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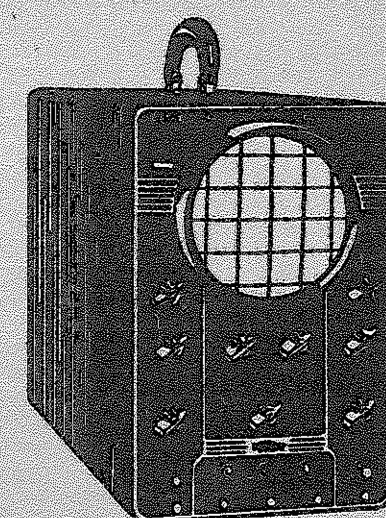
G. LEDGER

DU MONT

Cathode-ray Oscillograph

TYPE 274

Operating and Maintenance Manual



ALLEN B. DU MONT LABORATORIES, INC.

PASSAIC, N. J.

Obviously, the design of any piece of electrical indicating equipment results from a series of compromises which represent the designer's opinion of an ideal instrument consistent with contemporary engineering techniques and present-day production possibilities.

In developing this instrument, an attempt has been made to incorporate circuits the characteristic of which, we believe, will satisfy the greatest number of applications, and to this end many circuit combinations have been included to extend its flexibility and versatility.

We feel, however, that the real test of any instrument is the opinion of the man who uses it. This day-to-day test of the instrument's advantages and limitations will prove, more than any other method, just what characteristics are desirable, why the range of any given component or function of the equipment should be extended, and how important such modification is.

Because of the nature of the equipment manufactured by Allen B. Du Mont Laboratories, Inc., it is only by complete cooperation between the customer and our Engineering Department that satisfactory designs can be achieved. In an attempt to continually extend the applicability of our equipment to the problems of the engineer, we sincerely request suggestions advising in what manner the design of this equipment may be further extended to include these problems.

Operating and Maintenance Manual

for

DU MONT TYPE 274 CATHODE-RAY OSCILLOGRAPH

ALLEN B. DU MONT LABORATORIES, INC.
Passaic, New Jersey, U. S. A.

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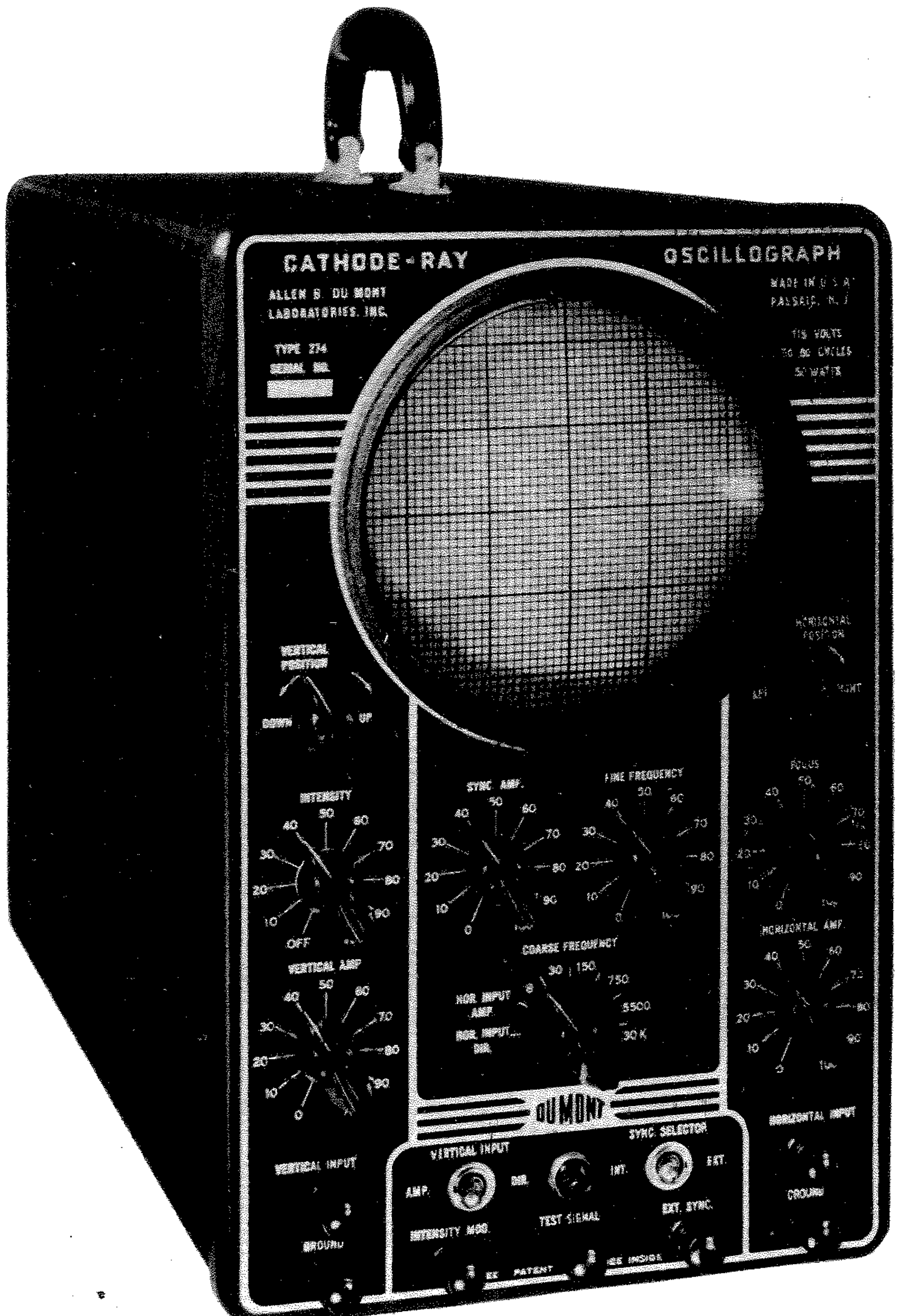


Figure 1 - 1
DuMont Type 274 Cathode-ray Oscillograph

Section I
GENERAL DESCRIPTION

1. PURPOSE

The Type 274 Cathode-ray Oscillograph is designed primarily for analysis of electrical circuits by a study of the wave forms of voltage and current at various points. As a general purpose instrument, however, it may be employed to study any variable, within the limits of its frequency response characteristics, which can be converted into electrical potentials. This conversion is made possible by the use of some type of transducer, such as a vibration pickup unit, pressure pickup unit, photo cell, microphone, or a variable impedance, which may be a carbon pile, variable inductance or variable capacitor.

2. CIRCUITS

a. In a specific problem the unknown quantity (which is usually plotted along the vertical or Y-Axis) is a function of some known quantity, such as time, measured along the horizontal or X-Axis. Circuits are incorporated in this instrument which generate a sawtooth-shaped voltage wave to be used as a time-base. This time-base is applied to the horizontal or X-Axis, so that the unknown quantity may be plotted as a linear function of time.

b. Provision is made so the intensity of the trace may be modulated. A terminal is provided on the front panel which is capacitively coupled to the control grid of the cathode-ray tube for the introduction of an external signal. Positive pulses applied to this terminal will intensify the trace at time intervals corresponding with the intervals between pulses. Negative pulses of approximately 15 peak volts will blank the beam.

c. A self-contained power supply furnishes the various voltages and currents for complete operation of the instrument. Power is also made available at the output socket on the rear of the cabinet for the operation of demonstration units, which will be available for use with this instrument.

3. PHYSICAL DESCRIPTION

Type 274 Cathode-ray Oscillograph is shown in Figure 1-1. It is enclosed in a green, metal cabinet provided with a plastic carrying handle attached to the top. All controls necessary for the operation of the instrument are located on the front panel. An octal socket, as a power take-off for the demonstration units, is mounted in the rear and also serves as a safety switch. A removable calibrated scale, Type 216-C, for making relative and quantitative measurements is mounted on the face of the cathode-ray tube.

4. FREQUENCY RANGE

a. TRANSIT TIME. - The cathode-ray tube is essentially an indicating device with a pointer of negligible inertia. For this reason the only frequency limitation occurs at deflection frequencies where the transit time of the electron beam across the face of the deflection plates must be considered. Since the electron velocity through the deflection plate space has a finite value, it is possible to apply a deflecting potential which reverses in polarity during the transit time of the electrons.

For example: assume that a 1,000 mc sine wave is applied to the vertical deflection plates. The period of one cycle will be .001 μs. Assume further that the transit time of the electron beam across the face of the deflection plates is .001 μs. The beam will then react to equal positive and negative deflection forces as it travels across the face of the plates, with a resulting deflection of zero. In the modern cathode-ray tube, this effect is not apparent at frequencies below 100 mega cycles per second and may normally be disregarded at the lower frequencies.

b. AMPLIFIERS. - The above frequency limitations apply when the cathode-ray tube beam is deflected directly from the signal source without employing any type of vacuum tube amplifier. Since potentials ranging from one hundred to one thousand volts may often be required for full scale deflection of a cathode-ray tube, amplifiers have been incorporated in this instrument to increase the sensitivity of the device so that it may give usable indications from relatively low potential sources. The frequency response of an amplifier imposes further limitations on the use of the cathode-ray tube. this instrument to the majority of problems.

The amplifiers incorporated in the Type 274 have been designed to give uniform response within ±20% over a frequency range from 20 to 50,000 sinusoidal cycles per second. The complete characteristics of the am-

TABLE 1—1

QUICK REFERENCE DATA

Cathode-ray Tube	
Type	5BP1A
Accelerating Potential	1200 volts
Vertical Axis	
Deflection Factor	
Direct	18 r.m.s. volts/inch ± 20%
Full Gain	0.65 r.m.s. volts/inch (max.)
Sinusoidal Frequency Response (full gain)—Uniform within ± 20% from 20 c.p.s. to 50 Kc., down not more than 50% at 100 Kc.	
Maximum Input Potential	400 r.m.s. volts or 600 d-c volts or 600 volts peak.
Input Impedance	
Direct	5 meg; 50 μμf
Amplifier	1 meg; 40 μμf
Horizontal Axis	
Deflection Factor	
Direct	18 r.m.s. volts/inch ± 20%
Full Gain	0.65 r.m.s. volts/inch (max.)
Sinusoidal Frequency Response (full gain)—Uniform within ± 20% from 20 c.p.s. to 50 Kc., down not more than 50% at 100 Kc.	
Maximum Input Potential	400 r.m.s. volts or 600 d-c volts or 600 volts peak.
Input Impedance	
Direct	5 meg; 60 μμf
Amplifier	5 meg; 40 μμf
Linear Time Base	
Gas Triode	884
Sweep frequency range	8 c.p.s. to 30 Kc.
Intensity-Modulation Circuit	
Input Impedance	470K; 45 μμf
Sensitivity	10 r.m.s. volts to blank
Test Signal—A test-signal terminal is provided to furnish a test signal of 6.3 volts at the power-line frequency.	
Positioning	more than 5 inches
Power Supply	
Primary-Power Potential	115 r.m.s. volts ±10%
Frequency	50-60 cycles
Power Consumption	50 watts approx.
Fuse Protection	One ampere
Tube Complement	
2—6SJ7 Amplifiers	
1—884 Sweep Generator	
2—80 Rectifiers	
1—5BP1A Cathode-ray Tube	
Physical Specifications	
Height	14″
Width	8⅝″
Depth	19⅜″
Weight	35 lbs.

plifiers are summarized in the quick reference table, Table 1-1.

5. TYPE OF INDICATION

a. LIMITATIONS. - It should be emphasized that the cathode-ray oscillograph does not offer the solution to a problem but that it merely supplies information and data regarding the characteristics of the problem. This information is meant to serve as a guide in analyzing the phenomenon which is being studied. The cathode-ray oscillograph is not designed for use as a corrective instrument, which, in itself, performs a specific operation on an electrical signal or on its source. It should rather be considered as an auxiliary instrument which indicates visually the essential characteristics of a signal, thus enabling the operator to quickly make a check on correct functioning or to isolate the causes of any malfunctioning of equipment.

b. INTERPRETATION. - One of the most important procedures used by the oscillograph operator, and the one which probably gives the most trouble to personnel inexperienced in oscillograph work, is the proper interpretation of the patterns traced on the screen of the cathode-ray tube. When interpreting the pattern obtained on the screen of the cathode-ray tube, it should be borne in mind that the unknown signal is always plotted as a function of some signal whose characteristics are known. If the characteristics of the signal on one axis are not known, it will be almost impossible to identify the characteristics of the signal under investigation on the other axis. For this reason it is generally common practice to use for the horizontal variable a sinusoidal signal of known frequency, or a sawtooth signal which has been synchronized to the same or some integral sub-multiple of the frequency of the unknown signal. The sinusoidal signal is often used in applications such as phase, frequency and rate determination. The sawtooth signal gives horizontal deflection which is linearly proportional to time, and it therefore gives a plot of the waveshape of the unknown signal versus time.

c. APPLICATIONS. - The information which may be gained from analyzing screen patterns in the above manner is of great value in determining the characteristics of a device which is under study. The path of a known signal through an amplifier may be followed, and the gain and distortion characteristics of the amplifier may be quickly and easily determined, as well as the point at which the circuit may be faulty. By use of the linear time base as the known function, an unknown waveform may be plotted and analyzed, or the dynamic characteristics of an unknown circuit may be studied. The waveform of a signal shown plotted as a function of the linear sawtooth sweep, will give indications showing the presence of undesirable harmonics, parasitic oscillations, or indication of the degree of faithfulness with which a device is following a desired cycle of operation.

A familiar case of operation where a sinusoidal standard signal is employed for horizontal deflection is found in the application of the cathode-ray tube for frequency comparison of two signals. The unknown signal is fed into the vertical input and the known signal standard frequency is fed into the horizontal input. In this way, the frequency of the unknown signal may be measured by the correct interpretation of the resulting Lissajous pattern.

Another common practice is to impress a modulated carrier upon the vertical input, and the modulation voltage on the horizontal. This results in the pattern known as the modulation trapezoid pattern for the purpose of studying percentage modulation.

Section II

THEORY OF OPERATION

1. THE CATHODE-RAY TUBE

a. FUNCTION. - As an indicating instrument the cathode-ray tube may be compared to the galvanometer, with the electron beam which is projected from the hot cathode analogous to the galvanometer needle. However, the cathode-ray or electron beam has great advantages over the needle in that it is practically without weight and therefore possesses a minimum of inertia, which makes for infinitely greater flexibility in operation. The beam requires negligible power for deflection so that accurate readings are obtained without loading the circuit under test. The beam can be moved vertically or horizontally or the vertical and horizontal movements may be combined to produce composite patterns on the tube screen. Thus the block diagram, Figure 2-1, shows the CRT as the recipient of signals from both the vertical and horizontal amplifiers.

b. OPERATION

(1) Figure 2-2 shows the internal details of the cathode-ray tube. Electrons emitted from the cathode flow through the control grid toward anodes 1 and 2, are accelerated by the high positive potentials on these anodes. The stream continues between two sets of deflecting plates, horizontal and vertical, and strikes the screen, which fluoresces at the point of impact. With no potential applied to the deflecting plates the cathode-ray beam will appear as a bright spot on the center of the tube screen. If a positive voltage is placed on the right horizontal plate; the beam, and thus the spot, will move to the right in proportion to the potential applied. Because the beam is a stream of electrons (negative electrical charges), it is electrostatically attracted toward an oppositely charged plate. If a negative charge is applied to the same plate, the spot will travel to the left, due to electrostatic repulsion between like charges.

(2) In the Type 274 Cathode-ray Oscillograph one of each of the pairs of deflection plates is connected to ground so that deflection voltages are applied to only one plate of each pair.

(3) An AC voltage applied to the horizontal deflection plate will, therefore, cause the spot to move alternately to one side and then the other. This motion will be continuously repeated until the voltage is removed. The visual indication, except at very low frequencies, will appear to be a straight line, due to the effect of persistence of vision (see paragraph c.)

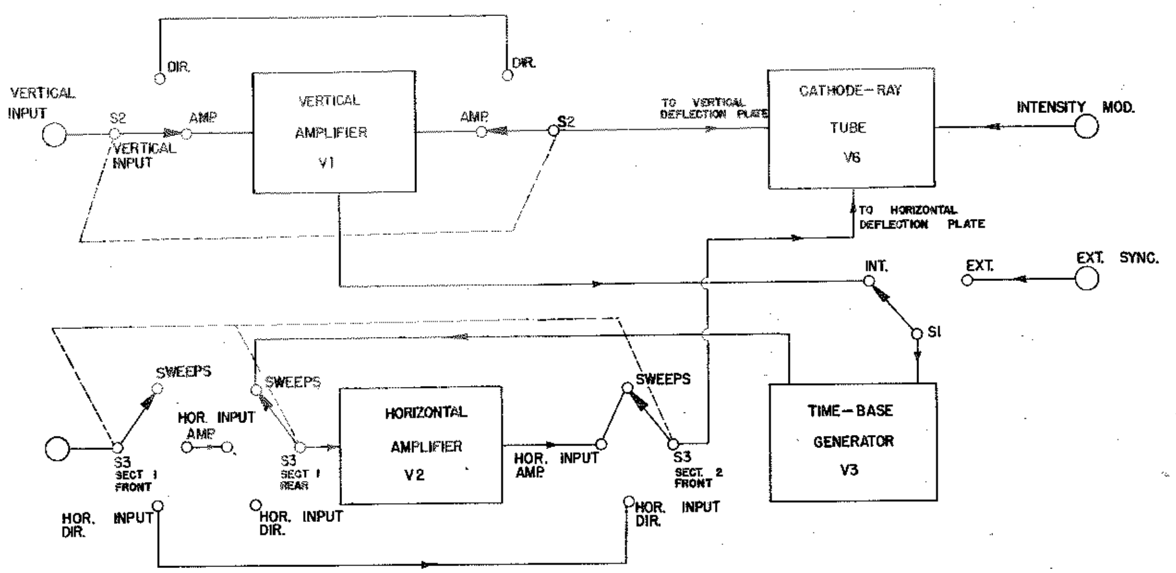


Figure 2 - 1
Block Diagram, Type 274 Cathode-ray Oscillograph

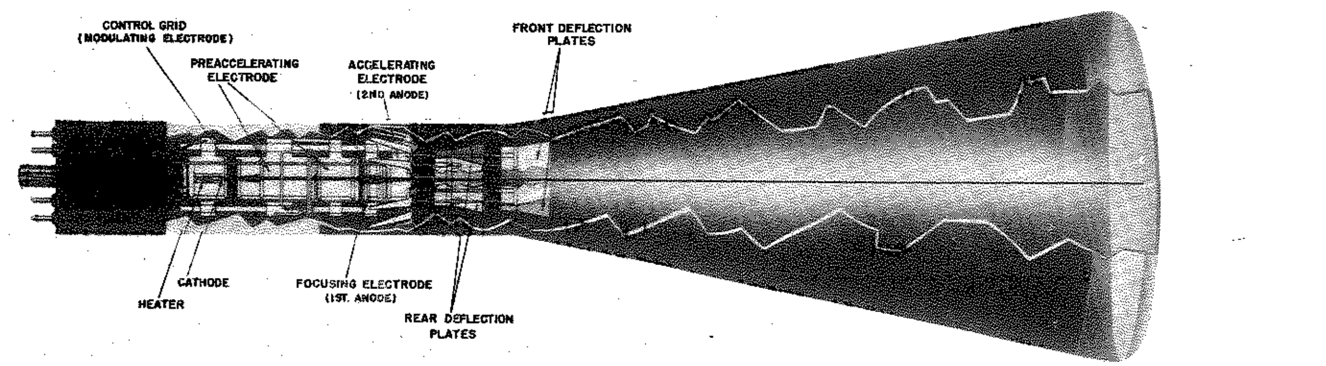


Figure 2 - 2
Internal construction of the Type 5BP1-A Cathode-ray Tube

(4) Vertical deflection is obtained in precisely the same way when the voltage is applied to the vertical plates.

(5) As a general rule the deflections representing amplitude are produced by applying voltage to the vertical deflection plate, and the pattern resulting from these deflections is said to be along the Y-Axis.

(6) Deflections representing time are usually produced by applying a voltage to the horizontal deflection plate. The patterns resulting from these deflections are said to be along the X-Axis.

(7) Another operation which may be performed upon the spot or trace is intensity modulation. In this application a voltage is applied to the grid of the cathode-ray tube and its variations modulate the emitted beam. This causes the spot or trace to become brighter or dimmer in accordance with the polarity of these variations. This principle is used to provide timing demarkations or reference points on the trace or pattern. These timing marks may be provided by an external source, the frequency of which is known. Intensity modulation is said to be performed on the Z-Axis of the CRT. A further use of this grid connection is to intensify the beam over portions of the trace where the writing rate of the spot is so rapid that the fluorescent screen is not sufficiently excited. Thus the intensity may be made more uniform throughout the entire trace. This feature particularly facilitates photographic recording of the patterns formed. It should be emphasized that the screen excitation (and therefore the pattern intensity) is a function of the beam current and the writing rate. The intensity of the spot at any instant regardless of its position on the screen may be controlled by a variation of this control grid (modulating electrode) bias.

c. PERSISTENCE OF VISION. - Any image reaching the retina of the eye registers and persists there for an appreciable period of time even though the object producing the image disappears almost at once from the field of vision. If an intermittently appearing image is reregistered at the rate of 16 or more times per second the image will appear continuous. As an example, "moving" pictures are really a series of "still" pictures projected successively at the rate of 16 or more per second. 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 due to this persistence of vision.

d. CIRCUIT. - A 5BP1-A cathode-ray tube is used in this instrument. As shown in the simplified schematic, Figure 2-3, the necessary potentials for operating this tube are obtained from a voltage divider made up of resistors R21 through R26 inclusive. The intensity of the beam is adjusted by moving the contact on R21. This adjusts the potential on the cathode more or less negative with respect to the grid which is operated at the full negative voltage—1200V. Focusing to the desired sharpness is accomplished by adjusting the contact on R23 to provide the correct potential for anode No. 1. Interdependency between the focus and the intensity controls is inherent in all electrostatically focused cathode-ray tubes. In short, there is an optimum setting of the focus control for every setting of the intensity control. The second anode of the Type 5BP1A is operated at ground potential in this instrument. Also one of each pair of deflection plates is also operated at ground potential. The cathode is operated at a high negative potential (approximately 1200 volts) so that the total overall accelerating voltage of this tube is regarded as 1200 volts since the

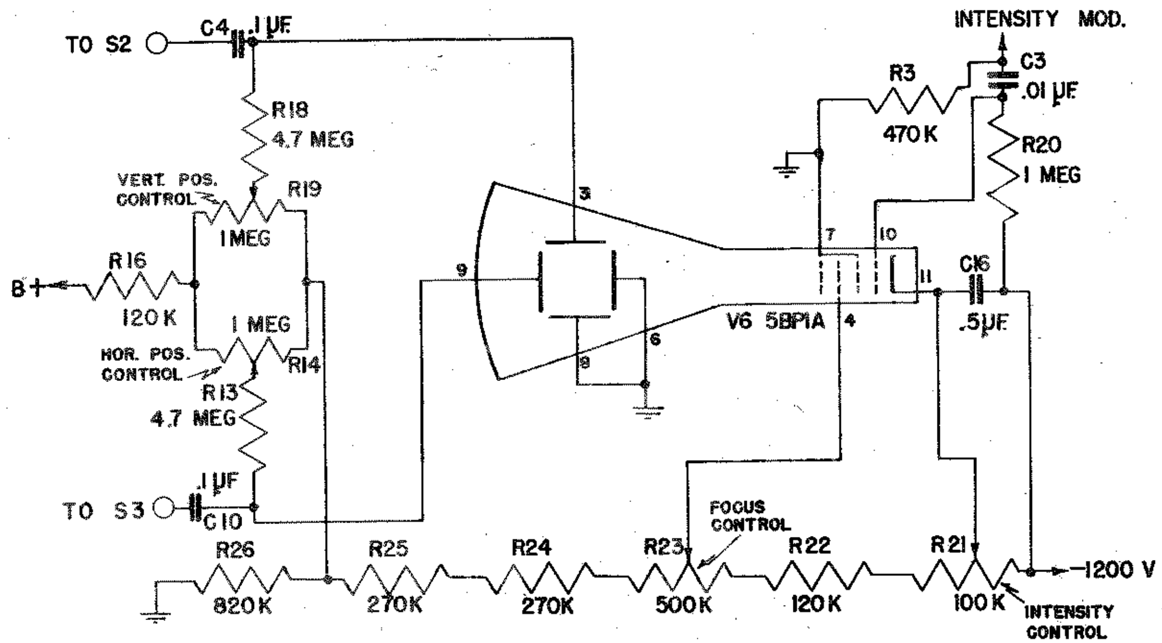


Figure 2 - 3

Schematic of Cathode-ray Tube circuits

second anode is operated at ground potential. The vertical and horizontal positioning controls which are connected to their respective deflection plates are capable of supplying either a positive or negative DC potential to the deflection plates. This permits the spot to be positioned at any desired place on the entire screen.

2. VERTICAL AMPLIFIER

a. INPUT. - The incoming signal which is to be examined is applied to the terminals marked Vertical Input and Ground. These terminals are connected through capacitor C1 so that the AC component of the signal appears across the vertical amplifier gain control potentiometer R1. Thus the magnitude of the incoming signal may be controlled to give the desired deflection on the screen of the cathode-ray tube. Also, as shown in Figure 2-1, S2 has been made available to by-pass the vertical amplifier and capacitively couple the signal from the input terminal to the vertical deflection plate if it is so desired.

b. AMPLIFIER. - In the schematic, Figure 2-4, V1 is a 6SJ7 pentode vacuum tube used as the vertical amplifier. As the signal variations appear on the grid of V1, variations in the plate current flowing through V1 will take place. Thus signal variations will appear in opposite phase and greatly amplified across the plate load resistor R7. The capacitor C2 has been added across resistor R2 in the cathode circuit of the tube to increase the frequency response of this amplifier at the high frequency end. This capacitor because of its low value serves very little use as a cathode by-pass at low frequencies but operates more effectively as the frequency of the signal increases.

c. OUTPUT. - The signal applied to the grid of V1 has been amplified by V1 and is now applied through the second half of S2 and capacitor C4 to the free vertical deflection plate of the cathode-ray tube.

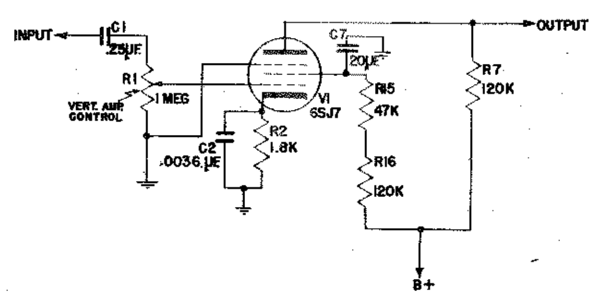


Figure 2 - 4

Amplifier schematic

3. HORIZONTAL AMPLIFIER

The horizontal amplifier circuit and the circuit of the vertical amplifier, described in the paragraph above, are identical except for the value of the gain control. A switch in the input circuit makes provision for the input from the Horizontal Input terminals to be capacitively coupled to the grid of the horizontal amplifier or to the free horizontal deflection plate thus by-passing the amplifier, or for the output of the sweep generator to be capacitively coupled to the amplifier, Figure 2-1.

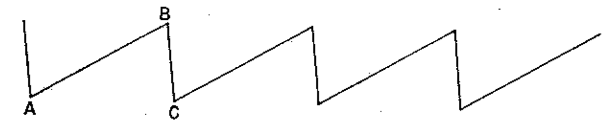


Figure 2 - 5

Sawtooth wave form

4. TIME BASE GENERATOR

a. GENERAL

Investigation of electrical wave forms by the use of the cathode-ray tube frequently requires that some means be available to determine the variation in these wave form amplitudes with respect to time. When such a time base is used, the patterns presented on the cathode-ray tube screen show the variation in amplitude of the input signal with respect to time. Such an arrangement is made possible by the use of the time base generator. In operation it moves the spot across the screen at a constant rate from left to right between selected points, returns the spot almost instantaneously to its original position, and repeats the procedure. This is accomplished by the voltage output of the sweep generator. The rate at which this voltage repeats the cycle of sweeping the spot across the screen is referred to as the sweep frequency. The sweep voltage necessary to produce the motion described above must be of a sawtooth wave form such as that shown in Figure 2-5.

The sweep occurs as the voltage varies from A to B, and the return trace, as the voltage varies from B to C. If AB is a straight line, the sweep generated by this voltage will be linear.

However, it should be realized that the sawtooth sweep signal is only used to plot variations in the vertical axis signal with respect to time. Specialized studies have made use of signals of various shapes which are introduced from an external source through the Horizontal Input terminals.

b. CIRCUIT. - The sawtooth voltage necessary to obtain the proper sweep is generated by means of the electronic circuit shown in Figure 2-6, which operates as follows. The gas triode used for this purpose is the Type 884 (V3). The heater heats the cathode which emits electrons as in the ordinary heater type triode. This tube contains an inert gas which ionizes when the voltage between the cathode and the plate reaches a certain value. The voltage at which breakdown will occur depends upon the bias voltage which is determined by the voltage divider resistors R12 and R17. With a specific negative bias applied to the tube in this way, the tube will fire at a specific plate voltage.

Capacitors C11 to C15 are selectively con-

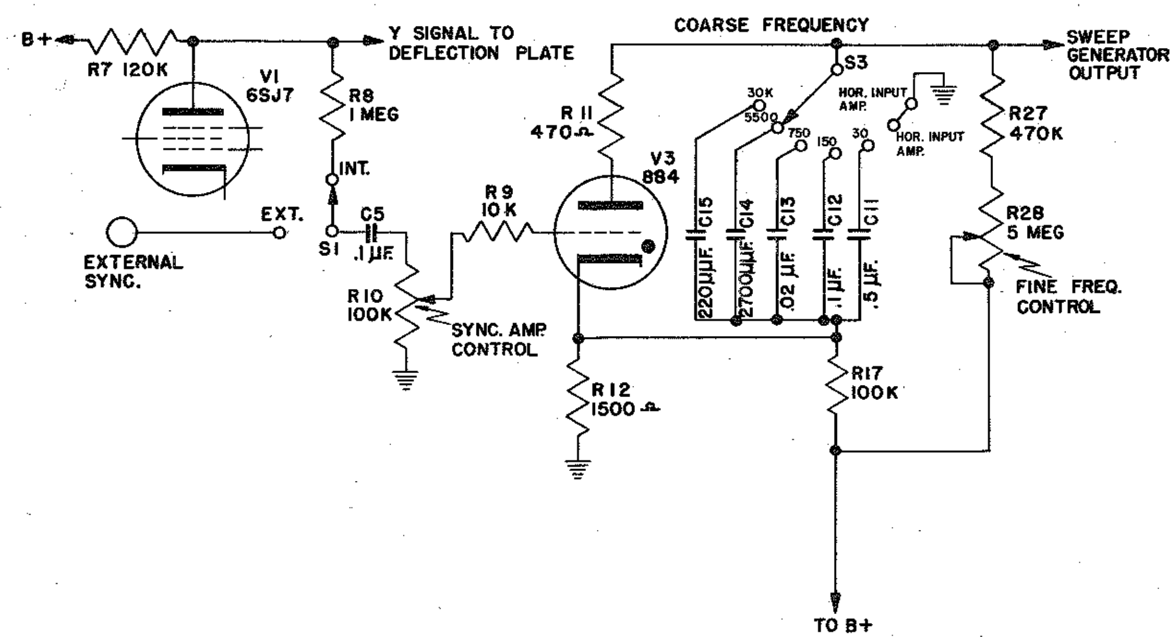


Figure 2 - 6

Schematic of sweep generator

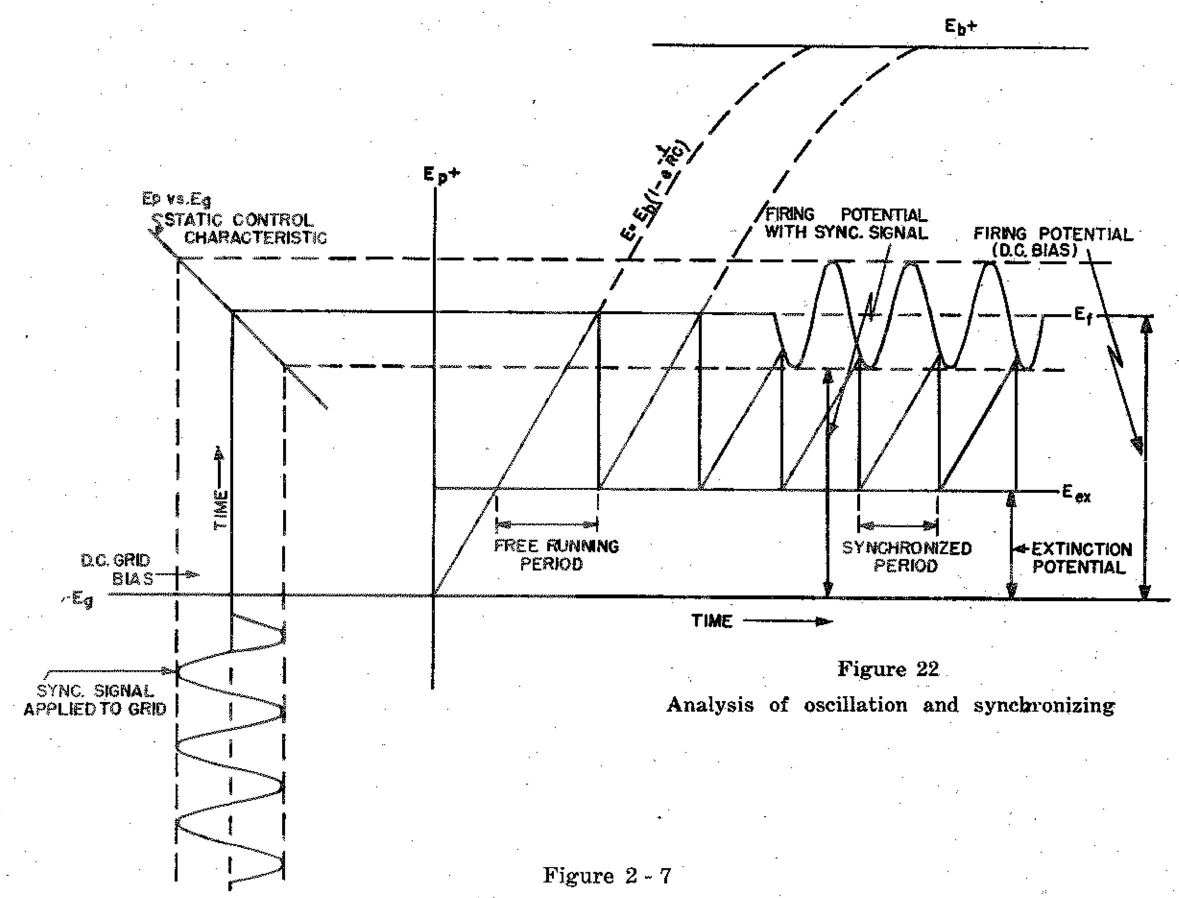


Figure 22
Analysis of oscillation and synchronizing

Figure 2 - 7
Analysis of synchronization of time-base generator

nected in parallel with this tube. Resistor R11 is added to limit the peak current drain by the gas triode. The plate voltage on this tube is obtained through resistors R28, R27, and R11. The voltage applied to the plate of V3 cannot reach the power supply voltage because of the charging affect this voltage has upon the capacitor which is connected across the tube. This capacitor charges until the plate voltage becomes high enough to ionize the gas in the tube. At this time, the tube starts to conduct and the capacitor discharges through the tube until its voltage falls to the extinction potential of the tube. When the tube stops conducting, the capacitor voltage builds up until the tube fires again. As this action continues, it results in the sawtooth wave form of Figure 2-5 appearing at the junction of R11 and R27.

c. SYNCHRONIZATION

(1) Provision has been made so the sweep generator may be synchronized from the vertical amplifier or from an external source. The switch, S1, shown in Figure 2-6, is mounted on the front panel to be easily accessible to the operator.

(2) If no synchronizing voltage is applied, the discharge tube will begin to conduct when the plate potential reaches the value of E_f (Firing Potential). When this breakdown takes place and the tube begins to conduct, the capacitor is discharged very rapidly through the tube, and the plate voltage decreases until it reaches the extinction potential E_x. At this point conduction ceases, and the plate potential rises slowly as the capacitor begins to charge through R27 and R28. The plate potential will again reach a point of conduction and the circuit will start a new cycle. The rapidity of the plate voltage rise is dependent upon the circuit constants R27, R28, and the capacitor selected, C11-C15, as well as the supply voltage E_b. The exact relationship is given by:

$$E_c = E_b(1 - e^{\frac{-t}{rc}})$$

Where E_c=Capacitor voltage at time t
E_b=Supply voltage (B+ supply – cathode bias)
E_f=Firing potential or potential at which time-base gas triode fires
E_x=Extinction potential or potential at which time-base gas triode ceases to conduct
e=Base of natural logarithms
t=Time in seconds
r=Resistance in ohms (R27 + R28)
c=Capacity in farads (C11, 12, 13, 14 or 15)

The frequency of oscillation will be approximately:

$$f = \frac{E_b}{rc}\left[\frac{1}{E_f - E_x}\right]$$

Under this condition (no synchronizing signal applied) the oscillator is said to be "free running."

(3) When a positive synchronizing voltage is applied to the grid, the firing potential of the tube is reduced. The tube therefore ionizes at a lower plate potential than when no grid signal is applied. Thus the applied synchronizing voltage fires the gas-filled triode each time the plate potential rises to a sufficient value, so that the sweep recurs at the same or an integral sub-multiple of the synchronizing signal rate. A graphic representation of this is shown in Figure 2-7.

5. POWER SUPPLY

a. GENERAL.

Figure 2-8 shows the power supply to be made up of two definite sections: a low voltage positive supply which provides the power for operating the amplifiers, the time base generator, and the positioning circuits of the cathode-ray tube, and the high voltage negative supply which provides the potentials necessary for operating the various electrodes of the cathode-ray tube and furnishes a negative voltage to the positioning controls.

b. THE LOW VOLTAGE POWER SUPPLY.

The low voltage power supply consists of a full wave rectifier, V5. The output of this rectifier is filtered by a capacitor input filter consisting of C9, L1, and C8. It furnishes B+ at approximately 400 volts at sufficient current to supply the tubes of the instrument as well as to have approximately 20 milliamperes available at the output plug on the rear chassis for operating the demonstration units.

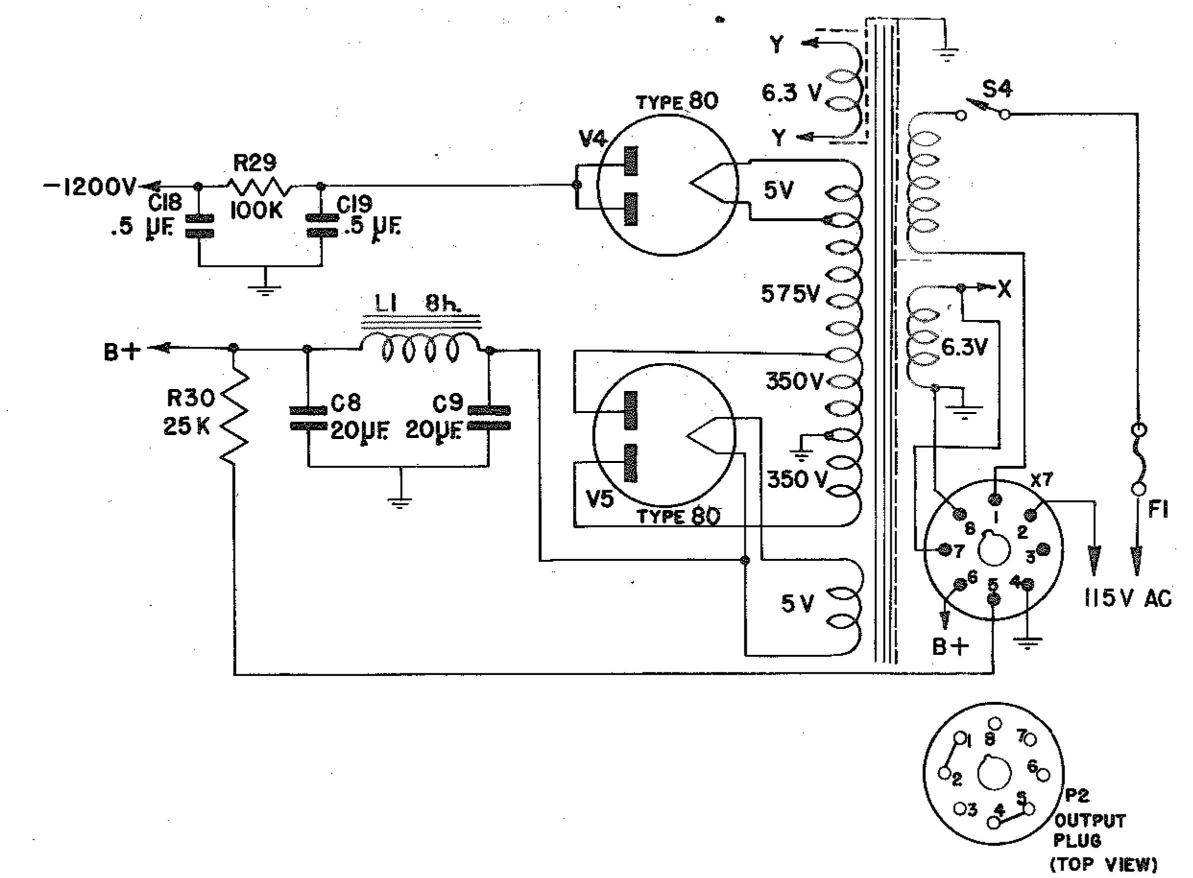


Figure 2 - 8
Schematic of power supply

c. THE HIGH VOLTAGE POWER SUPPLY.

The high voltage power supply employs a half wave rectifier, V4. The output of this rectifier is filtered by a resistance-capacitor filter consisting of C19, R29, and C18. A voltage divider network attached from the output of this filter obtains the proper operating potentials for the various electrodes of the cathode-ray tube.

d. SAFETY SWITCH.

A standard octal plug, P2, is inserted into the octal socket, X7, on the rear chassis of the instrument to act as a safety switch. The safety action occurs due to the fact that this plug contains a jumper which extends from Pin No. 1 to Pin No. 2 and completes the primary circuit of the power transformer. Without this plug in position, this circuit will remain open and no voltage can be obtained inside the cabinet. The physical construction of the Type 274 is such that the chassis cannot be removed from the cabinet without removing the safety plug.

WARNING

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OPERATING PERSONNEL MUST AT ALL TIMES OBSERVE ALL SAFETY REGULATIONS. DO NOT CHANGE TUBES OR MAKE ADJUSTMENTS INSIDE THE EQUIPMENT WITH THE HIGH VOLTAGE SUPPLY ON. DO NOT DEPEND UPON THE SAFETY SWITCH FOR PROTECTION, BUT ALWAYS REMOVE THE POWER CORD FROM THE LINE OUTLET. UNDER CERTAIN CONDITIONS DANGEROUS POTENTIALS MAY EXIST IN THE CIRCUITS WITH POWER CONTROLS IN THE OFF POSITION DUE TO CHARGES RETAINED BY CAPACITORS. TO AVOID SHOCK AND SEVERE BURNS ALWAYS DISCHARGE AND GROUND CIRCUITS PRIOR TO TOUCHING THEM. NEVER SERVICE OR ADJUST THE INSTRUMENT WITHOUT THE PRESENCE OR ASSISTANCE OF ANOTHER PERSON CAPABLE OF RENDERING AID.

Section III
OPERATING INSTRUCTIONS

1. INSTALLATION

In most instances, the Type 274 Cathode-ray Oscillograph is shipped with all tubes in place and ready for operation, including the cathode-ray tube. However, in some instances, the cathode-ray tube may be packed separately.

To install the cathode-ray tube the chassis must be removed from the cabinet. Two screws near the bottom of the rear panel hold the chassis in place. Remove these two screws, the screw at the top of the front panel, and the octal plug from the rear panel of the instrument, and unwind the power cord from its bracket. If the edge of the front panel is grasped with the fingers, the front panel, and chassis may be slid forward out of the cabinet. The power cord and its plug will conveniently feed through the hole provided in the rear of the cabinet.

To install the cathode-ray tube it is inserted through the front panel and tube shield as far as the socket. The socket prongs are then inserted into the correct position in the socket. A gentle push, with one hand on the face of the tube and the other hand bracing the rear vertical chassis, will seat the tube in the socket.

Before replacing the chassis in the cabinet, it will be well to see that all tubes are properly seated in their sockets. All tube locations are clearly indicated on the chassis. It is also advisable to inspect for any mechanical damage which may have occured in transit.

As soon as these operations have been completed, place the instrument back in its cabinet, put back the screws then prepare it for use by inserting the octal plug into the socket on the rear chassis.

2. PRECAUTIONS

WARNING

IT IS INADVISABLE TO OPERATE THIS CATHODE-RAY OSCILLOGRAPH WITH THE CASE REMOVED. DANGEROUS POTENTIALS AS HIGH AS 1200 VOLTS ARE EMPLOYED IN THIS INSTRUMENT AND SHOULD BE TREATED WITH PROPER CAUTION.

a. MAGNETIC AND ELECTRIC FIELDS

Magnetic and electrostatic shielding has been provided in this instrument. However, operation of the instrument in strong fields such as are found near transmitters, transformers, and power generating equipment, etc., may introduce spurious deflections.

Electrostatic pick-up may be minimized by the use of shielded input cables and connections and with a good electrical ground on the chassis of the instrument. Spurious magnetic deflections may be eliminated or reduced to an unobjectionable point by removing the instrument from the immediate vicinity of the disturbance; orienting the instrument in the field so that spurious deflection is at a minimum; or in extreme cases, by adding additional magnetic shielding in the form of a large iron or steel container in which the entire instrument may be placed.

b. POWER REGULATION

The Type 274 is designed to operate at a power line voltage of 115 volts a.c. at a frequency of 50 to 60 cycles per second. Steady variations of ± 10% from the normal operating value of 115 volts will cause little change in the operation of this instrument. Greater changes than this may cause the power supply to operate erratically and the operation of the instrument to become unsatisfactory. The conditions where power line variations are excessive, the manufacturer recommends the use of constant voltage transformers placed in the power line to the instrument. If such a regulator is used, the precautions of Paragraph 2a. should be observed.

c. SCREEN BURNING

When a small spot or line of high intensity is allowed to remain stationary on the screen of the cathode-ray tube, the entire energy of the beam is concentrated over a very small area and the power input per unit screen area is high. Under such conditions the screen is susceptible to burning and discoloration.

It is well to note that burning of the screen, until carried to excess, will in no way impair the operation of the tube, since the burning is localized to small areas, and the burned area is not completely insensitive.

3. OPERATION OF CONTROLS

a. GENERAL

The operation of the various controls of the Type 274 is presented in a brief tabular form in Table 3-1. Figure 3-1 is available for use with the table in locating these various

TABLE 3 - 1

TABLE OF OPERATING CONTROLS AND TERMINALS

Name of Control	Circuit Desig.	Component	Function
VERTICAL POSITION	R19	1 megohm potentiometer	Changes the d-c potential on the vertical deflection plate and thus the vertical position of the trace.
HORIZONTAL POSITION	R14	1 megohm potentiometer	Changes the d-c potential on the horizontal deflection plate and thus the horizontal position of the trace.
INTENSITY	R21	100,000 ohm potentiometer	Varies the voltage on the cathode of the cathode-ray tube and thus the intensity of the trace.
FOCUS	R23	500,000 ohm potentiometer	Varies the voltage on the focusing electrode of the cathode-ray tube and thus adjusts the focal point of the beam.
VERTICAL AMP	R1	1 megohm potentiometer	Varies the voltage of the input signal as it is applied to the grid of the vertical amplifier, thus controlling the amplitude of the vertical signal.
HORIZONTAL AMP	R4	5 megohm potentiometer	Varies the voltage of the input signal as it is applied to the grid of the horizontal amplifier, thus controlling the amplitude of the horizontal signal (whether signal is from the time-base generator or an external source).
COARSE FREQUENCY	S3	2 gang, 4 pole 7 position rotary switch	Switches to the various sweep capacitators as well as to positions for connecting an external signal, capacitively to the deflection plates, or through the horizontal amplifier.
FINE FREQUENCY	R28	5 megohm potentiometer	Provides a fine adjustment of the sweep frequency by controlling the rate at which the selected sweep capacitor is charged.
SYNC. AMP.	R10	100,000 ohm potentiometer	Varies the amplitude of the synchronizing voltage applied to the time-base generator thus enabling the operator to "lock-in" the signal being viewed.
VERTICAL INPUT	S2	Double pole double throw toggle switch	Switches the vertical input signal to the grid of the vertical amplifier or capacitively to the vertical deflection plate.
SYNC. SELECTOR	S1	Single pole double throw toggle switch	Provides a means for the operator to select a synchronizing signal from either an internal or an external source.
VERTICAL INPUT		Binding Post	Provides a terminal for the connection of an external signal to the vertical channel.
HORIZONTAL INPUT		Binding Post	Provides a terminal for the connection of an external signal to the horizontal channel.
INTENSITY MOD.		Binding Post	Provides a terminal for the connection of an external signal to the grid of the cathode-ray tube for the purpose of modulating the intensity of the trace.
TEST SIGNAL		Binding Post	Provides a terminal for a 60 cycle output voltage of approximately 6 volts a-c.
EXT. SYNC.		Binding Post	Provides a terminal for connecting an external synchronizing signal.
GROUND		Binding Post (TWO)	These binding posts are available to ground the chassis of the Type 274 to the ground of any input signals.

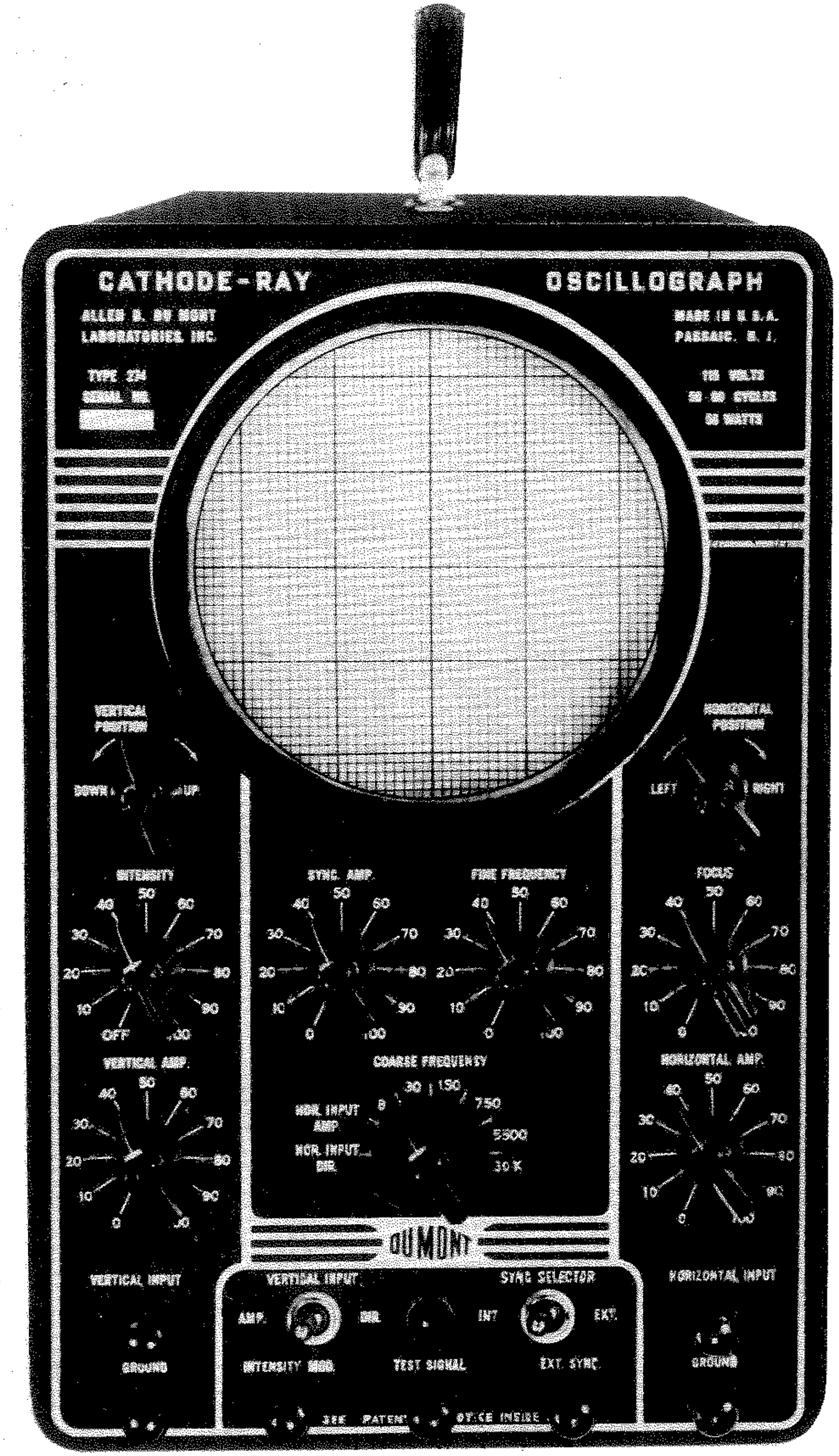


Figure 3 - 1

Front panel view of Type 274 Cathode-ray Oscillograph controls.

For the operator who is well acquainted with oscillographs, this table will probably furnish sufficient instructions to operate the instrument. To the new operator, however, the following discussion lists a step by step procedure for the efficient operation of the instrument. It is suggested that the new operator follow this procedure in learning the use of each of the operating controls.

b. PREPARING THE EQUIPMENT FOR OPERATION

Step 1. Locate the oscillograph on a level table or bench so the screen of the cathode-ray tube is in full view and a minimum amount of light is reflected from the face of the tube. The location must be sufficiently near a 115 volt a-c power source to be reached easily by the line cord of the instrument.

Step 2. Set the controls as follows:

VERTICAL POSITIONING	— pointing up
HORIZONTAL POSITIONING	— pointing up
INTENSITY	— OFF
FOCUS	— at 50
VERTICAL AMP	— at 0
HORIZONTAL AMP	— at 20
COARSE FREQUENCY	— on the line between 30 and 150
FINE FREQUENCY	— at 100
SYNC. AMP.	— at 0
SYNC SELECTOR switch	— EXT
VERTICAL INPUT switch	— AMP

Step 3. Plug the line cord into the power source, 115 volts at 50-60 cycles.

c. OBTAINING THE TRACE

Step 1. Turn on the equipment by rotating the INTENSITY control clockwise and set it at 50. The jeweled light located in the lower center of the front panel glows green when the equipment is turned on.

WARNING

NEVER ADVANCE THE INTENSITY CONTROL TO A POSITION WHICH CAUSES AN EXCESSIVELY BRIGHT SPOT TO APPEAR ON THE SCREEN. A VERY BRIGHT SPOT MAY BURN THE SCREEN AND DECREASE THE LIFE OF THE CATHODE-RAY TUBE. FOR THIS REASON A SHARPLY FOCUSED TRACE OR SPOT OF HIGH INTENSITY MUST NEVER BE PERMITTED TO REMAIN STATIONARY FOR ANY LENGTH OF TIME.

Step 2. Allow 30 seconds for the instrument to warm up.

Step 3. If no trace becomes visible near the center of the cathode-ray tube screen, advance the INTENSITY control until a trace is visible.

Step 4. Rotate the FOCUS control as required to the position where the trace is clear and sharp (least "fuzzy"). The trace then is described as being "in focus." Once in focus, both clockwise and counterclockwise movement of the FOCUS control defocuses the spot. Having reached a clear focus, the operator may decide that the trace is too bright. If such is the case, reduce the setting of the INTENSITY control and refocus. Figures 3-2 and 3-3 show a trace respectively "in focus," and "out of focus."

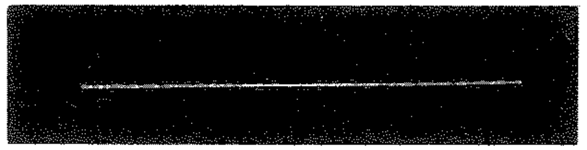


Figure 3 - 2
Trace "in focus"

Figure 3 - 3
Trace "out of focus"

Note

The action of the INTENSITY and FOCUS controls are inherently dependent on each other. Therefore, it may be necessary, whenever varying one control, to adjust the other control to obtain the best definition of the trace.

Step 5. Rotate the VERTICAL POSITIONING control counter-clockwise (DOWN) and clockwise (UP). The trace moves down and then up as the control is turned. Center the trace in the vertical plane.

Step 6. Rotate the HORIZONTAL POSITIONING control counter-clockwise (LEFT) and clockwise (RIGHT). The trace moves left an then right as the control is turned. Center the trace in the horizontal plane. The trace is centered horizontally when the ends of the trace are equally distant from their respective edges of the tube screen.

d. CONTROL OF FREQUENCY OF THE TRACE

The trace that has just been obtained and positioned is actually a single spot which

is being caused to move rapidly and repeatedly across the screen from left to right. As this beam moves across the screen the persistence of the human vision plus the persistence of the screen, causes the movement of this spot to blend into a continuous line as has been previously explained in Section 2, paragraph 1.c. The operator may prove this point to his own satisfaction by the following procedure:

Step 1. Set the COARSE FREQUENCY switch to HOR INPUT AMP. A spot, which is approximately round and possesses a very small diameter, should appear on the face of the cathode-ray tube. This spot will remain stationary.

CAUTION

Immediately after this spot has been observed, turn the COARSE FREQUENCY switch to the position between 8 and 30. This precaution is observed to avoid burning the tube screen by leaving a spot in one position on the screen.

Step 2. With the COARSE FREQUENCY switch set between 8 and 30, turn the FINE FREQUENCY control to 0.

The operator will observe that the spot which was obtained in the preceding step is now being caused to sweep across the face of the cathode-ray tube.

Step 3. By advancing the FINE FREQUENCY control slowly towards 100, the operator can observe that this spot is caused to sweep more and more rapidly across the screen. As the FINE FREQUENCY control reaches about 50 or 60 this spot will have blended into a solid line which appears to be flickering (varying in intensity). As the FINE FREQUENCY control approaches the 100, the flicker of this trace becomes negligible because the frequency of the sweep generator is now equal to, or above that frequency which produces persistence of vision.

By means of the two controls, the FINE FREQUENCY control, and the COARSE FREQUENCY switch, the frequency of the sweep generator can be adjusted to any frequency between 8 and 30,000 cycles per second. (It is an inherent characteristic of this instrument for the trace to become reduced in length as the frequency is increased and does not denote trouble.)

e. CONTROL OF LENGTH OF TRACE

The length of the trace is controlled by the HORIZONTAL AMP control. For the lower frequencies a maximum setting of the HORIZONTAL AMP control will cause the sweep to extend beyond the limits of the face of the tube. By setting the HORIZONTAL

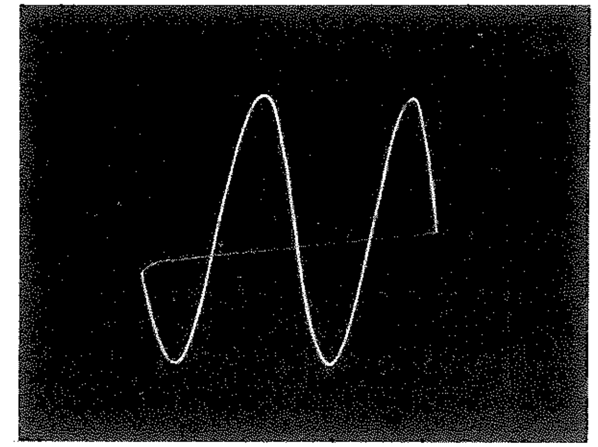


Figure 3 - 4
Sine wave

AMP control to 0, a spot is obtained on the cathode-ray tube because the signal from the sweep generator which causes the displacement of the spot from the center of the tube is at 0.

f. DISPLAYING A SINE WAVE

Preliminary Setting: VERTICAL AMP-20

Step 1. Connect a short wire from the TEST SIGNAL terminal to the VERTICAL INPUT terminal. The test signal is a 6.3 volt a-c signal.

Step 2. With the COARSE FREQUENCY control set at the 30-150 position, rotate the FINE FREQUENCY control until a sine wave (Figure 3-4) of one or more cycles can be identified on the screen. As the FINE FREQUENCY control is set towards the low frequency end of its scale (0), more cycles of the sine wave should appear.

Step 3. Stop the drifting of this wave as nearly as possible with the FINE FREQUENCY control. Regardless of this setting there will always be a slight drift.

Step 4. Set SYNC SELECTOR switch to INT. This setting permits part of the signal which is passing through the vertical amplifier to be impressed on the grid of the time-base generator thereby synchronizing the time-base generator to a submultiple of the wave passing through the vertical amplifier. The amplitude of the synchronizing voltage applied depends upon the setting of the SYNC AMP control. The theory of synchronization is explained more fully in Section 2.

Step 5. Increase the setting of the SYNC AMP control until the trace can be seen to "lock in."

CAUTION

Never use a higher setting of the SYNC AMP control than is necessary or the image may be distorted.

g. MODULATING THE INTENSITY OF THE TRACE

Step 1. Obtain two complete sine waves on the screen of the cathode-ray tube by the method explained in the preceding paragraph f.

Step 2. Connect a short wire between the TEST SIGNAL and INTENSITY MOD. terminals. (Do not remove the wire between the VERTICAL INPUT and TEST SIGNAL terminals).

Step 3. Reduce the intensity of the trace with the INTENSITY control (while maintaining focus with the FOCUS control) until the bottom peaks of the sine wave disappear. It will also be noted that as the bottom peaks are blanked out, the upper peaks are intensified. This is the result of using a sine wave as the modulating signal. The result just described is called **intensity modulation** and is discussed more fully under Laboratory and Lecture Applications.

WARNING

NEVER APPLY AN INTENSITY MODULATING SIGNAL LARGE ENOUGH TO SWING THE GRID OF THE CATHODE-RAY TUBE POSITIVE WITH RESPECT TO THE CATHODE. THIS UNWANTED CONDITION MAY CAUSE A SERIOUS REDUCTION IN THE LIFE OF THE CATHODE-RAY TUBE. AN INDICATION OF THE GRID SWINGING POSITIVE WITH RESPECT TO THE CATHODE IS RECOGNIZED BY MARKED DEFOCUSING ON THE SCREEN DURING THE POSITIVE PHASE OF THE INTENSITY MODULATING SIGNAL.

Note

It is advisable to connect a short lead from the INTENSITY MOD terminal to GROUND when this terminal is not in use. Such a connection results in a trace of more uniform intensity.

h. CONTROLLING THE SIZE OF THE PATTERNS

It is frequently desirable to examine more closely a particular part of a pattern or trace. In that event the pattern or trace may be expanded both horizontally and vertically by increasing the setting respectively of the HORIZONTAL AMP and VERTICAL AMP controls. These expanded traces may then be positioned to any part of the screen to obtain better definition of the part in question. Care should be taken however, to assure that the amplifiers are not overloaded by this procedure, or the wave form under examination will be distorted.

Note

All signals applied to the oscillograph from external sources require two wires to complete the connection. One wire carries the signal and the other wire serves as a ground. This results in all the signals, being observed or performing a function in the oscillograph, being referred to a common ground.

i. THE USE OF EXTERNAL SYNC

In many cases, an external signal is more suitable for synchronizing purposes than the signal applied to the vertical channel. This is particularly true if varying amplitudes of the same wave form are to be viewed in rapid succession. Since when using internal sync, the amplitude of the wave form passing through the vertical amplifiers also affects the amplitude of the synchronizing voltage; too much or too little voltage will be applied to the sync generator with different amplitudes of input signals. Thus the setting of the SYNC AMP control will necessarily require adjustment with each different amplitude of signal applied.

When using an external synchronizing voltage, connection is made from the external source to the EXT. SYNC terminal and the SYNC SELECTOR switch is thrown to the EXT position. Once the SYNC AMP control has been adjusted to apply the correct amount of synchronizing signal to the sweep generator, it will not be necessary to reset it as the various amplitudes of the signal are applied to the vertical channel. It will be necessary to use an external synchronizing voltage whenever the vertical amplifier is not used and the signal is capacitively or directly coupled to the deflection plates.

j. VERTICAL INPUT DIRECT

If the signal being viewed through the VERTICAL INPUT terminals is of sufficient amplitude to result in appreciable vertical deflection without amplification, the VERTICAL INPUT switch may be set on DIR. This connection capacitively couples the input signal to the vertical deflection plate of the cathode-ray tube and permits the signal to be viewed without amplification.

k. HORIZONTAL INPUT DIRECT

For certain applications it is frequently necessary to apply a signal other than the time base signal to the horizontal deflection plate. When such an occasion arises, the COARSE FREQUENCY switch should be turned to the HOR INPUT DIR position and an external signal should be connected to the HORIZONTAL INPUT terminal and GROUND. When the COARSE FREQUENCY switch is set in this position, the signal at the HORIZONTAL INPUT terminal is capacitively coupled to the horizontal deflection plate.

l. HOR INPUT AMP

If the signal applied to the HORIZONTAL INPUT terminal in the preceding paragraph is not of sufficient amplitude to result in satisfactory horizontal deflection, it may be connected through the horizontal amplifier by switching the COARSE FREQUENCY switch to the HOR INPUT AMP position. Under these circumstances, the horizontal amplifier is used to increase the amplitude of the horizontal signal and the desired deflection is controlled by the HORIZONTAL AMP control.

m. DIRECT DEFLECTION

The rear terminal strip is designed to provide means for eliminating the capacitor input to the deflection plates when it is desirable to connect a d-c signal directly to the deflection plate.

If it is desirable to connect such a signal to the VERTICAL deflection plate, it should be connected to the rear terminal marked D1. It is advisable to remove the jumper passing between the terminal marked VERT and D1 as shown in Figure 3-5.

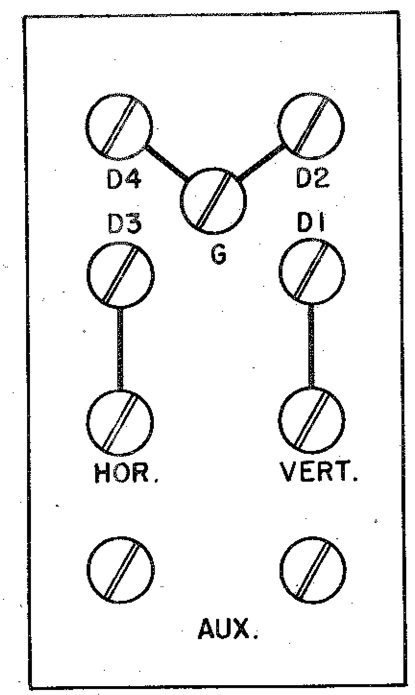


Figure 3 - 5
Rear terminal board

CAUTION

Connections to these terminals should be made with the power turned OFF.

If it is desirable to connect the external signal to the HORIZONTAL deflection plate, the connection should be made to the terminal marked D3. Likewise, the jumper between HOR, and D3 should be removed.

n. TURNING OFF THE EQUIPMENT

To turn off the equipment, rotate the INTENSITY control counterclockwise to the OFF position. When the equipment is operating but not in use, turn the INTENSITY control sufficiently counterclockwise to dim out the trace. This procedure will insure against burning the screen of the cathode-ray tube and increase its life.

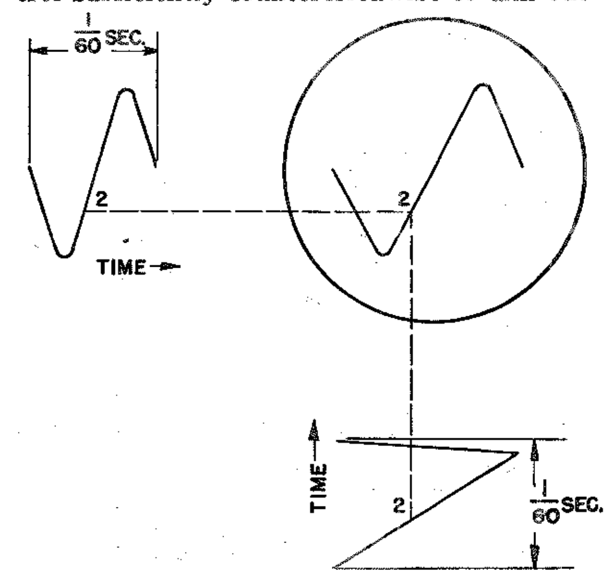


Figure 3 - 6

Projection drawing of a sinewave applied to the vertical axis and a sawtooth wave of the same frequency applied simultaneously on the horizontal axis.

4. DISPLAY OF WAVEFORMS

Together with a working acquaintance of the controls of the oscillograph, an understanding of how the patterns are traced on the screen must be obtained for a thorough knowledge of oscillograph operation. With this in mind a careful analysis of two fundamental patterns is discussed under the following headings:

a. Patterns plotted against time (using the sweep generator for horizontal deflection)

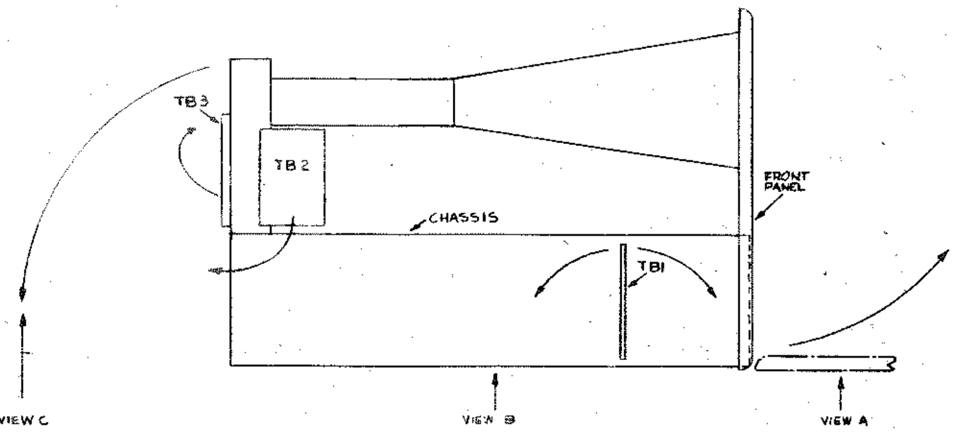
b. Lissajous Figures (using a sine wave for horizontal deflection)

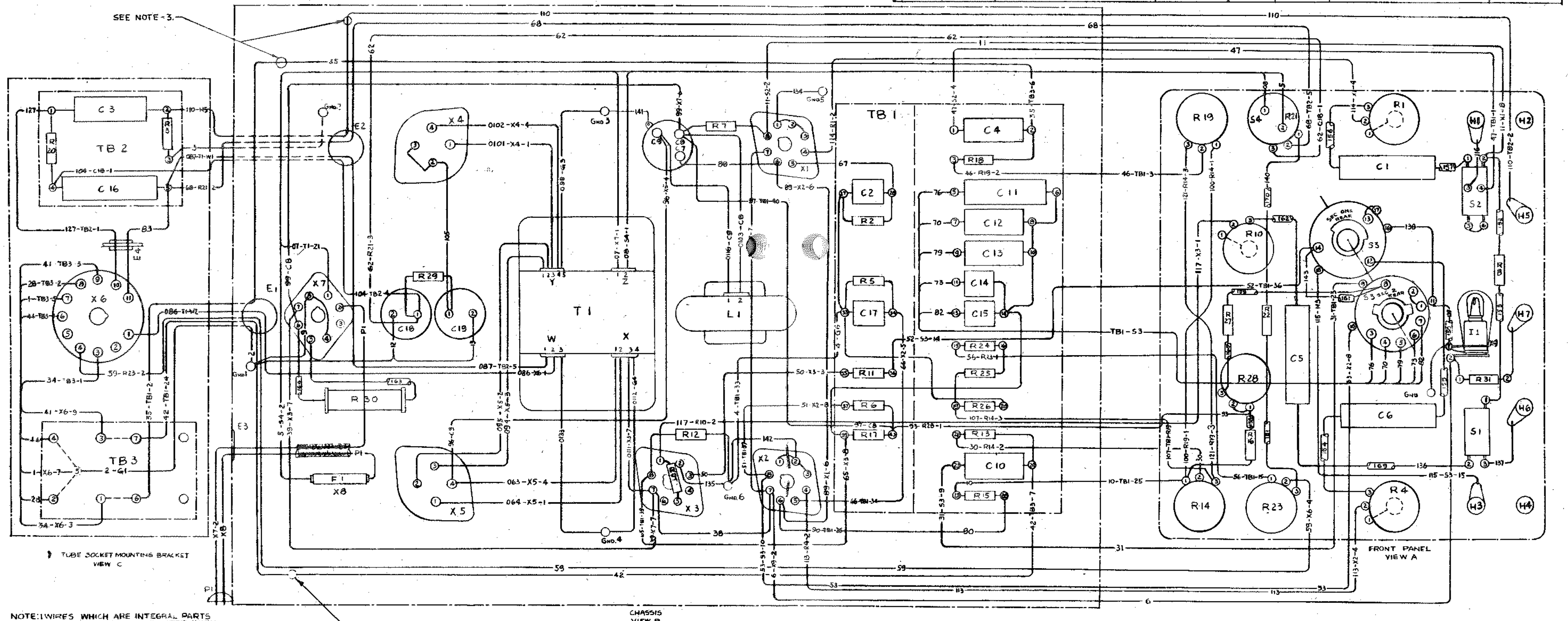
a. PATTERNS PLOTTED AGAINST TIME

(1) Preliminary. - A sine wave is typical of and convenient for this study. The connections necessary for producing a sine wave on the screen were previously discussed. This wave is amplified by the vertical amplifier and impressed on the vertical (Y-axis) deflection plate. Simultaneously the sawtooth wave, as discussed in Section 2, from the time-base generator is amplified and impressed on the horizontal (X-axis) deflection plates.

LIST OF PARTS			
NO. OF WIRE	PART NO.	DESCRIPTION	APPROX. LENGTH
1 - 13	23 - 2	BLACK	8 FT.
28 - 31	23 - 118	BLACK - RED TRACER	2 FT.
34 - 35	23 - 119	BLACK - BROWN TRACER	2 1/2 FT
37 - 39	23 - 84	BLACK - BLUE TRACER	2 1/2 FT
41 - 42	23 - 100	BLACK - GREEN TRACER	2 1/2 FT
44 - 47	23 - 57	BLACK - WHITE TRACER	2 FT
50 - 53	23 - 3	BLUE	2 1/2 FT
56	23 - 108	BLUE - RED TRACER	1 FT
59	23 - 58	BLUE - WHITE TRACER	2 1/2 FT
62 - 68	23 - 4	BROWN	5 FT
70	23 - 121	BROWN - BLACK TRACER	1/2 FT
73	23 - 122	BROWN - BLUE TRACER	1/2 FT
76	23 - 184	BROWN - GREEN TRACER	1/2 FT
79	23 - 185	BROWN - YELLOW TRACER	1/2 FT
82 - 83	23 - 224	BROWN - WHITE TRACER	1 FT
86 - 90	23 - 5	SLATE	1 FT
		SEE CONTINUATION	

LIST OF PARTS (CONTINUED)			
NO. OF WIRE	PART NO.	DESCRIPTION	APPROX. LENGTH
93 - 97	23 - 7	RED	2 1/2 FT
98		RED - YELLOW TRACER	
99	23 - 59	RED - WHITE TRACER	1 1/2 FT
100	23 - 101	RED - BLUE TRACER	1 FT
101 - 105	23 - 94	YELLOW	1 FT
107	23 - 123	YELLOW - BLUE TRACER	1 FT
110 - 117	23 - 1	GREEN	4 FT
121	23 - 172	GREEN - BROWN TRACER	1 FT
127	23 - 56	GREEN - WHITE TRACER	1/2 FT
133 - 143	23 - 29	BARE #20 COPPER	2 FT
150 - 162	24 - 111	INSULATING SLEEVING #18	2 FT
169 - 171	24 - 112	INSULATING SLEEVING #12	1 FT
	28 - 7	SOLDER (AS REQUIRED)	





SEE NOTE #3

NOTE: 1. WIRES WHICH ARE INTEGRAL PARTS OF COMPONENTS ARE INDICATED WITH "O" PREFIX
2. ALL ITEMS BEARING CIRCUIT SYMBOL DESIGNATIONS REFER TO OE-1663
3. - CRITICAL LEAD, ISOLATE.
4. TWIST ALL AC LEADS.

COMPONENT LOCATION AND WIRING DIAGRAM