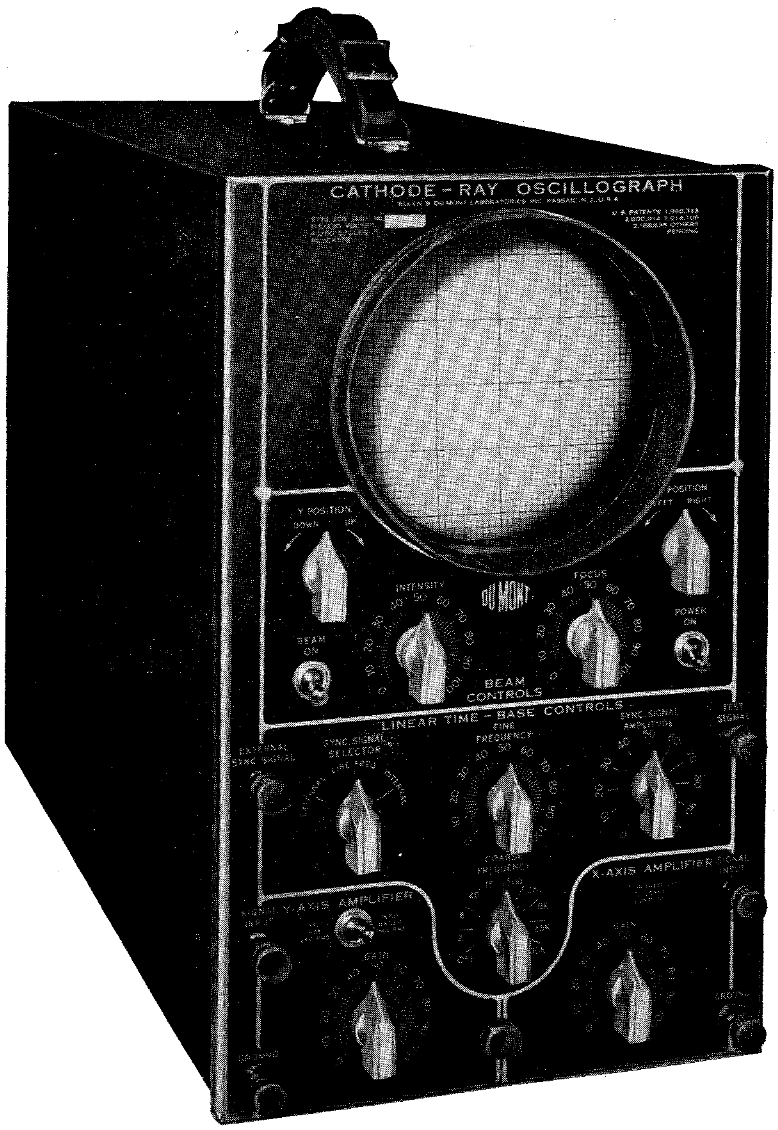
DU MONT

CATHODE-RAY OSCILLOGRAPH
TYPE 208

OPERATING INSTRUCTIONS

ALLEN B. DU MONT LABORATORIES, INC.
PASSAIC, NEW JERSEY
U. S. A.



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For

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1.00 DESCRIPTION

1.10 SPECIFICATIONS:

Cathode-ray Tube:
- Type .... 5LP1 or 5LP5
- Accelerating Potential .... 1400 volts

Input Impedance:
- Y-axis .... 2,000,000 ohms, 30 mmfd.
- X-axis .... 5,000,000 ohms, 25 mmfd.

Maximum Input Potential:
- Y-axis .... 250 r.m.s. volts
- X-axis .... 25 r.m.s. volts

Amplifier Frequency Response:
- Y-axis .... 2 to 100,000 sinusoidal cycles per second ± 10 per cent. 50% response at 325,000 sinusoidal cycles per second
- X-axis .... 2 to 100,000 sinusoidal cycles per second ± 10 per cent. 50% response at 250,000 sinusoidal cycles per second

Voltage Gain:
- Y-axis .... 2000 times
- X-axis .... 43 times

Deflection Factor:

Through amplifier:
- Y-axis .... 0.010 r.m.s. volts/inch
- X-axis .... 0.5 r.m.s. volts/inch

To deflection plates:
- Y-axis .... 21. r.m.s. volts/inch
- X-axis .... 22. r.m.s. volts/inch

Sweep Circuit:
- Frequency Range (Recurrent only) .... 2 to 50,000 cycles
- Direction of sweep .... Left to right

Power Supply:
- Potential .... 115/230 volts a.c.
- Frequency .... 40-60 cycles
- Power consumption .... 90 watts
- Fuse protection .... 1.5 amperes

Physical Specifications:
- Height excluding carrying handle and feet .... 14¼ inches
- Width .... 8 13/16 inches
- Depth .... 19½ inches
- Weight .... 54 pounds

1.20 PURPOSE

The Du Mont Type 208 Cathode-ray Oscillograph is an instrument designed for plotting an instantaneous visual curve of one electrical quantity as a function of another electrical quantity on the screen of the cathode-ray tube. The quantities usually vary recurrently, and the persistence of vision of the human eye causes the appearance of a continuous curve. In addition, photographic recordings can be employed to retain the trace for detailed study.

In a specific problem the unknown quantity, which is usually plotted along the Y axis, is plotted as a function of some known quantity which may be applied to the X axis. Circuits are also incorporated in the instrument which generate a sawtooth-shaped voltage wave for application to the X axis so that the unknown quantity may be plotted as a linear function of time.

This instrument has been designed primarily for analysis of electrical circuits by study of the waveform of voltage and current at various points in the network. It is obvious, however, that it may be applied to the study of any variable which may be translated into electrical potentials by means of some type of transducer such as a vibration pickup unit, pressure pickup unit, microphone, or a variable resistance such as a carbon pile.

1.30 FREQUENCY RANGE

The cathode-ray tube is essentially an indicating device with a pointer of negligible inertia and for this reason its frequency range is unlimited up to deflection frequencies where the electron-transit time of the 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, therefore, possible to apply a deflecting potential which reverses in polarity during the transit time of the electrons.

For example, suppose an electron travels across a deflection plate face in 0.001 microseconds and that at the moment the electron reaches the leading edge of the deflection plate a 1000 megacycle sinusoidal wave is applied. The electron will then have experienced a positive and an equal negative deflecting force by the time it reaches the trailing edge of the deflection plate and the resultant deflection will be zero. In modern cathode-ray oscillographs, this effect does not become apparent at frequencies below $2x(10)^8$ sinusoidal cycles per second, and it may, therefore, be neglected at lower deflection frequencies.

The above frequency limitations apply only when the cathode-ray tube 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 the cathode-ray tube, amplifiers have been incorporated in the Type 208 Cathode-ray Oscillograph to increase the sensitivity of the device so that it may give usable indications from relatively low-potential sources. The frequency response of these vacuum-tube amplifiers is, therefore, the limiting factor in applying the instrument to the majority of problems.

The amplifiers of this instrument have been designed to give uniform response over the frequency range from two to one-hundred-thousand sinusoidal cycles per second. The qualifications of this rating are discussed in Section 2.12.

1.40 TYPE OF INDICATION

Perhaps the chief trouble experienced by those using the cathode-ray oscillograph is the lack of a proper interpretation of the pattern traced on the screen of the cathode-ray tube. It should be remembered at all times that the cathode-ray oscillograph does not offer the solution to any problem but that it merely supplies information regarding the characteristics of the problem, which information may serve as a guide for the engineer to the type of reasoning required to analyze properly the phenomenon which is being studied. The cathode-ray oscillograph is not a machine in itself for accomplishing any purpose or for performing any desired operation upon an electrical signal; but rather it should be considered as an instrument which indicates many important characteristics of a signal, a knowledge of which will enable the engineer to deduce important facts regarding the source of this signal.

When interpreting the patterns 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 impossible to identify the characteristics of the signal under investigation. For this reason it is generally common practice to use a sinusoidal signal of known frequency, or a sawtooth signal which has been synchronized to the frequency of the unknown signal, for the horizontally-varying variable. The sinusoidal signal often is used in applications as phase and frequency 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 as time progresses.

The information which may be gained from analyzing these traces in the above manner is invaluable in determining the characteristics of the device which is under study. The time-rate of rise of the signal, which may be shown when it is plotted as a function of the linear sawtooth sweep circuit which is incorporated in the Type 208 Cathode-ray Oscillograph, will give indications showing the presence of undesirable harmonics, vibration at a frequency which bears some definite relationship to other parts of the equipment, or changes indicating the degree of faithfulness with which the device is following the desired cycle of operation. A familiar case of operation where a sinusoidal standard signal for horizontal deflection is employed is found in the application of the cathode-ray tube to the plotting of the pressure-displacement curve of an internal combustion engine. If a pressure-sensitive pickup be placed in the cylinder head of the engine, and a sinusoidal signal of frequency corresponding to the rotational speed of the engine be utilized for horizontal deflection, a pressure-displacement curve will be obtained. This is true since both a pure sine wave and the piston displacement follow the laws of simple harmonic motion, because the piston is driven from the rotating crankshaft.

1.50 POWER SUPPLY

The Type 208 Cathode-ray Oscillograph incorporates a self-contained power supply for complete operation of the instrument from 115 or 230 volt, 40-60 cycle alternating-current power. It may also be operated on other voltages and frequencies when suitable voltage or frequency changing devices are employed. Care should be taken to operate the instrument only on the power supply for which it has been designed.

2.00 PRINCIPLES OF OPERATION

2.10 FUNDAMENTAL THEORY

The innumerable uses to which a cathode-ray oscillograph can be put are perhaps not generally appreciated. Probably the chief reason for this is a tendency to accept the instrument for what it can do rather than for what intelligent uses can be made of it. An important fact to bear in mind is that the cathode-ray oscillograph is an indicating device, and its indications must be interpreted with regard to the manner in which they were obtained and with regard to the associated equipment employed.

In the following paragraphs of this section some of the fundamentals of the operation and application of the cathode-ray tube will be reviewed briefly in an endeavor to suggest implicitly to the user some of the less conventional ways in which a cathode-ray oscillograph can be employed.

2.110 The Intensifier Cathode-Ray Tube

The intensifier cathode-ray tube is a high-vacuum cathode-ray tube employing the principle of post-deflection acceleration of the electron beam to provide on increase in both intensity and deflection sensitivity over those obtainable in conventional cathode-ray tubes. The tube consists of a long evacuated glass bulb having at one end an electron gun which generates and focuses a beam of electrons into a fine point on the fluorescent screen or phosphor coated on the inside of the bulb at the opposite end. As the electron beam impinges on the screen, there is emitted a spot of light of a color determined by the nature of the chemical coating. Since the beam of electrons in motion actually constitutes an electric current, it can be deflected by means of magnetic as well as electric fields, and a measure of its motion is given by the change in position on the screen of the fluorescent spot of light. The application of a field not varying with time (magnetostatic or electrostatic, as the case may be) causes the beam to assume and maintain a new position, while the application of a field varying with time, or alternating field, causes the spot to move practically instantaneously, since the mass of an electron is negligible. To the latter type of fields are applied the terms magnetodynamic or electrodynamic when they are respectively magnetic or electric.

Magnetodynamic deflection is seldom used in cathode-ray oscillographs, since the variation with frequency of the field produced by a magnetic deflection coil would not permit true delineation on the cathode-ray tube screen of the signal voltage actually being applied to the coil except for pure single-frequency sinusoids.

Therefore, electrodynamic deflection is used in the Type 208 Cathode-ray Oscillograph.

Curve-plotting generally is done with orthogonal (Cartesian) coordinates, and therefore the cathode-ray tube is designed to provide such coordinates. To accomplish this, the electron beam is directed between first one pair of deflection plates and then between another pair at right angles to the first; the fields that cause deflection of the beam are produced by the corresponding potential differences applied between the plates of each pair. Since the position of the luminescent spot is determined by the resultant of the fields deflecting the beam, it is apparent that along each axis an electrostatic field can be used to determine the zero-signal position of the beam and a superimposed electrodynamic field will determine the instantaneous position of the spot. The actual instantaneous position of the spot is thus the vector sum of the two orthogonal fields, and its motion over the screen will be a graphical plot of the deflecting signal applied to one set of plates as a function of that applied to the set normal to it.

Since the ease with which the electron beam is deflected by an electric field varies inversely with the axial component of velocity of the electron beam during deflection (and thus with the potential applied to the gun to accelerate the beam), and since the intensity of the fluorescent spot increases with acceleration potential, a means for producing a large spot motion with a small signal voltage is desirable. Such a means is provided in the intensifier cathode-ray tube, in which the beam is accelerated partically before deflection and partially after deflection, reaching the desired high final velocity (and thus brilliance) while retaining the desirable deflection sensitivity of cathode-ray tube operated at much lower acceleration potentials. Obviously the sensitivity of a cathode-ray oscillograph, such as the Du Mont Type 208, which employs such a tube is greater than that of one utilizing a conventional type of cathode-ray tube for identical amplifier design and accelerating potential.

Even the intensifier cathode-ray tube, however, is a relatively insensitive indicating device, requiring potentials measured in hundreds of volts for full-screen deflection. It is necessary, therefore, to provide amplifiers to increase the sensitivity of indication and make possible full-screen deflection with relatively small potentials. Thus it becomes necessary to know the characteristics of the amplifiers to determine whether the signal to be studied is suited to oscillographic investigation.

In most investigations it is desired to plot the phenomenon under study as a function of time. For this purpose there has been provided in the Type 208 Cathode-ray Oscillograph a sweep circuit which generates a sawtooth wave of voltage for the horizontal or X-axis deflection of the electron beam. The spot thus travels horizontally from left to right at a constant time-rate and, on reaching its extreme of travel, returns rapidly to start another excursion along the linear time-base. When the repetition rate of the sawtooth waves is an integral divisor of the frequency of the vertical or Y-axis signal, the pattern appears stationary and can be studied in detail.

For a given accelerating potential, the intensity of the fluorescent spot is a function of the beam current. The beam current is determined by the bias potential on the modulating electrode, and the intensity control for a cathode-ray tube sets the value of that quantity. Since the return trace of the linear time-base deflection tends to become visible at high sweep frequencies, a pulse is taken from the sweep circuit in the Type 208 Cathode-ray Oscillograph to blank out the spot of light during the sawtooth return time.

2.12 Amplifiers

It is generally found that the amplitudes of signals to be studied with the cathode-ray oscillograph are too small for direct application to the deflection plates of the cathode-ray tube. In the Type 208 Cathode-ray Oscillograph this difficulty has been overcome by the use of amplifiers of unusually high gain and wide frequency band. A combination of compensated resistance-capacitance-coupled and direct-coupled amplifiers is used, together with suitable impedance transforming and other auxiliary circuits. In order to interpret the patterns produced on the cathode-ray tube screen, it is necessary to know the transmission characteristics of the amplifiers and networks. The amplifier providing deflection along the Y-axis in the Type 208 Cathode-ray Oscillograph will provide faithful reproduction of square waves of voltage from 4 to beyond 30,000 cycles per second. At 2 cycles per second, the distortion amounts to approximately 5% sawtooth.

For generally satisfactory squarewave reproduction, it has been determined empirically that a transmission system must have uniform sinusoidal response from f/10 to 10f, where f is the frequency or repetition-rate of the squarewave signal. For this reason, the gain of the Type 208 instrument has been designed to be uniform over the frequency-range from two to one-hundred-thousand sinusoidal cycles per second, which range covers the majority of commercial requirements.

It is important to note that it is the INSTANTANEOUS rate-of-change of voltage of a complex or composite signal, and not its repetition rate alone, that determines whether the transmission characteristic of a given amplifier is adequate for the distortionless amplification of that signal.

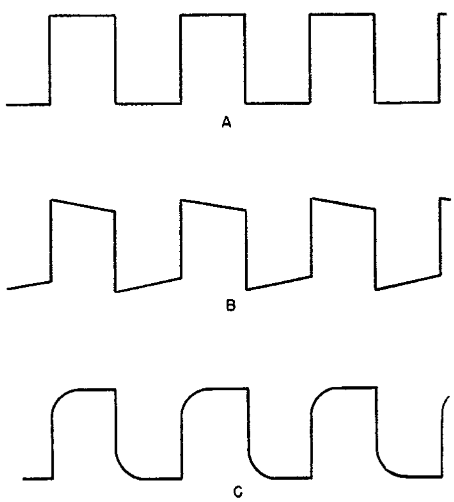


Fig. 1

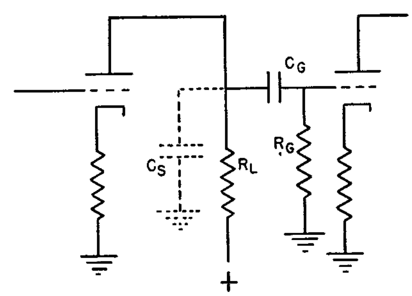
A convenient means for testing the transmission characteristics of an amplifier is found in the application of square waves of voltage to the input of the network and the analysis of the waveform of the resultant output as plotted on the cathode-ray tube screen. Figure 1 (A) shows a typical square wave of voltage.

Such a square wave may be analyzed in terms of its harmonic content, taking the repetition rate as fundamental frequency. It can be shown that for perfect square wave reproduction an infinitely wide band of frequencies must be passed without attenuation or relative phase shift. In a practical case, reasonably good reproduction can be expected under the conditions mentioned above.

If the amplifier gain falls appreciably as signal frequency decreases from the square-wave repetition rate, sawtooth distortion, or downward sloping of the flat top, results, as shown in Figure 1 (B). On the other hand, if response falls with increasing frequency near the square-wave repetition rate, the rapid change in potential necessary for sharp wave fronts cannot take place, resulting in distortion as shown in Figure 1 (C). Since rapid changes in amplitude response with frequency usually are accompanied by rapid changes in phase shift, further distortion to the square wave of voltage is to be expected.

Thus square waves of voltage of two frequencies, one near the low-frequency limit and one near the high-frequency limit of uniform sinusoidal frequency response, will give a considerable amount of information concerning the transmission characteristic of a given network: the steepness of the wave-front gives an indication of the transient response, while the flatness of the top indicates the steady-state response to be expected.

A typical resistance-capacitance coupled amplifier circuit is shown in Figure 2 (A).



A

Fig. 2

The stray and tube-capacitance lumped and indicated as C_s tend to reduce the load impedance with increasing frequency; thus the gain of the amplifier would tend to fall off at higher frequencies. Again, the time constant of the circuit C_g R_g might be too small to maintain a charge across the condenser C_g during the period represented by the flat top of a square wave, causing the top to slope downward as in Figure 1 (B).

The decrease in plate load impedance with frequency can be compensated by a suitable inductance, L_1 in Figure 2 (B). Since the inductive reactance increases with frequency, the resultant plate load impedance stays essentially constant with frequency over the operating range. Too large an inductance for a given

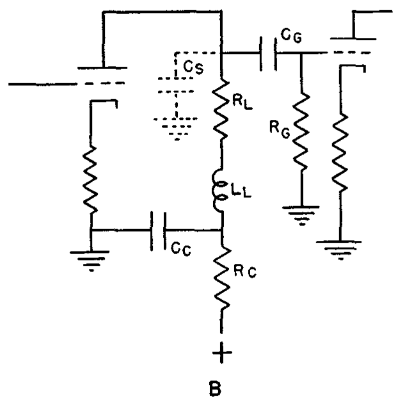


Fig. 2

resistance will cause peaking in the network response at some frequency, and transient response will show the effect of non-uniform gain. Too small an inductance will not give maximum band-width for uniform response, but it will not produce the relatively sharp high-frequency cut-off resulting from the use of larger inductances. In general, an inductance value is desirable which is equal to or somewhat smaller than that which just begins to produce inflections in the sinusoidal frequency response characteristic curve.

Low-frequency response can be improved by increasing C_g R_g, but the maximum value of R_g is limited by vacuum-tube grid current considerations and the maximum value of C_g by physical size and capacitance to ground. Plate circuit compensation, provided by the circuit C_cR_c in Figure 2 (B) produces a voltage wave of such a nature as to compensate for the inadequacy of the circuit C_gR_g. Suitable proportioning of C_cR_c with respect to C_gR_g makes possible excellent low-frequency response.

In the Du Mont Type 208 Cathode-ray Oscillograph both low-frequency and high-frequency compensation have been employed. As a result, excellent reproduction of square waves from two to thirty thousand cycles per second is possible. The actual sinusoidal frequency response is shown in Figure 3.

In addition to the compensated resistance-capacitance-coupled amplifiers described above, several basically new departures are embodied in the Type 208 Cathode-ray Oscillograph. First of these is the use of a direct-coupled deflection amplifier, permitting the use of a new and improved positioning means to be described later. The second is the introduction of a new type of phase-inverter circuit which provides improved frequency response characteristics. A simplified block diagram of these new circuits is shown in Figure 4.

A signal to be amplified for deflection along the Y axis passes through a two-step attenuator having positions for signal input voltages under 25 volts r.m.s. and under 250 volts r.m.s. The purpose of this attenuator is to limit to 25 volts r.m.s. the signals applied to the impedance-matching stage V_1. A low-impedance continuously variable attenuator R_1, used as gain control is coupled to its cathode and feeds a two-stage resistance-capacitance coupled amplifier. The output of this amplifier goes to the positioning stage V_2, from which the signal is taken at various D.C. potential levels in R_2, and fed to the grid of V_3. The tubes V_3 and V_4 together constitute a direct-coupled phase inverter circuit whose output circuits have a d.c. connection to the cathode-ray tube deflection plates. A change in potential at the grid of V_3 is amplified and shifted in phase by 180° at the plate of V_3, and a signal appears at the plate of V_4 amplified by the same amount but in phase with the grid signal. Thus, if the grid of V_3 is made positive, the plate of V_3 is made less positive than normal and the plate of V_4 is made more positive by the same amount. As a result, the cathode-ray tube

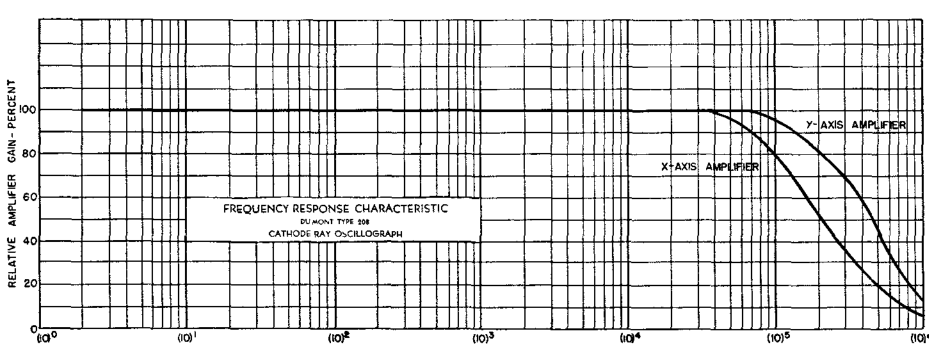


Fig. 3

beam will be changed in its position on the screen. This, essentially, is the mechanism of position control and direct-coupled amplification. The same general circuit arrangements are used for deflection along the X axis, as shown in Figure 4.

arranged to make the average deflection-plate potential equal to ground potential.

2.130 Input Circuits

The ideal measuring instrument would have no effect upon the circuit to which it is con-

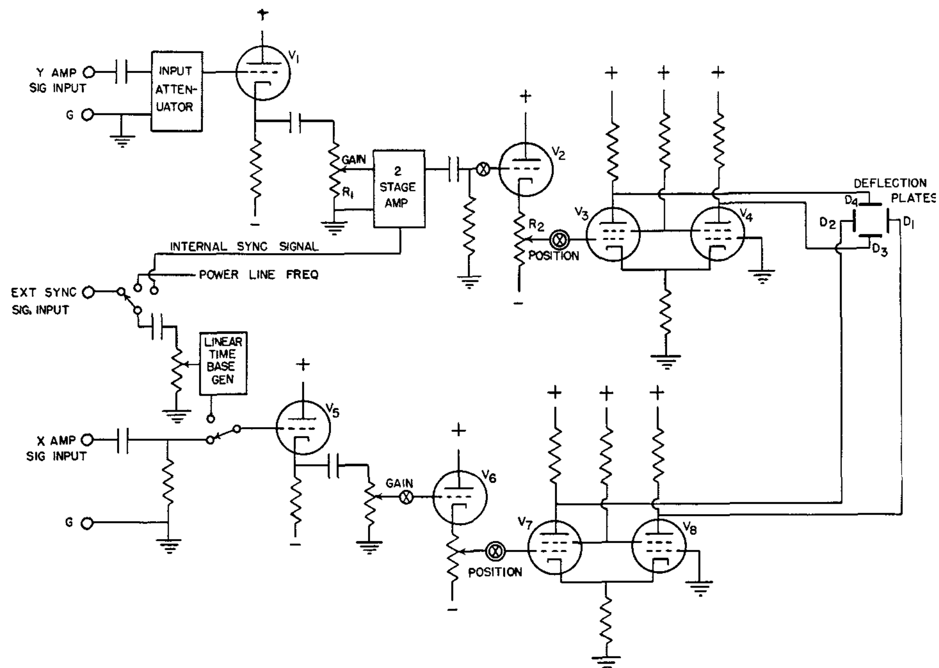


Fig. 4

Obviously the amplifier circuits could be broken at the points marked with a circled X and a signal introduced there. The amplification of such signals would be effective down to zero frequency, or d.c., and at the same time the positioning controls could be used to center the pattern. An alternative connection for direct-coupled amplification could be made by breaking the circuits at the points marked with the doubly-circled X, with improved high-frequency response but without position control. In either case it is necessary to limit the peak values of signal to ± 11 d.c. volts to prevent overload and to make a d.c. grid return to ground through a resistance not greater than one to five megohms.

Since, in some instances, direct deflection of the cathode-ray tube beam can be used to advantage, provision has been made to permit the necessary connections at the rear of the cabinet. When one set of deflection plates is connected to an external signal at ground reference potential and the other is connected to either amplifier, as when a linear time-base is being used, no defocusing of the cathode-ray tube beam occurs because the amplifier output coupling network is

nected. This requirement demands infinite input resistance and zero shunt capacitance. In the case of a vacuum-tube equipment, there exists a further requirement in that the input signal to the grid of a vacuum-tube must remain within the operating range of the device. This requirement introduces the need for a satisfactory input attenuator, preferably having the ideal characteristics outlined above, to operate without distortion upon the unknown signal to reduce its amplitude within the desired range.

When a high resistance potentiometer is used as input attenuator, or as an attenuator in any part of the amplifier circuit, a variable frequency-distortion is introduced at all except one intermediate setting of that control between zero and maximum, resulting in non-uniform frequency transmission. On the other hand, a low-resistance input potentiometer, while relatively free of frequency discrimination, tends to load the circuit being studied and can give questionable results. Again, when a low-resistance input potentiometer is used, the input coupling condenser must be large to give the large RC product necessary for low-frequency operation, and, because of its physical size, it increases the input capacitance of the instrument.

In the Du Mont Type 208 Cathode-ray Oscillograph input circuits are incorporated which provide high input resistance and low shunt capacitance, yet a low-impedance continuously variable attenuator permits the use of attenuation settings other than minimum without discrimination against certain frequencies. This is accomplished by using a vacuum tube as an impedance transformer, which function it performs without frequency discrimination. The signal input terminals are capacitively coupled to the impedance transforming stage with no intermediate attenuating means, and thus it is important to avoid overloading that stage. Signals up to 35 volts peak or 25 volts r.m.s. can be applied directly, but where signals of greater amplitudes are to be studied it becomes necessary to reduce their amplitudes. This has been provided for in the Y-axis Amplifier in the form of a constant-input-impedance attenuator having two positions, one for signals under 25 volts r.m.s. and the other for signals under 250 volts r.m.s. Whenever possible the attenuator switch should be kept in the second position to reduce the possibilities of input stage overload. For either position the input corresponds to two megohms resistance and approximately 30 micromicro-farads shunt capacitance. Thus there will be no change in loading imposed by the instrument when changing from one position to the other.

An almost identical input circuit is provided for the X-axis amplifier. Here the input resistance is five megohms, and the maximum allowable peak signal voltage is 35 volts.

2.140 Positioning Circuits

The unique positioning circuits used in the Type 208 Cathode-ray Oscillograph set a new standard of performance. In conventional oscillographs, as the lower limit of frequency response is reduced the time constants of the cathode-ray tube deflection-plate-coupling circuits become larger and larger, with the result that positioning becomes more and more sluggish. Paradoxically, it was by extending this lower frequency limit to zero that all sluggishness was eliminated in this new instrument. Examination of Figure 4 and reference to Section 2.13 will indicate how this is accomplished. When the arm of potentiometer R_2 is moved upward, toward the cathode of V_2, the potential of the grid of V_3 is given a positive increment Δe. This increment is amplified and shifted in phase by 180° through V_3, appearing at its plate as a change in potential—$V_a\Delta e$, where V_a is the voltage amplification of the stage. Thus the potential of the upper deflection plate D_4, is made more negative and repels the electron beam. At the same time, a change in potential of—(—$V_a\Delta e$) or $V_a\Delta e$, appears at the plate of V_4, thus making the cathode-ray tube deflection plate D_3 more positive by that amount and attracting the electron beam toward it. The average potential of the space between deflection plates has been maintained constant, but the fluorescent spot has assumed a new position on the cathode-ray tube screen. Signal potentials superimposed upon the steady positioning potential will continue to move the spot about its new base position.

2.150 Linear Time-Base Oscillator

In most investigations of an unknown phenomenon the electrical quantities corresponding to the phenomenon are plotted as a linear function of time and the resultant wave-forms analyzed. To facilitate this method of investigation a linear time-base generator has been built into the Du Mont Type 208 Cathode-ray Oscillograph. The output of this generator is a sawtooth wave of voltage the increase of which is essentially linear with time and the decrease rapid as compared to its rise. Figure 5 depicts

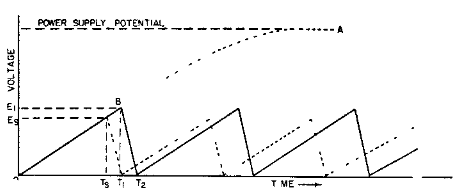


Fig. 5

the variation of voltage with time in such a wave, and Figure 6 gives the schematic circuit of a relaxation oscillator using a gas triode for generating it.

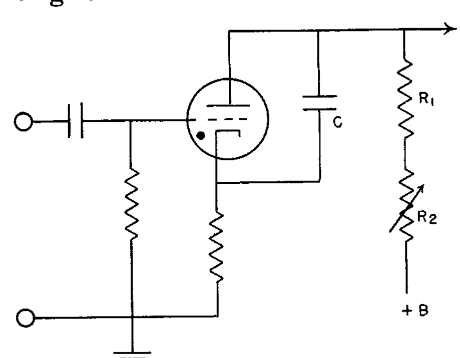
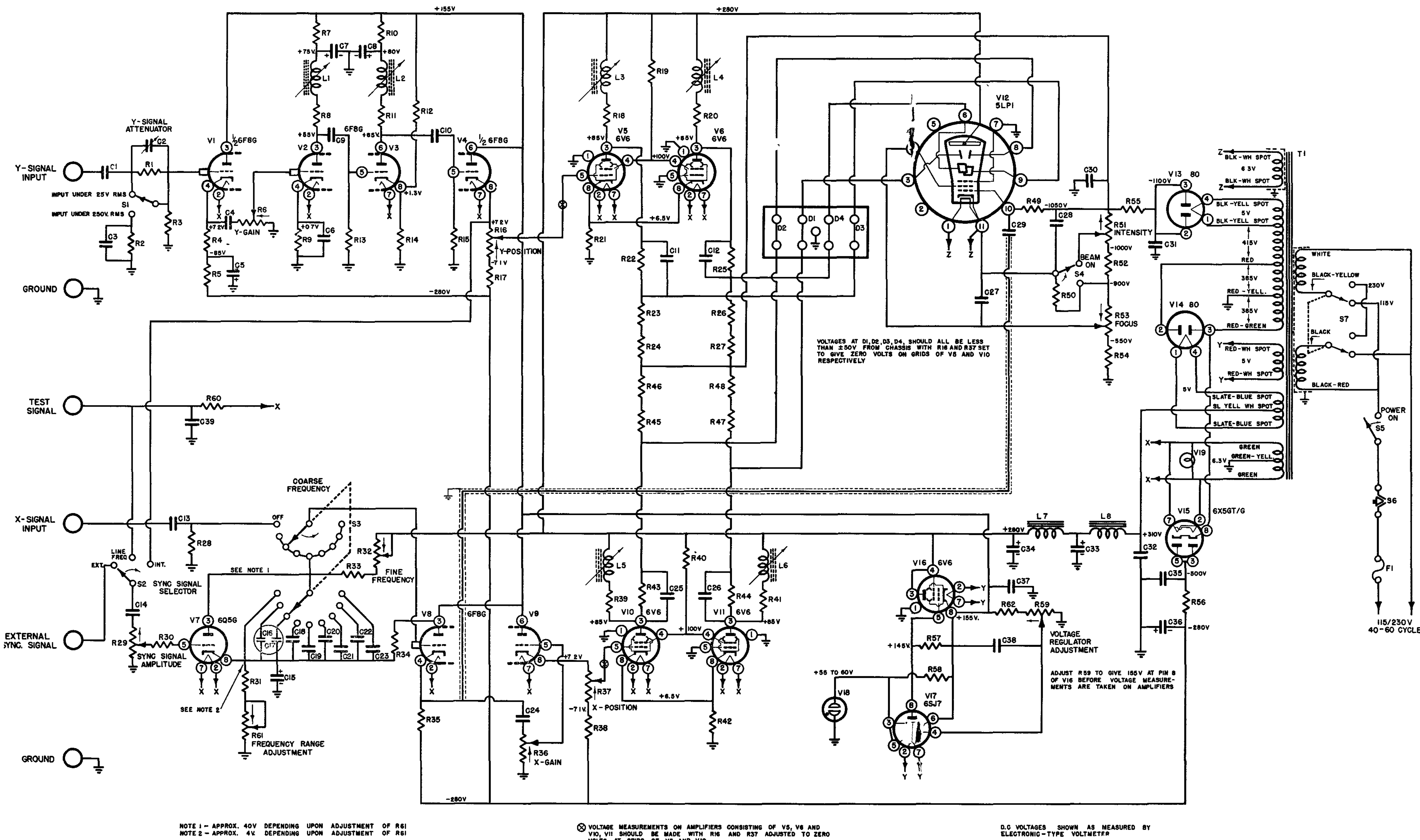


Fig. 6

Tolerances given ne... ...
Closer tolerance parts may be substituted.



SCHEMATIC OF CIRCUIT
TYPE 208
CATHODE-RAY OSCILLOGRAPH
DD-825-D-5

Pin connections of V1 and V4 should be interchanged

PARTS LIST

C1 0.5 μf. 600V.
C2 4-30 μμf. trimmer
C3 200 μμf. 500V.
C4 8 μf. 200V.
C5 24 μf. 350V. elec.
C6 7000 μμf. 500V.
C7 30 μf. 150V. elec.
C8 30 μf. 150V. elec.
C7 and C8 common neg.
C9 1 μf. 200V.
C10 1 μf. 200V.
C11 0.25 μf. 400V.
C12 0.25 μf. 400V.
C13 0.25 μf. 400V.
C14 0.1 μf. 1000V.
C15 25 μf. 50V. elec.
C16 1 μf. 400V.
C17 0.2 μf. 400V.
C16-C17 common can
C18 0.04 μf. 400V.
C19 0.01 μf. 400V.
C20 2500 μμf. 500V.
C21 600 μμf. 500V.
C22 125 μμf. 500V.
C23 70 μμf. 500V.
C24 8 μf. 200V.
C25 0.25 μf. 400V.
C26 0.25 μf. 400V.
C27 0.1 μf. 1000V.
C28 0.1 μf. 1000V.
C29 50 μμf. 1200V.
C30 0.5 μf. 1500V.
C31 0.5 μf. 1500V.
C32 1 μf. 1000V.
C33 16 μf. 450V. elec.
C34 40 μf. 450V. elec.
C35 1 μf. 1000V.
C36 16 μf. 450V.
C37 1 μf. 200V.
C38 1 μf. 200V.
C39 0.1 μf. 1000V.

F1 1.5 amps. fuse

L1 1-3.1 mh.
L2 1-3.1 mh.
L3 7-19 mh.
L4 7-19 mh.
L5 7-19 mh.
L6 7-19 mh.
L7 10.5 h. 310 ohms d.c.
L8 10.5 h. 310 ohms d.c.

R1 2 meg. ½W. ± 5%
R2 250K. ½W. ± 5%
R3 2 meg. ½W.
R4 100K 1W.
R5 250K 1W.
R6 100K pot.
R7 25K 1W.
R8 8K 1W.
R9 250 ohm ½W.
R10 25K 1W.
R11 8K 1W.
R12 50K 1W.
R13 1 meg. ½W.
R14 250 ohm ½W.
R15 1 meg. ½W.
R16 15K pot.
R17 300K 1W.
R18 25K 10W.
R19 150K 1W.
R20 25K 10W.
R21 400 ohm 1W.
R22 750K 1W.
R23 5 meg. 1W.
R24 5 meg. 1W.
R25 750K 1W.
R26 5 meg. 1W.
R27 5 meg. 1W.
R28 5 meg. ½W.
R29 100K pot.
R30 10K ½W.
R31 500 ohm ½W.
R32 4 meg. pot.
R33 500K 1W.
R34 40K 3W.
R35 250K 1W.
R36 500K pot.
R37 15K pot.
R38 300K 1W.
R39 25K 10W.
R40 150K 1W.
R41 25K 10W.
R42 400 ohm. 1W.
R43 750K 1W.
R44 750K 1W.
R45 5 meg. 1W.
R46 5 meg. 1W.
R47 5 meg. 1W.
R48 5 meg. 1W.
R49 100K ½W.
R50 1 meg. ½W.
R51 100K pot.
R52 200K 1W.
R53 500K pot.
R54 1 meg. 1W.
R55 50K 1W.
R56 50K 3W.
R57 500K 1W.
R58 100K 1W.
R59 500K pot.
R60 10K ½W.
R61 1K pot.
R62 500K 1W.

S1 S.P. D.T. toggle
S2 S.P. 3T. 60° rotary
S3 D.P. 9T. 30° rotary
S4 S.P. D.T. toggle
S5 S.P. S.T. toggle
S6 Safety Switch
S7 D.P. D.T. Slide Switch

T1 Power Transformer Part No. 20-92

V1-V4 Type 6F8G
V2-V3 Type 6F8G
V5 Type 6V6
V6 Type 6V6
V7 Type 6Q5G
V8-V9 Type 6F8G
V10 Type 6V6
V11 Type 6V6
V12 Type 5LP1 or 5LP5
V13 Type 80
V14 Type 80
V15 Type 6X5GT/G
V16 Type 6V6
V17 Type 6SJ7
V18 ¼W. Neon
V19 Pilot Light No. 44 6.3V. Bayonet Base

K = ohms × 1000 example 15K = 15000 ohms.

C 6 is .005 uF.

CATHODE-RAY TUBES

Types 5LP1, 5LP2, 5LP4, 5LP5

Formerly designated as Types 2511A5, 2511B5, 2511D5, 2511C5

CHARACTERISTICS

HEATER				
Voltage, a.c. or d.c.				6.3 volts
Current				0.6 ampere
DEFLECTION				Electrostatic
FOCUS				Electrostatic
SCREEN	5LP1	5LP2	5LP4	5LP5
Phosphor	P1	P2	P4	P5
Fluorescence	Green	Green	White	Blue
Persistence	Medium	Long	Medium	Short

MECHANICAL CHARACTERISTICS

Overall length	16 3/4″ ± 3/8″
Maximum diameter	5 5/16″ ± 1/16″
Bulb	C42 ½ YIC
Base	Medium magnal
Basing	RMA Basing Designation 11F

The basing is such that:

1. The direction of the trace produced on the screen by deflecting electrodes D_3 and D_4 will not deviate more than ±10° from a plane through pin No. 6 and the axis of the tube, while the angle between the direction of this trace and that of the trace produced on the screen by deflecting electrodes D_1 and D_2 will be 90° ±3°.
2. With deflecting electrode D_1 (pin No. 3) positive with respect to D_2 (pin No. 8) the spot will be deflected approximately toward pin No. 3, while with deflecting electrode D_4, (pin No. 6) positive with respect to D_3 (pin No. 9) the spot will be deflected approximately toward pin No. 6.

DIRECT INTERELECTRODE CAPACITANCES (NOMINAL)

Control electrode (grid) to all other electrodes	8.0 uuf
Deflecting Plate D_1 to Deflecting Plate D_2	2.6 uuf
Deflecting Plate D_3 to Deflecting Plate D_4	1.9 uuf
D_1 to all other electrodes	8.2 uuf
D_3 to all other electrodes	5.6 uuf
D_1 to all other electrodes except D_2	5.6 uuf
D_2 to all other electrodes except D_1	5.6 uuf
D_3 to all other electrodes except D_4	3.7 uuf
D_4 to all other electrodes except D_3	3.7 uuf

RATINGS

Heater voltage	6.3 volts
Heater current	0.6 amp. ± 10%
Anode No. 3. (Intensifier electrode) voltage (E_{b3})	4000 volts max.
Anode No. 2 (Accelerating electrode) voltage (E_{b2})	2000 volts max.
Anode No. 1 (Focusing electrode) voltage (E_{b3})	1000 volts max.
Grid (Control electrode) voltage (E_{c1})	Never positive
Peak voltage between Anode No. 2 and any deflecting electrode	500 volts max.
Grid (Control electrode) voltage (E_{c1})	1.5 megohms max
Impedance of any deflecting electrode circuit at heater supply frequency	1.0 megohms max

TYPICAL OPERATION

Heater voltage	6.3	6.3	6.3	volts
Anode No. 3 voltage (E_{b3})	2000	3000	4000	volts
Anode No. 2 voltage (E_{b2})	1000	1500	2000	volts
Anode No. 1 voltage (E_{b1}) for focus when E_{c1} is 75% of cut-off value	250	375	500	volts ± 20%
Grid voltage (E_{c1}) for beam cut-off	—30	—45	—60	volts ± 50%
Deflection Sensitivity:				
D_1D_2	0.49	0.33	0.25	mm/d.c. volt (av.)
D_3D_4	0.56	0.37	0.28	mm/d.c. volt (av.)
Deflection Factor:				
D_1D_2	52	77	103	d.c. volts/inch ± 20%
D_3D_4	45	68	90	d.c. volts/inch ± 20%

Deflection with Intensifier at Second Anode Potential:

	FACTOR	SENSITIVITY
D_1D_2	42 d.c. volts/kv. in. ± 20%	0.60 mm. kv./d.c. volt (av.)
D_3D_4	38 d.c. volts/kv. in. ± 20%	0.67 mm. kv./d.c. volt (av.)

SPOT POSITION

When the tube is operated at (1) normal heater voltage; (2) E_{b2} 2000 volts; (3) E_{b1}, adjusted for focus; (4) E_{c1} set at such a value as will avoid damage to the screen; (5) with each of the deflecting electrodes connected to Anode No. 2 through a one megohm resistor; and (6) with the tube shielded against external influences:

The spot will fall within a 30 mm. square, the center of which coincides with the geometric center of the tube face, and the sides of which are parallel to the traces produced by deflecting electrodes D_1 and D_2 and by deflecting electrodes D_3 and D_4 respectively.

Taking as zero reference voltage the potential of the plate of the gas triode shown in Figure 6 when it is in a conducting condition, the curve of Figure 5 shows the variation with time of the potential at the plate of the tube as the condenser C charges through the resistor R_1+R_2 and discharges through the tube itself. The potential E_1 at which breakdown (ionization) of the tube occurs in a given circuit is a function of the potential of its grid, and by applying a synchronizing signal to the grid it is possible to lock in the discharge-tube oscillator when its free-running period T_1 is slightly longer than its synchronized period Ts. Oscillations then occur at the slightly higher frequency, as indicated by the dotted line. By adjusting the grid bias potential so that breakdown occurs early on the condenser charging curve OA, as at potenial B_1, only the relatively straight portion OB of the exponential charging curve OA is utilized, and the resulting wave has an essentially linear increase.

Referring again to the solid curve of Figure 5, the time corresponding to the interval T_1-T_2 is known as the return-trace time. During this interval the beam returns to the position on the screen corresponding to T_0 and is ready to start its next excursion. Since on its return path the spot is moving rapidly it will produce only a light return trace which will not in general cause confusion of the pattern under observation, as the sweep frequency is increased, the return time T_1-T_2 in Figure 5 stays essentially constant while the interval from O to T_1 is decreased. As a result, T_1-T_2 become an increasingly large percentage of the sweep period O-T_2, and the speed of spot travel becomes more nearly equal on the forward and return traces. The resultant intensities of the two traces become more nearly equal. For this reason a pulse is applied to the modulating electrode of the cathode-ray tube during the return-trace time to eliminate that portion of the sweep from observation.

The repetition rate of the linear time-base can be decreased by increasing the time constant $C(R_1+R_2)$, Figure 6, and increased by decreasing that factor. In the Type 208 Cathode-ray Oscillograph the repetition rate can be varied from 2 to 50,000 cycles per second in eight steps.

2.160 Power Supply

The power supply of the Type 208 Cathode-ray Oscillograph consists of three separate rectifier and filter systems and an electronic voltage regulator all operating from a single power transformer. The primary of the power transformer may be operated on alternating current of from 40 to 60 cycles per second, and a built-in switch permits operation on either 115 or 230 volts.

A type 80 full-wave rectifier feeding a two-section inductance-capacitance filter supplies 300 volts for the deflection amplifiers and sweep oscillator and for the cathode-ray tube intensifier electrode. This same source feeds an amplified electronic voltage regulator which supplies 155 volts to the positioner- and low-level-amplifier-stages. Halfwave rectification in a Type 6X5GT tube supplies -300 volts through a resistance-capacitance filter for certain amplifier and positioning networks. The cathode-ray tube gun circuits are supplied with -1100 volts from a resistance-capacitance filter fed from a half-wave rectifier using a type 80 tube.

3.00 OPERATING INSTRUCTIONS

3.10 INSTALLATION

The Type 208 Cathode-ray Oscillograph is shipped with all tubes, including the cathode-ray tube, in place and ready for operation.

When it becomes necessary to remove the cathode-ray tube, the chassis should be removed from the cabinet after the two retaining screws at the rear have been removed. **Do not loosen any screws on the front panel.** When the chassis and front panel have been slid forward out of the cabinet, the tube may be removed from its socket, which is mounted on the rear chassis. To facilitate this operation, remove the two Type 6V6 tubes adjacent to the cathode-ray tube socket. The metal shield should be loosened by removing the single screw which clamps the shield supporting bracket to the rear chassis. The insulated connector cap should be removed from the intensifier terminal on the wall of the cathode-ray tube near the supporting ring collar of the front panel. A screw driver or similar device may then be used to pry the base of the tube from the socket, and after this is accomplished the tube may be removed with ease by lifting the socket end enough to clear the rear chassis.

Before the oscillograph is turned on for the first time, it is best to insure that all tubes are placed in their respective sockets and all cap connectors are secure and clear of shields. Also note that the intensifier cap is connected.

The line voltage selector switch should be checked to insure that the primary of the power transformer is connected for the proper line voltage (either 115 or 230 volts, 40 to 60 cycles).

The chassis may then be placed back in the cabinet and the retaining screws tightened to close the safety switch. The a.c. power cord should then be plugged in at the back of the cabinet and connected to a power source of proper voltage and frequency. Should the trace produced by the sweep circuit deviate from the horizontal, the chassis should again be removed from the cabinet and the cathode-ray tube rotated suitably. Whenever the chassis is removed from the cabinet, care should be taken to permit all high voltage condensers to discharge completely before any exposed wiring or connections are handled.

3.110 Vacuum-Tube Locations

All vacuum-tube locations are plainly marked on the chassis. The Type CD2005 ¼-watt neon bulb fits into a socket mounted on the main sub-assembly. The types and functions of the various tubes are given in the parts list.

3.120 Power Supply

The Type 208 Cathode-ray Oscillograph is adjusted for operation from 40 to 60 cycle power lines at either 115 volts or 230 volts as specified on the customer's order. Should it be desired to change the instrument for operation on 230 volts instead of on 115 volts, or vice-versa, it is necessary only to remove the chassis from the cabinet, invert it and, with the power cord removed, throw the switch alongside the power transformer in the direction of the desired operating voltage.

When external voltage- or frequency-changing or regulating devices are used in conjunction with the oscillograph or associated equipment, such devices should be located at least six feet from the oscillograph to avoid spurious magnetic deflection distortion as discussed in Section 3.310.

The high-voltage section of the power supply delivers approximately 1100 volts negative with respect to ground. The low-voltage section delivers 300 volts positive with respect to ground to the amplifiers and sweep oscillator. In addition, an electronic voltage regulator delivers 155 volts for the operation of all low-level stages. Its regulation and output voltage are determined by a factory adjustment of potentiometer R59, mounted directly behind the primary voltage selector switch, and its setting should not be changed except to compensate for variations in regulator tubes. A voltmeter should always be used when this adjustment is made to return the output voltage to 155 volts. A fourth supply provides 300 volts negative with respect to ground for certain amplifier and positioning circuits.

3.20 CONTROLS

All controls and terminals for the Type 208 Cathode-ray Oscillograph, with the exception of the cathode-ray tube deflection plate connections, are located on the front panel.

Related controls are grouped together and the groups have been outlined plainly. Furthermore, the groups have been marked appropriately as Beam Controls, Linear Time-base Controls, Y- axis Amplifier, and X-axis Amplifier. Controls for deflection along the Y- (or vertical) axis are on the left side of the instrument and controls for X- (or horizontal) axis deflection are on the right side.

3.210 Beam Controls

The group of beam controls is located toward the top of the front panel and includes, in addition to the main power switch, a beam switch for standby operation, controls for intensity and focus, and controls for the position of the cathode-ray tube spot.

3.211 Power Switch

The main power switch has been provided on the front panel to control the power supply to the instrument. When it is thrown to the "power on" position, the pilot light so indicates. This switch should always be thrown to the off position before the instrument is removed from its cabinet.

3.212 Intensity Control

The intensity control sets the modulating-electrode-to-cathode bias potential and thus determines the beam current. In general, it is desirable to keep the intensity setting as low as is consistent with convenience in use, in order to conserve tube life. In particular, a sharply focused spot or line should not be permitted to remain stationary on the screen at high intensity.

3.213 Focus Control

The focus control serves to set the potential of the focusing electrode of the cathode-ray tube gun. In general, there will be a setting for optimum focus at each intensity level.

3.214 Beam Switch

In many cases it is desirable to keep the cathode-ray oscillograph in standby condition, ready for operation without the delay of the usual warm-up period. Especially when patterns are to be photographed from the cathode-ray tube screen is it convenient to turn the beam off with the instrument otherwise operating and all controls adjusted for the desired conditions. This control operates to increase the modulating-electrode-to-cathode bias to beyond cutoff when the beam switch is in the "OFF" position.

3.215 Y-Position Control

The Y-position control permits adjustment of the position of the trace along the Y- or vertical-axis. In use its effect is to shift the calibrated scale supplied with the instrument to desired parts of the pattern being studied permitting easier study of assymetric signals. Certain compensations for external magnetostatic fields are also possible.

A new positioning circuit is used in the Type 208 Cathode-ray Oscillograph to provide a new standard of performance. The use of direct-coupled circuits makes positioning instantaneous, eliminating the time lag and slow drift to a new equilibrium which are inherent in other circuits having even relatively poor low frequency response. Another outstanding feature is the unusually wide range through which the beam may be moved. This wide range permits the study of the extremes of patterns expanded in the deflection amplifiers to greater than full-screen deflection. The effective positioning range in the Type 208 Cathode-ray Oscillograph is more than three times full screen width, or over fifteen inches.

The direction of shift is plainly marked "UP" or "DOWN" on the front panel.

3.216 X-Position Control

The X-position Control permits adjustment of the position of the spot or pattern along the X- or horizontal axis.

The characteristics and circuits of the X-position Control are identical with those of the Y-position Control discussed in Section 3.213, excepting that all such effects occur along the X-axis. The direction of shift is marked "LEFT" or "RIGHT."

3.220 Linear Time-Base Controls

The Linear Time-base Controls, labeled with that designation, are grouped in the center area of the front panel. They include coarse- and fine-frequency controls, synchronizing signal selector switch, synchronizing signal amplitude control, and an external synchronizing signal terminal. The five controls determine completely the operation of the gas discharge tube used as oscillator in the linear time-base circuit.

3.221 Coarse Frequency Control

The setting of the coarse frequency switch determines the range of sweep frequencies in which the fine frequency control (Section 3.222) operates. The repetition rate of the linear time-base is continuously variable from 2 to more than 50,000 per second. The ranges are marked on the front panel as a guide, but they are not to be considered an exact calibration. The limits of the range selected are given by the figures on either side of the knob pointer at any position, and they are as follows: 2, 8, 40, 150, 500, 2K, 8K, 25K, 50K. The figure K represents KILO or one thousand; thus, 50K represents 50,000.

The extreme counter-clockwise position, marked OFF, prevents the sweep circuit from oscillating, and it also automatically connects the input circuit of the X-axis amplifier to the X-axis Signal Input Terminal Post.

3.222 Fine Frequency Control

When the proper range of sweep frequencies has been selected by means of the Coarse Frequency switch (Section 3.221), the exact frequency required to stabilize the pattern on the screen can be chosen by means of the Fine Frequency Control. The sweep frequency so selected should be equal to or slightly less than that of the signal or a submultiple thereof; the amplitude of synchronizing signal (Sections 3.223, 3.224, and 3.225) required to make the pattern stationary will then be so small as not to disturb the linearity of the time base.

3.223 Synchronizing Signal Selector Switch

The source of the signal to which the linear time-base repetition is synchronized is determined by the setting of the Synchronizing Signal Selector Switch. The following sources are available: External Line Frequency, and Internal.

In the External position, the switch permits synchronizing the discharge tube to a signal connected between ground and the External Synchronizing Signal terminal post (Section 3.225) which, in general, will be different from that being amplified in the Y-axis Amplifier. A signal amplitude of 0.5 volt r.m.s. will in general be adequate for synchronization within the rated frequency range; pulses of short duration might require somewhat greater amplitudes. The input circuit resistance is 100,000 ohms, capacitively coupled.

When the switch is thrown to the Line Frequency position, the sweep oscillator can be synchronized to the frequency of the power line supplying the instrument. This position is often useful when employing the line frequency as a standard frequency source.

A signal having the same phase and waveform as that applied to the Y-axis Amplifier Signal Input terminal post can be used to synchronize the linear time-base when the selector switch is thrown to the position marked "INTERNAL." Since this source is available only when the signals are being amplified, the synchronizing signal should be connected to the EXTERNAL SYNCHRONIZING SIGNAL terminal post (Section 3.225) when direct deflection plate connections are used. Under such conditions it might be necessary to employ an auxiliary impedance-matching vacuum-tube circuit to prevent excessive signal sources by the synchronizing circuit. Such an impedance-transformer may be copied after the input circuits of this instrument.

3.224 Synchronizing Signal Amplitude Control

The frequency of oscillation of a gastriode relaxation oscillator of the type shown in Figure 6 is determined by both the time constant $C(R_1+R_2)$ and the ionization or breakdown potential of the triode. The breakdown potential, shown as E_1 on Figure 5, can be reduced by making the control grid less negative with respect to its cathode; and if an alternating grid potential has the proper amplitude, phase, and frequency it can be made to change the sweep oscillation frequency and keep it locked to this synchronizing signal. This corresponds to a reduction in charging time to the interval O-T_s and in breakdown potential to the value E_s. The amplitude of the signal producing this synchronizing effect is determined by the setting of the synchronizing signal amplitude control. The minimum (farthest counter-clockwise) setting of this control should be used at all times, since too large a synchronizing signal can distort the output wave-form- of the sweep oscillator and thereby introduce non-linearity. With the pattern brought nearly to stability by means of the Fine Frequency Control alone (Section 3.222), the Synchronizing Signal Amplitude Control should then be advanced from zero just enough to prevent drifting of the pattern.

3.225 External Synchronizing Signal Input Terminal

When a signal other than that from the power line or from the signal being amplified in the Y-axis Amplifier is to be used for sweep-circuit synchronization, it should be connected to the External Synchronizing Signal Terminal post. Under such conditions, the Synchronizing Signal Selector switch (Section 3.223) should be thrown to "EXTERNAL."

3.230 Y-Axis Amplifier

The Y-axis Amplifier controls consist of the Signal Input terminal post, input amplitude selector switch, and amplifier gain control. The input circuit to the amplifier presents a constant resistance of two megohms and a shunt capacitance of approximately 30 micro-microfarads in either position of the amplitude selector switch, to which it is capacitively connected. An impedance transformer stage couples the input to a low-impedance continuously-variable attenuator used as a gain control free of frequency discrimination. This control is followed by a two-stage resistance-capacitance-coupled amplifier which connects to the positioning circuit and the final direct-coupled balanced deflection amplifier stage. The overall gain of the amplifier is approximately 2000 times, uniform from below two to one-hundred-thousand sinusoidal cycles per second, within plus or minus fifteen per cent. The Deflection vs. Frequency characteristic of the Y-axis amplifier is given in the curve of Figure 3. The effective range of deflection is approximately three times full screen diameter. Excellent stability of pattern position results from the use of electronic voltage regulation of the plate power supply to the low-level stages. A position shift of less than 0.125 inch results from a line voltage surge of 5% of rated operating potential.

Because of the excellent low-frequency response of the amplifiers in the Type 208 Cathode-ray Oscillograph, the observer should always take cognizance of the fact that low-frequency components present in the signals being studied, or such components which may be introduced from switching, change the d.c. level of the signal, and they will be amplified and shown on the cathode-ray tube screen. If, therefore, the beam disappears on occasion and requires several seconds to return to the screen, its disappearance can usually be traced to the application of a large change in d.c. level on the input circuit to the amplifier due to signal unbalance, switching, or some similar cause. The speed of its return is determined by the time-constants of the coupling networks and, in general, will decrease with improved low-frequency response.

In certain cases it is desired to neglect the low-frequency components of a signal to study only those of higher frequency. For example, it might be required to measure the ripple voltage at the output of a power-supply filter with no regard to the relatively low-frequency components arising from line-voltage surges. To accomplish this, the signal should be coupled to the Signal Input Terminal through a 0.1 microfarad condenser of suitable voltage rating, and a 100,000 ohm resistor should be connected from that terminal to ground. The resultant short time-constant circuit will effectively eliminate the low-frequency surges.

When signal amplitudes of not more than 25 volts r.m.s. are applied to the Y-amplifier Signal Input post, the amplitude selector switch should be thrown to the position marked INPUT UNDER 25 VOLTS R.M.S. For signals of 25 volts r.m.s. or more, or for signals of unknown amplitude, the attenuator switch should be thrown to the position marked INPUT UNDER 250 VOLTS R.M.S., which is the value of the maximum permissible input signal.

3.231 Y-Axis Amplifier Signal Input Terminal Post

The signal used to provide deflection along the Y- or vertical axis, generally the unknown signal, should be connected between ground and the Signal Input terminal post. Signals up to 250 volts r.m.s. amplitude may be connected to these terminals directly; signals of greater amplitude should be applied through a suitable external attenuator. Before studying any signal it should be ascertained whether the transmission characteristics of the amplifier are suitable for distortionless amplification of that signal. When signals of zero frequency (direct-current) or of high radio-frequencies (above about one megacycle) are to be studied, they can be connected to the cathode-ray tube deflection plate terminal posts at the rear of the instrument (Section 3.252). An alternative connection for zero-frequency signals of suitable amplitude which preserves positioning capabilities is described in Section 3.262.

3.232 Y-Amplifier Input Attenuator

The Y-axis input circuit of the Type 208 Cathode-Ray Oscillograph provides two megohms resistance together with freedom from frequency distortion usually present at intermediate settings of the continuously variable attenuator when such high input resistances are used. As a result of this, it is necessary to limit the peak value of signal applied to the grid of the first stage to values which fall within its operating range. An attenuator is provided for this purpose, marked with the maximum signal voltages that it is permissible to apply directly to the Signal Input terminal. When no component of the signal has an amplitude greater that the peak amplitude corresponding to 25 volts r.m.s. the attenuator switch may be thrown to the position marked INPUT UNDER 25 VOLTS R.M.S. For inputs corresponding to a maximum of 250 volts r.m.s., or for signals of unknown amplitude, the switch should be thrown to the position marked INPUT UNDER 250 VOLTS R.M.S. Greater signal amplitudes require external attenuation.

3.233 Y-Axis Amplifier Gain Control

The Y-axis Amplifier Gain Control is a continuously variable low-impedance attenuator following the input coupling stage. As is the case with all attenuating systems of this type, it is desirable to keep its setting high and to keep the attenuation of the Y-AXIS AMPLIFIER INPUT ATTENUATOR (Section 3.232) high to prevent overload of the input grid circuit.

The setting of the Y-axis Amplifier Gain control determines the amplitude of deflection along the Y- or vertical axis.

3.240 X-Axis Amplifier

The X-Axis Amplifier Controls consist of the SIGNAL INPUT terminal post and amplifier GAIN control. An input resistance of five megohms shunted by approximately 25 micromicrofarads is capacitively coupled to the input terminal post. An impedance transforming vacuum-tube stage feeds into a low-impedance continuously variable attenuator used as Gain control. The positioning circuit follows, feeding the final direct-coupled balanced deflection amplifier stage. The overall gain of the amplifier is approximately 40 times, uniform from two to one-hundred-thousand, sinusoidal cycles per second within ± ten per cent. The deflection vs. frequency characteristics of the X-axis amplifier is given in the curve of Figure 3. The effective range of deflection is approximately three times full screen-diameter. Electronic regulation of the voltage supply to the low-level stages provides excellent frequency stability.

Just as in the case of the Y-axis amplifier, the excellent low-frequency response of the X-axis amplifier will increase the time of recovery from changes in d.c. level. In particular, there will be such a surge when switching from internal sweep to external signal, and the resultant recovery will be a normal characteristic.

The input circuit to the X-axis Amplifier is automatically connected to the output of the sweep oscillator tube (Sections 3.220-3.225) when the Coarse Frequency control (Section 3.221) is set at an operating position. When an external signal is to be amplified for deflection along the X-or Horizontal axis, it should be connected between Ground and the X-amplifier Signal Input post; the Coarse Frequency switch should then be thrown to the position marked "OFF," which operation automatically connects the input of the X-axis Amplifier to the Signal Input post.

3.241 X-Axis Amplifier Signal Input Terminal Post

An external signal to be amplified for deflection along the X- or Horizontal axis should be applied between Ground and the X-amplifier Signal Input Post. The maximum signal amplitude applied should not exceed that corresponding to a signal of 25 volts r.m.s. External attenuation should be provided for greater signal amplitudes.

3.242 X-Axis Amplifier Gain Control

The X-axis Amplifier Gain control is a continously-variable low-impedance attenuator following the impedance-transforming input stage It operates to determine the amplitude of deflection along the X- or Horizontal axis.

3.250 Miscellaneous Controls

3.251 A. C. Test Signal Terminal Post

A signal of power-line frequency having an amplitude of approximately 2.7 volts r.m.s. to ground, is provided as a convenient source of signal for test purposes. The internal resistance of the source is 10,000 ohms and its shunt capacitance is 0.1 microfarad.

3.252 Deflection Plate Terminal Posts

Provision has been made in the Type 208 Cathode-ray Oscillograph for the direct connection of the input signal to the deflection plates of the cathode-ray tube. A terminal board accessible at the rear of the cabinet carries nine terminal posts, the center post being ground and the others in vertical pairs being deflection plate terminals (upper) and amplifier output terminals (lower). The arrangement of and actual connections to this board are shown on the schematic circuit diagram.

For normal operation of the instrument, with signal input to the front panel terminal posts, each rear terminal board post is connected to the post directly below it.

Whenever direct connection of signal to deflection plates is desired, the proper set of jumpers should be removed. A balanced (pushpull) signal may then be applied to the two free deflection plate terminals, a common ground return having first been provided. When an unbalanced signal source is to be used, one deflection plate should be connected to ground. A deflection-plate-current d.c. return path of not more than five to ten megohms must always be provided between each deflection plate and ground.

When high-impedance signal sources are used, it is possible to utilize the positioning circuits provided in the instrument. For such a mode of operation, five megohm resistors should replace the jumpers normally used, and the signal should be applied to the deflection plates as described above. The ends of these resistors at which position voltage is applied should be by-passed adequately.

3.260 Special Operating Conditions

Certain specific types of measurements are more conveniently and readily achieved when connections are made to the cathode-ray oscillograph in a manner other than that described in sections 2.230 to 3.233. Two such connections are described below.

3.261 Wide-Band Direct Deflection

When frequencies or frequency components above approximately one-half megacycle or below two cycles per second are to be studied, it is usually desirable to connect the signal directly to the deflection plates. Procedure for making these connections is outlined in Section 3.252 above. It should be remembered that lead lengths should be reduced as much as possible, particularly as frequency is increased. This type of connection permits operation from zero-frequency (d.c.) to approximately one hundred megacycles.

3.262 Amplified Direct-Coupled Operation

Some types of measurement require amplification of zero-frequency (d.c.) signals or components. Such measurements are readily made with the Type 208 Cathode-ray Oscillograph. To adapt the instrument for d.c. amplification it is necessary merely to remove the grid cap of V_4 (See schematic diagram), which is the type 6F8G tube nearest the front panel and located directly behind the Y-axis Amplifier Signal Input post, and to connect to its top cap the signal circuit under investigation. The deflection sensitivity of the instrument with such a connection will be approximately 0.5 volt r.m.s. or 1.5 volts d.c. per inch deflection, and the maximum signal that may be applied in that manner is 7.5 volts r.m.s. or plus or minus 11 volts d.c. When this connection is used, an external amplitude control should be provided. When direct-coupled amplification is required along the X- or Horizontal axis, it may be achieved in a manner similar to that described above. It will be necessary, however, to unsolder the grid connection on the socket of V_9, the type 6F8G between the front panel and the type 6Q5G. The application of signal at either of these points, shown on the schematic diagram by circled crosses on the grid leads of V_1 and V_6, preserves intact the feature of front-panel position control in the instrument. This is not available under the mode of operation outlined in Section 3.261.

Somewhat better high-frequency response is obtainable, at the sacrifice of positioning capabilities, by breaking the circuit at the grid socket pin of either V_5 for Y-axis deflection or V_{10} for X-Axis deflection and connecting the signal there. The sensitivity remains at approximately 0.5 volt r.m.s. per inch, and it decreases to 50 per cent at one megacycle.

It is important, at no matter which grid the signal is applied, that the grid-to ground circuit be completed. A resistor of not more than one or two megohms resistance will in general be satisfactory.

3.30 PRECAUTIONS

WARNING: Do not operate this cathode-ray oscillograph with the cabinet removed. There are potential differences as high as 1400 volts in this instrument, and it should be treated with proper caution.

3.310 Magnetic Fields

The cathode-ray tube used in the Type 208 Cathode-ray Oscillograph has been provided with magnetic shielding, and the case of the instrument itself provides some protection against external magnetic fields. It is good practice, however, to keep the instrument as remote as possible from magnets, power transformers, reactors, or busses carrying either direct or alternating current. The fields produced by such currents cause depositioning or relative tilting of the deflection axes and other spurious deflections and can magnetize the cathode-ray tube electrodes or instrument cabinet. Should this occur they can be demagnetized by subjecting them to a strong alternating magnetic field which is gradually decreased in intensity.

3.320 Power Line Regulation

The amplifiers of the Type 208 Cathode-ray Oscillograph operate from a regulated voltage source and use balanced circuits. They will, in general, be free of disturbance from normal power line fluctuations. Where extremely large power line voltage fluctuations are encountered, however, or where extreme stability of spot position is required, it might be desirable to employ a regulated power supply. When regulation of the a.c. power line is utilized, precautions against spurious magnetic fields from the regulating device should be observed (Section 3.310).

3.33 Screen Burning

When a small spot or line of high intensity is allowed to remain stationary on the cathode-ray tube screen, 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 or discoloration. The use of the beam switch thus is indicated to turn the beam off when there is limited deflection.

4.00 MAINTENANCE

The components of the Type 208 Cathode-Ray Oscillograph have been selected and tested to provide long, trouble-free operating life, and the only service necessary should be the replacement of vacuum tubes; the locations of the vacuum tubes are plainly marked on the chassis.

4.10 REPAIRS

Should any trouble develop in this instrument, it may be serviced with the aid of the schematic diagram and its accompanying parts list. Major repairs, however, are usually handled by the factory.

Under no circumstances should the instrument or cathode-ray tube be returned to the factory without proper return authorization and shipping instructions. In any correspondence with the factory concerning repairs, the type and serial numbers of the instrument and cathode-ray tube must be given, together with a description of the trouble encountered.

The "DU MONT OSCILLOGRAPHER"

The "Du Mont Oscillographer," a bi-monthly publication, is published regularly by Allen B. Du Mont Laboratories. It is sent free of charge to engineers, research workers, and all those engaged in the application of cathode-ray equipment. When sending requests for subscriptions and address-change notice, please supply the following information: name, company name, company address, type of business, and title of individual.

PATENT NOTICE

Manufactured Under One or More of the Following U. S. Patents

1,844,117	2,098,231	2,190,020	2,229,556	1,960,333	2,153,800	RE. 21,326
2,245,409	1,999,407	2,157,749	2,201,309	2,245,428	2,000,014	2,162,009
2,207,048	2,249,942	2,014,106	2,163,256	2,208,254	2,249,943	2,067,382
2,164,176	2,209,507	2,269,115	2,082,327	2,185,705	2,221,398	2,269,129
2,085,576	2,186,634	2,225,099	2,280,700	2,087,280	2,186,635	2,227,822
2,280,738	2,290,592	2,297,742	2,297,752	2,299,471	2,299,510	2,315,848
2,319,691	2,321,149	2,328,259		Other Patents Pending		

ALLEN B. DU MONT LABORATORIES, INC.

Passaic, N. J., U. S. A.

COMPONENT PARTS LOCATION

TYPE 208

CATHODE-RAY OSCILLOGRAPH