each line or division. This completes the calibration of the vertical amplifier, and the VERTICAL GAIN CONTROL should not be further disturbed. Remove the SYNCHRONIZING INPUT CONTROL from the calibrate position and proceed to measure voltage applied to the Vertical Input Terminals as follows:

Vertical Input Ratio	Deflection Per Inch	Deflection Per Division
1	IV	.IV
10	10V	IV
100	100V	10V

In making voltage measurements, do not disturb the VERTICAL GAIN CONTROL but adjust the input ratio to provide a satisfactory pattern size. The peak to peak voltage is then read in the same manner as reading an indicating voltmeter. FOR EXAMPLE: A pattern 1.5" (15 division) high, with the VERTICAL INPUT RATIO at "1", would be 1.5 volts. With the ratio at 10, the voltage is 15 volts, and with the ratio at 100, the voltage indicated is 150 volts, peak to peak.

The above calibration of 10 volts, peak to peak, for 1'' (10 divisions) is used as a practical example; however, the VERTICAL GAIN CONTROL may be set to provide other sensitivity ratios in the calibrating procedure. FOR EXAMPLE: With the INPUT RATIO at 10, the calibrating voltage may be adjusted to produce 2'' (20 division) deflection. In this case the sensitivity per inch would be 5 volts rather than 10 and would result in .5, 5, and 50 volts per inch sensitivity using the three input ratios.

The calibration of the Wide Band Amplifier section is accomplished in exactly the same manner.

C. HORIZONTAL FREQUENCY CONTROL

By means of the 2 controls, the Vernier and the Saw-Tooth Sweep Frequency Range, the frequency of the sweep generator can be adjusted to any frequency between 20 cycles and 50 KC. In general the sweep frequency will be set at some sub-multiple of the frequency of the signal being observed. This setting will determine the number of cycles or waveforms displayed on the screen.

D. INTENSITY MODULATION

By throwing the INTENSITY MOD. switch to 60 cycles and reducing the intensity of the trace, it will be noted that part of the trace will be brightened, and the other half will be almost entirely blanked out. The result is known as intensity modulation and is accomplished by applying 60 cycle sine wave to the grid of the cathode ray tube. This feature will find its most useful application when the CRO-2 is used with a 60 cycle external sweep signal applied to the horizontal plates. By this intensity modulation, the return trace is blanked out. This is an extremely valuable feature when used in TV alignment. The external connection for intensity modulation may be used to apply any voltage to the grid of the CR tube. This application will find much use when it is desired to insert timing markers on the trace.

WARNING: A SIGNAL LARGE ENOUGH TO SWING THE GRID OF THE CATHODE RAY TUBE POSITIVE WITH RESPECT TO THE CATHODE SHOULD NEVER BE APPLIED. SUCH A CONDITION MAY CAUSE A REDUCTION IN THE LIFE OF THE CR TUBE. THIS CONDITION IS RECOGNIZED BY A MARKED DE-FOCUSING ON THE SCREEN DURING POSITIVE PHASE OF THE INTENSITY MODULATION SIGNAL.

VI. APPLICATIONS

A. GENERAL

It is the purpose of this section to briefly cover a few of the many applications of a cathode ray oscilloscope. A working acquaintance of the controls of the CRO-2 and an understanding of how the patterns are traced on the screen will enable the operator to apply the instrument to many applications outside the scope of this instruction manual.

B. DISPLAY OF WAVEFORMS

1. Patterns Against Time

Waveforms are usually displayed in one of two methods, patterns plotted against time (with the saw-tooth sweep generator used for horizontal deflection) and Lissajous Figures (using sine wave for horizontal deflection.)

Previously the operations for providing a sine wave on the screen were outlined. The sine wave is amplified and applied to the vertical deflection plates. The saw-tooth wave is amplified and impressed on the horizontal plates. If each are 60 cycles, the time required to sweep from the beginning on one complete waveform to the next would be 1/60 second.

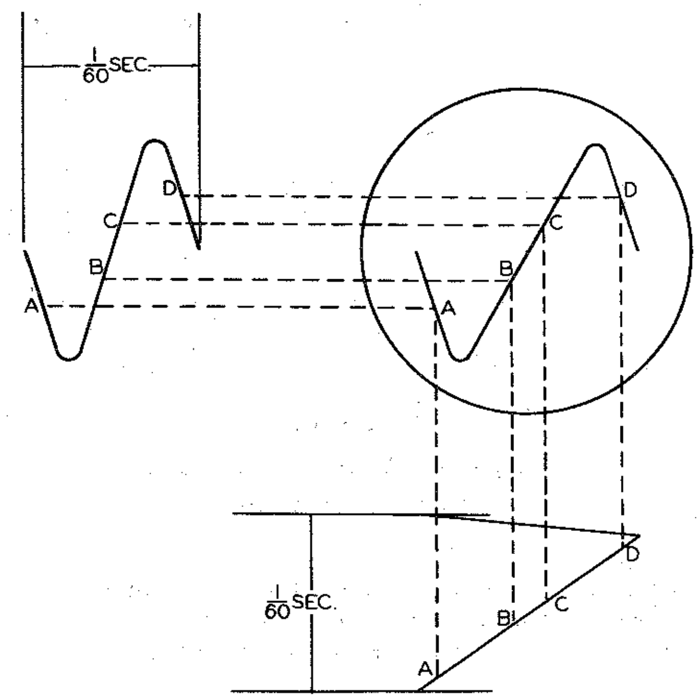

Figure 10
Projection Drawing - 60 cycle frequencies applied simultaneously, Sine Wave to Vertical Plates, Saw-tooth Wave to Horizontal Plates

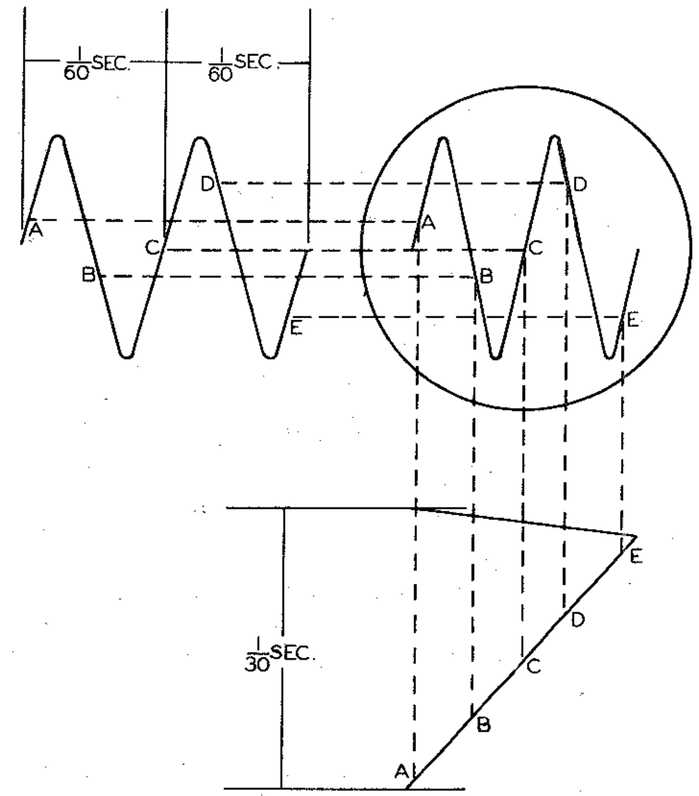

Figure 11
Projection Drawing - showing resultant pattern when Saw-tooth Wave is one half of that frequency applied to Vertical Plates

Visualizing that each point on the saw-tooth corresponds to the sine wave, (Fig. 10), it can be seen that these successive points trace out the wave on the screen. Using the same visualization and (Fig. 11), it can be seen that if the horizontal sweep is 30 cycles or 1/30 second in length, two sine waves will be produced.

This ratio holds for any frequency. As an example: In observing a 1,000 cycle sine wave, the saw-tooth oscillator is set at 1,000 cycles, one waveform will appear. If set at 500 cycles, 2 waveforms; 250 cycles, 4 waveforms, etc.

2. Patterns Against Sine Waves

The presentation of Lissajous Figures can be analyzed by the same method used for sine wave presentation. Referring to Figure 12 it can be seen that there are two complete loops formed and the ratio of frequency, horizontal to vertical is 2:1. If the horizontal frequency is 60 cycles, then the frequency of the signal applied to the vertical plate is 30 cycles. Inversely, if the vertical frequency is 60 cycles and the horizontal frequency 30 cycles, and the two loops are along the vertical axis and one along the horizontal (Figure 13), then the ratio is 1:2.

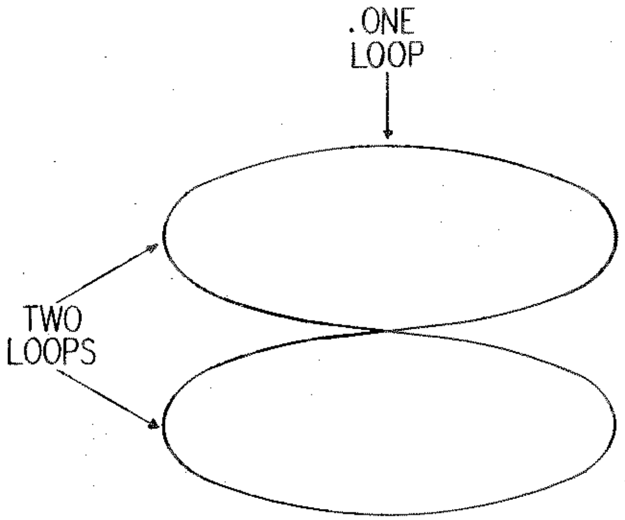

Figure 12
Frequency Ratio of Lissajous Pattern 2:1 Ratio

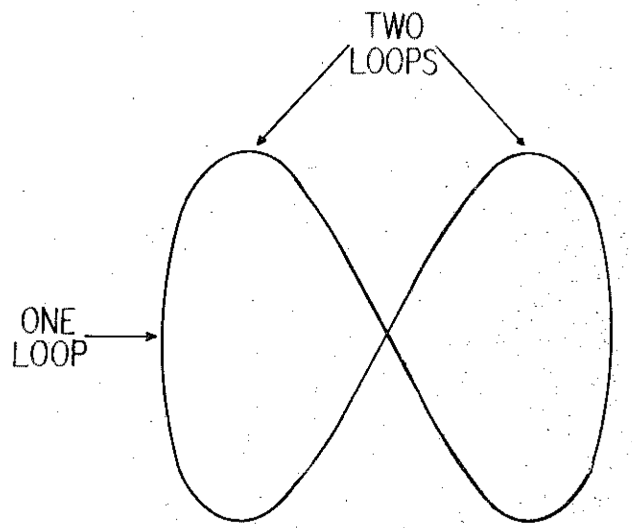

Figure 13
Frequency Ratio of Lissajous Pattern 1:2 Ratio

The ratio of any two sine waves, hence the frequency can be determined by counting the loops formed by the intersecting waves and using the ratio along with one known frequency to calculate the frequency. More examples are shown in Figure 14.

This frequency relationship, determined by the ratio of the number of loops touching the two perpendicular sides is most readily calculated when the two signals are out of phase.

3. Phase Difference Patterns

This also comes under the heading of Lissajous Patterns. It involves the determining of phase difference between 2 signals of the same frequency. Obtaining this type of pattern can be done by following this procedure.

1. Connect one signal to the vertical input terminals. Connect the other signal to the horizontal input terminal.
2. Turn both the horizontal and vertical amplifier gain controls to zero and center the spot on the calibrated screen.
3. Connect a common ground between the two signals to be checked.
4. Adjust the VERTICAL GAIN to give approximately 3 inches of deflection. Be sure that the vertical lines on the calibrated scale coincide with this deflection line.

5. DO NOT CHANGE the vertical gain control. Remove the signal from the vertical input terminals.
6. Increase the gain of the Horizontal Amplifier until the deflection is exactly the same as that to which the vertical was adjusted.
7. Reconnect the vertical input signal.

The resulting pattern will give a picture of the phase difference between the two waves. If these two waves are of the same frequency but different in phase and maintain that difference exactly, a stationary pattern will result. Fig 5 shows patterns produced by various phase relationships.

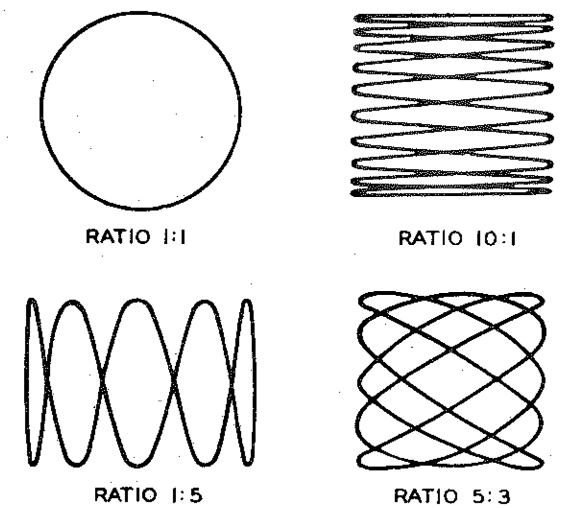

Figure 14
Typical Lissajous Patterns

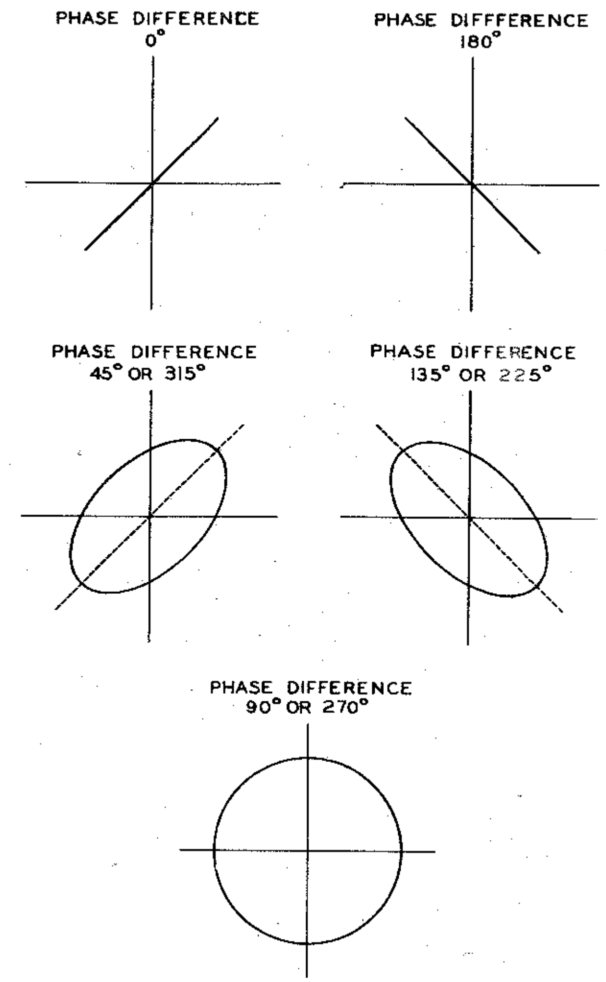

Figure 15
Typical Phase Shift Patterns

Determination of the phase angle of a stationary pattern may be made from the relationship of maximum vertical height and the intersection of the curve with the vertical axis, Figure 16. By use of this relationship:

$$\text{Sine } \Theta = \frac{\text{Y Intersection}}{\text{Y Maximum}}$$