

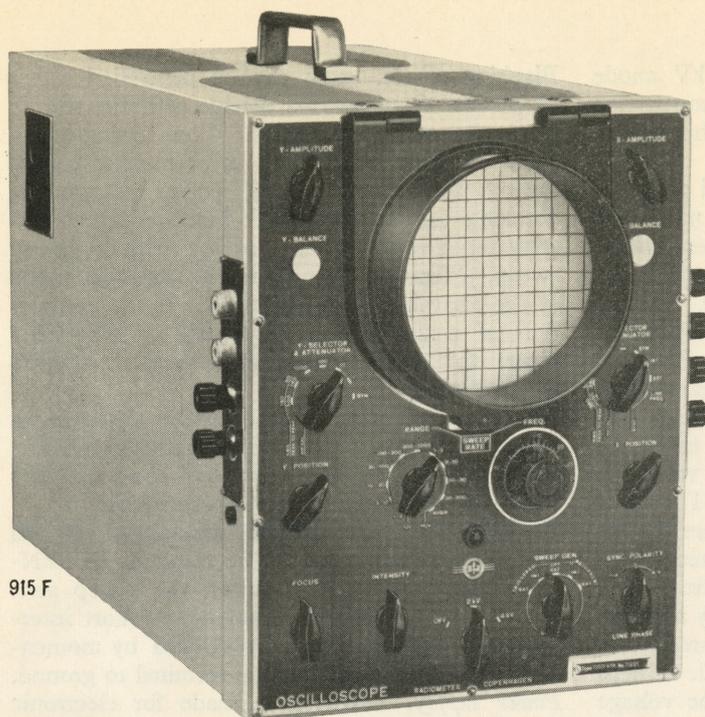
INSTRUCTION MANUAL

Type OSG41
CATHODE-RAY OSCILLOSCOPE



RADIOMETER

ELECTRONIC MEASURING INSTRUMENTS
FOR SCIENTIFIC AND INDUSTRIAL USE



Cathode-Ray Oscilloscope type OSG41

Introduction

The type OSG41 oscilloscope is an instrument which offers considerable advantages over earlier types. Both the vertical and the horizontal amplifiers are direct-coupled, so as to provide for constant amplification from d-c upwards. The sweep system is widely flexible thus providing for several combinations of recurrent sweep, triggered sweep, internal or external synchronization and automatic blanking.

There are numerous applications. Some random examples are video and carrier-frequency investigations, acoustical research, servo-mechanism studies, measurements of dynamic balance, vibrations, stress and strain, and neurophysiological studies.

In addition to the scientific possibilities of the oscilloscope the relatively large screen diameter, good light intensity, and sharp focusing make it most suitable for demonstrations to an audience.

Special features

Wide frequency range: d-c to 5 Mc/s.

Amplifier designed for minimum pulse distortion. High-impedance probe supplied as a standard accessory.

The input circuits of both amplifiers provide for measuring both balanced or single-ended input voltages.

Internal calibration voltages for vertical and horizontal amplifier.

Description

The main components of the oscilloscope are a cathode-ray tube, a vertical-deflection amplifier

(Y-amplifier), a horizontal-deflection amplifier (X-amplifier), a sweep generator, and power supplies.

The cathode-ray tube has a screen diameter of 130 mm (5"), and is provided with an extra intensifier electrode. The intensifier voltage can be set to 2000 or 4000 volts. The highest voltage is used when an especially high light intensity is required, e.g. at lecture demonstrations and photographic recordings, or when working with fast sweeps, triggered at a low repetition rate. The cathode-ray tube is completely enclosed in a Mu-metal magnetic screen.

The X and Y deflection plates are connected to jack switches. When a banana-pin is plugged into one of the jack switches, the corresponding amplifier is disconnected, while the X and Y position controls remain operative.

The vertical amplifier is a 3-stage direct coupled push-pull amplifier designed for minimum pulse distortion, and the frequency response is down 3 dB at 3-4 Mc, and 6 dB at 5-6 Mc. The vertical amplifier provides for a maximum deflection sensitivity of about 15 mV per cm at 2 kV anode voltage. At 4 kV the sensitivity is 15-20 % low. The Y-attenuator is R-C compensated and has a constant input impedance of 1 megohm shunted by 30 pF.

The probe furnished with the oscilloscope increases the input impedance to 10 M Ω shunted by 6 pF, introducing an attenuation of 1:20.

The horizontal amplifier is a 2-stage direct coupled push-pull amplifier, which is also designed for minimum pulse distortion. Its frequency response is down 3 dB at 0.8 Mc and 6 dB at 1.4 Mc. The maximum horizontal deflection sensi-

tivity is about 30 mV per cm at 2 kV anode voltage. The X-attenuator is R-C compensated and has an input impedance of 1 megohm shunted by 40 pF.

The controls for horizontal and vertical positioning function without delay and will move the trace approximately 3 times the screen width. The input circuits of both amplifiers provide for balanced or single-ended input voltage. Internal line frequency signals for easy voltage calibration of the amplifiers are provided. The calibration signals are given in rms and peak-to-peak values. The sweep generator is designed as a linear sawtooth generator which can be used for either recurrent or triggered sweep. The sweep voltage is amplified by the horizontal amplifier. The trace length can be magnified to about 3 times the effective screen diameter. The sweep frequency controls are calibrated directly in sweep frequency. Sweeps can be triggered equally well by negative and positive pulses or by making or breaking a contact between a terminal and ground. Sweeps can be synchronized internally with the voltage fed to the Y-amplifier or with the line frequency. The phase of the line frequency synchronization can be continually varied over a phase range of 180 degrees.

Blanking of the beam can be controlled either by means of an external voltage or automatically from the sweep generator. When using automatic blanking, the beam will be blanked except during the actual sweep period. Automatic blanking can be used with both recurrent and triggered sweep. When working with triggered sweep, a flip-flop generator will start the sweep at the arrival of a trigger pulse. At the completion of a sweep the beam will automatically return to the starting position to await another trigger signal.

The sweep generator is followed by a linearizing tube. This tube is coupled as cathode follower and it supplies a sweep voltage of about 10 volts which can be drawn from a separate jack.

The light intensity can be modulated by an external a-c voltage fed to the terminal INTENSITY MODULATION, when the sweep generator is set to external blanking. A short interruption of the trace can be produced by momentarily shorting the modulation terminal to ground.

Power supply. Provision is made for electronic regulation of critical voltages so as to obtain a high degree of stability with respect to zero level and sensitivity.

SPECIFICATIONS

Cathode-ray tube:

Diameter of screen: 130 mm (5 inches).
Plate voltage: 2 kV + 2 kV intensifier voltage.
Deflection sensitivity approx. 28 V per cm.

Vertical amplifier:

Maximum sensitivity: about 15 mV per cm.
Frequency range: d-c - 3 Mc (3 dB) - 5 Mc (6 dB).
Designed to provide optimum transient response.
Attenuation: 1:1, 1:10, 1:100, 1:1000 stepwise + 1:12 continuously.
Calibration: 2 voltages, line frequency.
Input: single ended (with attenuator) or double ended (continuous attenuation only).
Input impedance: $1 M\Omega \neq 30 pF$.
Probe: Voltage division 1:20, input impedance $10 M\Omega \neq 6 pF$.

Horizontal amplifier:

Maximum sensitivity: about 30 mV per cm,
Frequency range: d-c - 0.8 Mc (3 dB) - 1.4 Mc (6 dB).
Designed to provide optimum transient response.
Attenuation: 1:1, 1:10, 1:100 stepwise + 1:12 continuously.
Calibration: 2 voltages, line frequency.
Input: single ended (with attenuator) or double ended (continuous attenuation only).
Input impedance: $1 M\Omega \neq 40 pF$.

Sweep system:

Recurrent sweep: 1 c/s - 100 kc/s, calibrated dial, uncalibrated to 300 kc/s.
Triggered sweep: from single sweep to 100 kc/s repetition rate, max. speed 50 mm/ μ sec.
Max. trace expansion: 3 times screen diameter.

Synchronization:

- 1) Internal from signal being observed, either polarity.
- 2) External from signals of either polarity 0.1 volt or larger.
- 3) Power line frequency, adjustable phase.
- 4) By "making" or "breaking" an external connection.

Aut. blanking: effective on recurrent and triggered sweeps at sweep frequencies from 10 c/s to 100 kc/s.
Sweep voltage at output terminal: 10 volts peak to peak.

Light intensity modulation:

15 volts peak to peak for 100% light modulation.
Input impedance: $0.5 M\Omega \neq 60 pF$.

Power supply:

110, 127, 150, 200, 220, or 240 volts, 50-60 cycles.
Consumption: 175 watts.

Over-all dimensions:

H: 400 mm, W: 310 mm, D: 570 mm.

Weight:

29 kilos.

Vacuum tube complement:

- | | |
|------------|----------|
| 2 - EB91 | or 6AL5 |
| 4 - ECC81 | or 12AT7 |
| 7 - EF80 | or 6BX6 |
| 2 - EY51 | or 6X2 |
| 1 - GZ34 | or 5V4 |
| 1 - PL81 | or 21A6 |
| 4 - PL83 | or 15A6 |
| 1 - 85A2 | or 5651 |
| 1 - DG13-2 | or 5CP-A |

Data subject to change without notice.



Type OSG41
CATHODE-RAY OSCILLOSCOPE

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Type OSG41 CATHODE-RAY OSCILLOSCOPE

Introduction:

The type OSG41 Oscilloscope is an all-round precision laboratory instrument incorporating d-c coupled amplifiers for the Y (vertical) and X (horizontal) amplifiers.

The direct-coupled amplifiers in conjunction with sweep speeds as low as 10 cm/sec are very useful when slow phenomena are observed, as for instance studies of complex electrical waveforms containing a-c components superimposed on d-c components, biological studies, and the study of mechanical vibrations, dynamic balance, stress and strain, etc. On the other hand the wide frequency range of the vertical amplifier and the highest sweep speeds of up to 50 mm/ μ sec are of great importance when examining complex voltages containing at the same time very high and very low frequency components, as for instance television video signals.

The cathode-ray tube (CR tube) is provided with an intensifier electrode which ensures good light intensity even at very fast sweeps triggered at a relatively low repetition rate.

Section I

GENERAL DESCRIPTION

The Oscilloscope incorporates a cathode-ray tube with high voltage power supply, amplifiers for vertical and horizontal deflection, a sweep generator for producing time base voltages, a synchronization amplifier for the amplification and differentiation of synchronization signals and a power supply for the amplifiers and the sweep generator.

(1) Cathode-ray tube

Type DG13-2 tube with 130 mm (5") screen of medium persistence. The cathode and grid of the CR tube are at a mean potential of about -1800 volts. The first anode (focusing anode) is at a potential of about -1200 volts. The second anode and the de-

deflection plates are at a mean potential of +200 volts. The ~~third anode~~ or intensifier anode voltage can be set to +300 or to +2200 volts by means of a switch. The switch positions are marked "2 kV" (kilovolts) and "4 kV", as these values are the approximate cathode to intensifier-anode voltages. "4 kV" is chosen when the highest light intensity is required. All values of deflection sensitivity are referred to an intensifier voltage of 2 kV. At 4 kV the sensitivity values will be 15-20% lower.

The deflection plates are normally connected to the vertical and horizontal amplifiers. Banana-plug jacks mounted on the side panel provide for connection to the deflection plates through 0.01 μ F coupling condensers. When banana plugs are inserted in these jacks the amplifiers are disengaged while the positioning voltages are still fed to the deflection plates through 2 M Ω resistors.

The input capacitance at the plate input terminals is about 15 pF each. The sensitivity at the deflection-plate terminals is about 1 mm/volt rms.

In front of the tube is placed a hinged shading hood on which a calibrated graticule is mounted to aid in making quantitative measurements. The hood and graticule can readily be removed, and the hinges can be used to provide means for fixing cameras, etc. The CR tube is completely enclosed in a Mu-metal magnetic shield to protect the tube from the effects of magnetic fields.

- (2) The Y amplifier (vertical amplifier) is a 6 tube push-pull amplifier with direct coupling. The maximum overall gain is 1500-2000 times giving a maximum deflection sensitivity of 1.5-2 mm/mV rms. The gain can be continually reduced by about 22 db with a low-impedance AMPLITUDE control, which only slightly affects the frequency response of the amplifier.

Typical frequency response curves for the Y and X amplifiers are shown in figure 1 on page 3. The amplifiers are designed to give minimum pulse distortion, i.e. shortest rise time possible combined with a reasonably small amount of overshoot.

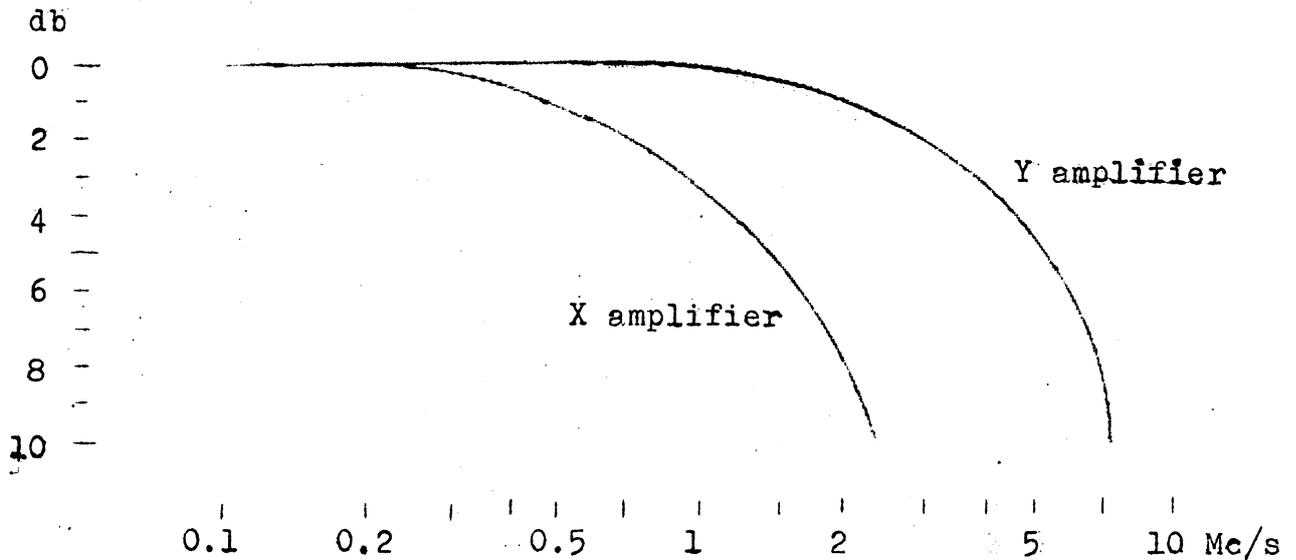


Figure 1 Typical frequency response curves

A Y-BALANCE potentiometer (see simplified diagram) is used for adjusting the cathode resistors of the input stage. When this potentiometer is properly set the Y-AMPLITUDE control can be varied without affecting the d-c balance of the Y amplifier. The BALANCE may be adjusted occasionally to compensate for variations in line voltage and for changes in tube characteristics and components, resulting from aging, changes in temperature, etc.

Vertical positioning of the fluorescent trace is accomplished by varying the Y-POSITION potentiometer which varies the d-c level of the plates of the input tubes. A factory adjusted potentiometer (P1) is so set that the trace is at the center of the CR-tube screen when the Y-POSITION potentiometer is at the center of its traverse. The positioning circuit has sufficient range that any portion of a vertical deflection of three times the screen diameter may be centered on the screen.

A Y-SELECTOR & ATTENUATOR switch is placed between the input terminals and the amplifier. This 7-position switch provides for the selection of:

Position	Y Amplifier connected to
1	Calibrating voltage 50 mV rms, 180 mV peak to peak
2	Calibrating voltage 180 mV rms, 500 mV peak to peak
3	Unbalanced input, attenuation 1:1000 (60 db)
4	Unbalanced input, attenuation 1:100 (40 db)
5	Unbalanced input, attenuation 1:10 (20 db)
6	Unbalanced input 1:1, no attenuation
7	Balanced input, no attenuation

The input impedance at the "Y₁" terminal is 1 MΩ shunted by 30 pF. The impedance at the "Y₂" terminal is 1 MΩ shunted by 20 pF. As the calibrating voltages depend on the power line voltage, these voltages will only be correct when the line voltage is nominal.

A VOLTAGE DIVIDER PROBE can be connected to the "Y₁" terminal. The attenuation of the probe and cable is 1:20 or 26 db. Input impedance of the probe is 10 MΩ \neq 5-6 pF. The voltage dividers of the Y-Attenuator and the voltage divider probe are capacitively compensated so that their frequency response is flat within 1 db through the entire frequency range of the Y Amplifier. The probe may be connected to the "Y₁" terminal when only a-c voltages are to be observed.

- (3) The X amplifier (horizontal amplifier) is a 4-tube direct coupled push-pull amplifier. The maximum overall gain is about 700 giving a maximum deflection sensitivity of 0.7 mm/mV rms. A typical frequency response curve for the X Amplifier is shown in fig. 1. The principle of the X-AMPLITUDE (gain control), the X-BALANCE, and the X-POSITION are identical with those of the Y Amplifier.

The X-SELECTOR & ATTENUATOR switch has 9 positions with the following functions:

Position	X Amplifier connected to
1	Calibrating voltage 100 mV rms, 280 mV peak to peak
2	Calibrating voltage 360 mV rms, 1000 mV peak to peak
3	Unbalanced input, terminal X_1 , attenuation 1:100 (40db)
4	Unbalanced input, terminal X_1 , attenuation 1:10 (20db)
5	Unbalanced input, terminal X_1 , no attenuation
6	Balanced input, terminals X_1 & X_2 , no attenuation
7	X amplifier to sweep generator. Sync. voltage from Y deflection plate (INT. Sync.)
8	X amplifier to sweep generator. Sync voltage from X_1 terminal (EXT. SYNC.)
9	X amplifier to sweep generator. Sync. voltage from LINE voltage via phase control

The input impedance at the X_1 terminal is 1 MΩ shunted by 30-40 pF. Input impedance at the X_2 terminal is 1 MΩ shunted by 20 pF. When the X-SELECTOR switch is in pos. 7, 8, or 9 the sweep generator is functioning according to the position of the SWEEP GEN. switch. As the X amplifier is working as a sweep voltage amplifier, sweep width and horizontal positioning is adjusted with the X-AMPLITUDE and X-POSITION controls respectively. The positioning circuit has the same range as that of the Y amplifier, i.e. three times the screen diameter of the CR tube.

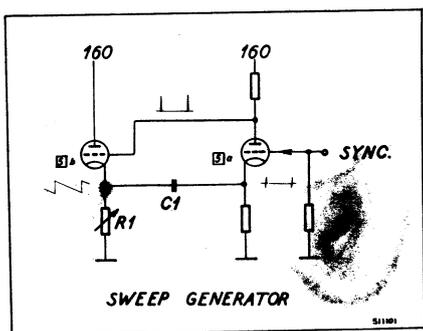
The output voltage of the Y and X amplifiers is sufficient to produce an undistorted deflection of 80-100 mm, and there is only little distortion present in a full-screen picture at 2 kV intensifier voltage. When the picture (trace) is expanded beyond the screen limits, the distortion of the on-screen part of the picture is usually negligible, but appreciable distortion may be introduced if the off-screen part of the picture contains high-frequency transients.

(4) Sweep Generator, etc.

The function of the sweep generator circuit is to furnish saw-tooth voltages either recurrent (periodical) or triggered (driven). The saw-tooth voltage is fed through the X Amplifier to the horizontal deflection plates when the X-SELECTOR is in positions 7, 8, or 9.

(4a) Recurrent Sweep

The sweep generator is a two-tube, cathode-coupled multivibrator circuit as shown in the diagram below. The condenser C1



is discharged through resistor R1 until tube 5b starts conducting. A positive signal is then passed to the cathode of tube 5a, and the anode current of this tube is reduced, which results in the grid of tube 5b becoming more positive, thus increasing the anode current of this tube still further

and charging condenser C1. As the overall gain of the circuit exceeds unity the effect is cumulative and the cathode voltage of tube 5b rapidly reaches a maximum while the anode current of tube 5a returns to its original value. This circuit condition then remains until the charge of the condenser C1 has leaked away through R1 sufficiently to start the flow of anode current again in tube 5b.

The charging of the condenser C1, which corresponds to the fly-back of the light spot on the CR tube may be started a fraction of a cycle earlier by a small negative signal applied to the grid of tube 5a. The grid of this tube is therefore employed as a synchronizing electrode when the sweep generator is employed as a recurrent-sweep generator.

The discharge of condenser C1 through resistor R1 will only give a linear sweep voltage across C1 if the voltage across resistor R1 is constant. To ensure this a cathode-coupled linearizer tube 6a is incorporated. This tube has a grid to cathode gain of approximately 0.97 or very close to unity. It is coup-

led to the sweep generator circuit in such a way that it tends to keep a constant voltage across resistor R1. The linearization improvement obtained is about 30 times. The other half of the tube 6 is coupled as a clamping diode which holds the upper limit of the saw-tooth voltage at a constant level. The cathode of tube 6 a is coupled to the X amplifier input through an attenuating and balancing network and to the terminal "OUT" through a condenser. The "OUT" terminal provides a saw-tooth voltage of about 10 volts peak to peak for external use.

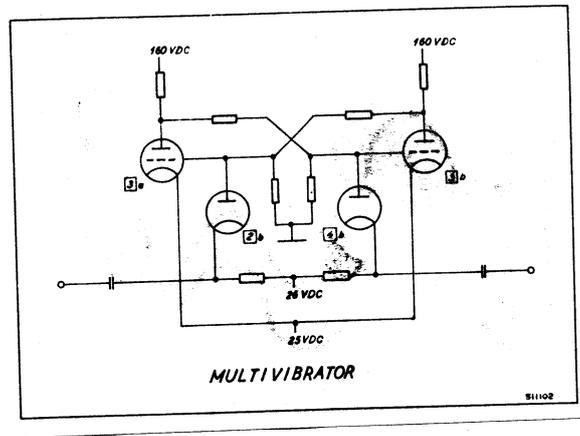
(4b) Blanking at recurrent sweep

The charging current of the condenser C1 will develop a positive pulse across resistor R2. This pulse is fed to the grid of tube 3a and develops an amplified negative pulse at the anode of tube 3a. When the sweep generator switch is in the position marked RECURRENT SWEEP, INT. BLANKING the negative pulse is fed from the anode of tube 3a to the grid of the CR tube and the light is suppressed during the fly-back period. With normal light intensity the blanking is effective for sweep frequencies between 10 c/s and 100 kc/s. The time constant of the coupling condenser and grid resistor of the CR tube is too small to give effective blanking at the lowest sweep frequencies, while the wiring capacity and electrode capacities make blanking ineffective at the highest sweep frequencies.

(4c) Triggered Sweep

When used as a triggered time base generator the sweep generator must be brought to reside in a stable condition where the condenser C1 is charged so that it is ready for a sweep without delay. The stopping or locking in this condition is accomplished by means of a two-tube circuit (tubes 3a and b) which is coupled to the sweep generator in such a way that it acts as a flip-flop multivibrator with the stable régime coinciding with the charged condition of the condenser C1.

The two-tube multivibrator (tubes 3a and b - see diagram on next page) is direct coupled and the different electrode potentials are so selected that one tube is practically cut off while the other tube is conducting. The multivibrator is symmetrical



and principally it has two stable conditions. Through the triggering diodes [2]b or [4]b a negative signal can be fed to the grid of the conducting triode. This will start a cumulative action of short duration which brings the circuit to flip over to the other stable condition.

In the actual circuit the multivibrator tubes [3]a & b have been coupled to the sweep generator [5]a & b via the triggering diode [4]b. A resistance inserted in the anode of tube [5]b develops a negative pulse when the condenser C1 is being charged during the ordinary sweep cycle. This negative pulse is fed to the diode [4]b and triggers the multivibrator [3]a & b to the condition in which tube [3]b is almost cut off. The anode potential of tube [3]b then increases to a higher value which is adjusted so that it will just keep the condenser C1 charged via the diode [4]a. When the condenser C1 is kept in the charged state the sweep generator is locked in a stable condition, and it will remain there until the anode potential of tube [3]b is lowered.

If a negative signal is applied to the cathode of the triggering diode [2]b it will release one sweep cycle in the following way:

- 1) The multivibrator circuit [3]a & b is initiated to flip over to the condition where [3]a is cut off and tube [3]b is conducting. This lowers the anode voltage of tube [3]b and the discharge of condenser C1 will start through resistor R1.

- 2) The rate of discharge is determined by the capacitance of C1, the resistance of R1, and the voltage across R1. The discharge will continue until the potential of the cathode of tube [5] b has decreased to such a value that tube [5] b starts conducting.
- 3) Regeneration via tube [5] a rapidly increases the anode current of tube [5] b, and condenser C1 is charged. The sudden rise in anode current of tube [5] b develops a negative pulse at the anode of tube [5] b. This negative pulse makes the multivibrator [3] a & b flip over to the condition where tube [3] b is cut off. In this condition the anode potential of tube [3] b is again increased and it will keep the condenser C1 in its charged state until another trigger signal is fed to the cathode of diode [2] b.

(4d) Blanking at triggered sweep

It will be seen that tube [3] a is cut off during the discharge period of C1. In this period the anode potential of the tube is increased and a positive rectangular pulse is passed to the grid of the CR tube, and the light intensity is increased to a higher value during the trace period. If the sweep time is more than about 30 milliseconds, corresponding to a recurrent sweep frequency of 30 c/s, the light intensity may not be constant during the sweep but will decrease somewhat. This is due to the insufficient time constant of the coupling condenser and grid resistor at the grid of the CR tube. When using such low sweep speeds, constant light intensity may of course be obtained by setting the SWEEP GEN. switch to position EXT. BLANKING.

(4e) Synchronization

The sweep generator may be synchronized either by the signal applied to the Y Amplifier (INT. SYNC.) by an EXT. SYNC. signal applied to the X₁ terminal or by an internally supplied voltage of power LINE FREQ. and adjustable PHASE.

The sync voltage is fed from the X-SELECTOR switch to the grid of the first sync amplifier tube [1] a. When LINE FREQ. synchronization is selected this tube acts as an ordinary voltage

amplifier. When INT. or EXT. SYNC. is selected, tube [1]a is employed as a phase splitter, so that signals of the same polarity as that of the input signal may be derived from its cathode load, while amplified signals of the opposite polarity may be taken from its plate load. Tube [1]b is another sync. amplifier with a center-tapped gain control which permits selection of either POLARITY of the sync signal.

The POLARITY control is ganged with the LINE PHASE control, which will vary the phase of the line frequency sync voltage over a phase range of 180 degrees.

As the gain of tube [1]a is less than unity for signals drawn from the cathode load and about 20 for signals drawn from the anode load, the maximum sync amplifier gain will be obtained when the polarity control is in its extreme counter-clockwise position ("minus" polarity).

When the polarity control is in its "plus" position the total gain will be somewhat smaller, but the frequency range of the sync amplifier will be considerably extended.

From the anode of the last sync amplifier stage the sync signal is fed through a limiting diode [2]a and a differentiating network $C_3 - R_3$. The sync signal is now (in the form of sharp pulses) applied to the grid of tube [5]a (when recurrent sweep is employed), or to the triggering diode of tube [3]a.

(5) Intensity Modulation

When the SWEEP GEN. switch is in one of the positions marked EXT. BLANKING, the light intensity may be modulated by an external a-c voltage fed to the terminal INTENSITY MODULATION. About 15 volts peak to peak is necessary to fully modulate the light intensity. The input impedance at the MODULATION terminal is about 0.1 M Ω shunted by 60 pF.

A d-c voltage of about 130 volts is present at the MODULATION terminal when the SWEEP GEN. switch is set to EXT. BLANKING. This voltage has a source resistance of several megohms, and it can be utilized to produce a black mark in the trace, if the modulation terminal is shorted to ground during a short

time interval. In some mechanical applications of the Oscilloscope such momentary shorting to ground is readily accomplished by some moving part of the machinery under test.

(6) Power Supply

The necessary supply voltages are obtained from a 50-60 cycle power line. A voltage selector can be set to the following power line voltages: 110, 127, 150, 200, 220, or 240 volts, a-c.

A conventional full-wave rectifier circuit supplies "320" volts d-c to the output stages of the Y and X amplifier. From this rectifier is also furnished an electronically regulated supply of 160 volts for the sweep generator circuit and the input stages of the amplifiers. A voltage divider is connected across the 160 volt supply, and a tapping of this divider is connected to ground so that the common supply minus is 30 volts negative with respect to ground.

The supply voltages for the CR tube are obtained from a separate high voltage supply. The transformers are completely sealed in compound and mounted with the associate rectifiers as a single unit. Half wave rectification is employed and one rectifier furnishes -2000 volts for the cathode of the CR tube while the other rectifier tube will deliver +2000 volts to the intensifier anode. The primaries of the high voltage transformers are designed for 200 volts a-c. This voltage is obtained from the main (low voltage) transformer that acts as an autotransformer.

Section II

OPERATING INSTRUCTIONS

(1) Connection. Control of INTENSITY and FOCUS

Before connecting to the power line make sure that the line voltage selector is set to the correct voltage. The voltage selector is accessible when the cover plate at the rear end of the Oscilloscope is removed. Before the instrument leaves the factory the voltage selector is always set to 220 volts.

The instrument is switched on with the combined switch and high-voltage selector at the lower middle of the front plate. For ordinary purposes the selector is set to "2 kV" (kilovolts) while it is set to "4 kV" when extra high light intensity is required. The light intensity is adjusted to a suitable value with the INTENSITY control, and adjustment to sharp focus (i.e. small light spot diameter) is made by the FOCUS control.

The light intensity should not be increased more than necessary, as too high light intensity will result in poor focusing and it may also influence the deflection sensitivity considerably.

The light spot can be moved to any place on the screen and about one screen diameter "off-screen" with the Y-POSITION and X-POSITION controls. However, the light spot should only remain stationary on the screen for a short while to avoid damaging the screen. Therefore an a-c voltage should always be present at one of the deflection plate pairs, e.g. the sweep voltage.

(2) Vertical Deflection (Y deflection)

After a warm-up period the amplifier should be balanced so that the setting of the Y-AMPLITUDE control has no influence on the position of the trace.

The plug button is removed to make the Y-BALANCE screwdriver adjustment accessible.

Set the X-SELECTOR to calibrating voltage of e.g. "100 mV RMS" and the Y-SELECTOR to maximum attenuation in position "1000". Set the Y-AMPLITUDE to maximum gain (completely clockwise) and adjust the Y-POSITION so that the horizontal line hits the

center of the screen. Now set the Y-AMPLITUDE to minimum gain (counter-clockwise), and the trace will probably move up or down. With the Y-BALANCE control the trace is returned to the center of the screen, and now an adjustment of the Y-AMPLITUDE should not affect the trace position.

If there is still a slight influence left, the balancing procedure may be repeated until a variation of the AMPLITUDE control does not affect the trace position on the screen.

Resetting of the BALANCE adjustment should only be necessary when conditions have changed considerably, e.g. when the Oscilloscope has been switched on for a long time so that the temperature of the amplifiers has increased, when there has been a major change in line voltage, or when the tube characteristics have changed due to aging, etc.

Input voltage, single-ended (asymmetrical) with respect to ground, is connected to the ground terminal and the Y_1 terminal. If superimposed d-c voltages must be eliminated, the Y_1' terminal should be used. The peak value of the input voltage should not exceed 500 volts. The Y-ATTENUATOR is set to one of the positions "1000", "100", "10", or "1" where a suitable height of image can be obtained when the Y-AMPLITUDE is used for fine adjustment. In position "1000" the attenuation is 1:1000 or 60 db. In position "100" ~~the attenuation is 1:100~~ or 40 db, and so on. A positive voltage fed to the Y_1 terminal will move the spot in upward direction.

Double-ended (symmetrical) input voltage is connected to terminals Y_1 and Y_2 , and the Y-SELECTOR is set to position SYM. (symmetrical). In this position the differential feature of the push-pull amplifier greatly minimizes the effect of in-phase components, but the ground terminal should be connected to a potential deviating less than 2 volts from the mean value of the input signals, as otherwise the amplifier may be overloaded. At maximum gain the discrimination against in-phase components is about 100 times, so that an in-phase signal of one volt will only produce the same deflection as a signal of 10 mV applied between the input terminals Y_1 and Y_2 . The symmetrical input also provides a means of mixing two signals without interaction.

The built-in attenuator is out of action when symmetrical input is employed. However, the voltage divider probe (see page 4) may be used at the Y_1 and Y_1' input terminal.

Symmetrical input voltages may also be connected to the deflection-plate terminals on the side panel. Banana-plug connectors are then inserted in the terminals, and connection is automatically established to the deflection plates through 0.01 μ F capacitors. As the Y-amplifier is still connected to the deflection plates through a 2 M Ω resistor, the Y-SELECTOR should be set to the "1000" position to avoid disturbance from signals picked up by the Y-input terminals. The deflection-plate input is preferably used when frequency components beyond the range of the Y amplifier are to be observed, e.g. when amplitude modulation of radio frequency signals higher than 5 Mc/s is examined.

The VOLTAGE DIVIDER probe should be employed when signals are to be observed in circuits with high impedance when only very slight loading can be tolerated. The voltage division factor of the probe is 20, which should be considered when quantitative measurements are made. The peak value of voltages fed to the probe should not exceed 300 volts.

Calibration of the Y-deflection sensitivity can be made by setting the Y-SELECTOR to one of the CAL. positions. The value of the calibrating voltage applied internally to the Y amplifier in the CAL. position is stated in mV (millivolts) RMS and mV PEAK TO PEAK. By means of the Y-AMPLITUDE control and the 140 mV peak to peak calibrating voltage the deflection sensitivity may be so set that the calibration voltage will give a total deflection of e.g. 14 divisions on the graticule of the CR-tube screen. The deflection sensitivity is then 10 mV peak to peak per division when the attenuator is in position "1", 100 mV per division with the attenuator in position "10", and so on.

When the line voltage is nominal, the accuracy of the calibration voltages is about 2%. If the light INTENSITY control is set to another position it may be necessary to repeat the voltage calibration procedure, as the intensity control has some influence on the deflection sensitivity.

(3) Horizontal Deflection (X-deflection)

Balancing of the X amplifier should be made with the X-SELECTOR in position "100" and the Y-SELECTOR set to a calibrating voltage, e.g. "50 mV RMS". The X-BALANCE adjustment is set to such a position that the X-AMPLITUDE control does not affect the trace position, the procedure being equivalent to that of the Y-balancing.

The X-INPUT terminals, the X-ATTENUATOR, the X-AMPLITUDE, and the X-POSITION controls are used in the same manner as the corresponding terminals and controls for vertical deflection. The peak value of the voltage fed to the X_1 and X_1' terminals should not exceed 500 volts. Not more than 10 volts peak should be fed to terminal X_2 .

(4) Using the sweep generator

When the sweep generator is used to produce a horizontal time base, the X-SELECTOR should be set to one of the three SYNC. positions INT., EXT., or LINE FREQ. In all other positions of the X-SELECTOR the sweep generator is cut off. The sweep length and sweep position is set by the X-AMPLITUDE and X-POSITION controls.

(4a) When recurrent (periodical) sweeps are required, set the SWEEP GEN. switch to one of the RECURRENT positions. Usually the INT. BLANKING position is employed. In this position the light is suppressed during the fly-back (right to left movement of light spot). The sweep speed is set by the SWEEP RATE controls, the RANGE switch being used for coarse setting and the FREQ. control being used for fine setting.

The approximate sweep frequency can be read from the SWEEP RATE controls. A suitable stationary pattern is obtained when the sweep frequency is $1/2$ or $1/3$ of the frequency of the voltage being observed (the voltage fed to the Y-terminals). Synchronization with this voltage can be obtained by setting the X-SELECTOR to the INT. SYNC. position and adjusting the SYNC. POLARITY control and the sweep FREQ. control until locking occurs. The SYNC. POLARITY control will give minimum synchronizing effect when it is set to the middle position. Increas-

ing synchronization is obtained by turning it either to the "-" (minus) or "+" side. The two directions will feed sync voltages of opposite phase (180° phase shift) to the sweep generator. The maximum sync amplifier gain is obtained when the "-" side is employed while the best frequency response of the sync amplifier is obtained on the "+" side. The best setting of the SYNC. POLARITY control is found by experiments, but too much synchronization may distort the sweep voltage.

Synchronization of the sweep generator with an external voltage is accomplished by setting the X-SELECTOR to the EXT. SYNC. position and applying the external sync voltage to the X_1 or X_1' terminal. The voltage should not exceed 100 volts. The use of SYNC. POLARITY control is like that of internal sync.

Synchronization with the power line frequency may be obtained by setting the X-SELECTOR to the LINE FREQ. position. In this position the SYNC. POLARITY control is used as a LINE PHASE control by means of which the phase of the sync. voltage can be varied continually over a range of 180 degrees.

When the RANGE switch of the sweep generator is set to position HIGH, sweep frequencies up to 300 kc may be generated at a somewhat reduced sweep length. In the HIGH range the sweep oscillations may stop when the FREQ. control is set to a low frequency, but oscillations should start when synchronizing voltage is applied.

- (4b) When triggered sweeps are required the SWEEP GEN. switch should be set to one of the TRIGGERED positions. With this type of sweep, the normal rest position of the CR-tube beam is at the left side of the screen until it is released by a trigger signal. It then moves across the screen at a speed determined by the setting of the SWEEP RATE controls. At the end of the sweep the beam is rapidly returned to its rest position to await another trigger signal.

When the SWEEP GEN. switch is set to the INT. BLANKING position the beam intensity is increased during the actual sweep and the light INTENSITY control should be set to such a position that the beam is cut off during the remaining time.

Trigger signals can be obtained internally from the waveshape under observation, from an external voltage applied to the X_1 or X_1' terminal, and from the power line frequency as selected in the different SYNC. positions of the X-SELECTOR. The trigger signal should be of such a shape and amplitude that the duration of the amplified and differentiated trigger signal is shorter than the sweep time selected by the SWEEP RATE controls. If this is not fulfilled, more than one sweep may be released by a single trigger pulse. With suitable trigger signals single sweeps may be released at a repetition rate of more than 100,000 sweeps per second.

Single sweeps may also be released by a mechanical switch connected between the X_1 terminal and ground. The X-SELECTOR is set to EXT. SYNC. If the SYNC. POLARITY control is turned slightly to the "minus" side, a sweep will be released when the mechanical switch is opened. If the SYNC. POLARITY control is turned to the "plus" side a sweep will be released when the mechanical switch is closed. The voltage at the X_1 terminal is about 30 volts negative to ground. The switch current is less than one milliamp.

(5) Light Intensity Modulation

Set the SWEEP GEN. switch to one of the positions labelled EXT. BLANKING. Modulating voltage is fed to the terminal INTENSITY MODULATION. The best results are obtained when the modulation voltage has "flat topped" positive peaks, so that the light intensity remains constant during the "on" period. When intensity modulation is employed, care should be taken not to drive the grid of the CR tube positive with respect to cathode, as this may damage the tube.

The input impedance at the INTENSITY MODULATION terminals is about 0.1 Mo.

Momentary connection of the MODULATION terminal to GROUND may be used to produce a blanking period of short duration. The voltage at the MODULATION terminal is about 130 volts positive. The d-c source resistance is several megohms.

(6) Output Voltage

The sweep generator waveshape having a peak to peak amplitude of about 10 volts is available at the terminal labelled "N\OUT". Loading of this terminal with an impedance of less than 10 k Ω may distort the sweep voltage.

Section III

M A I N T E N A N C E

The Oscilloscope can be removed from the cabinet when the two fastening screws in the handle have been removed.

(1) Tube Replacement

All tubes except Nos. 3, 5, 7, 8, 13, and 14 can be replaced right away. When the input stage tubes of the Y or X amplifier (Nos. 7, 8, 13 or 14) are replaced it is usually necessary to reset the "position coarse" potentiometers P_1 and P_3 respectively. These potentiometers should be so set that the light spot is at the center of the CR-tube screen when the POSITION controls are in the middle position, the Y or X SELECTOR is set to position "100" or "1000" and the AMPLITUDE control is set to maximum gain. If the range of P_1 and P_3 is not sufficient to bring the spot close to the screen center, the tubes in the input stage should be interchanged or replaced. In general it is possible to replace a tube by one of the same type in a less critical place (e.g. Nos. 9, 10, or 18)

If the trace moves in a vertical direction when the Y-ATTENUATOR is switched from position 10 to position 1, this is generally due to grid current in tube No. 8.

When tubes have been replaced in the Y or X amplifier it may be necessary to readjust the potentiometer P_2 on the Y chassis (astigmatism correction). This potentiometer is set to a position that provides for the best focusing on all parts of the screen.

When tube No. 3 in the sweep generator is replaced, it may be necessary to readjust potentiometer P_4 . The SWEEP GEN. switch is set to the extreme left position (triggered sweep, external blanking), the X-SELECTOR is set to LINE-FREQ. synchronization, and the SWEEP RATE controls are set to 500 c/s. P_4 is now so adjusted that the sweep generator works properly. Usually the generator will work over a fairly wide angle of rotation. The potentiometer should be set at the middle of this range. This procedure may be repeated at a sweep rate of 1 to 3 c/s when

- single sweeps are released by connecting the X_1 terminal to ground.
- Tube No. 5 (the sweep generator tube) must have good insulation between filament and cathode (pin No. 5). Poor insulation may result in too high sweep frequency when the sweep FREQ. control is set to low frequencies.

Hum voltages developed in tube No. 5 (and to some extent in tube Nos. 1 and 2) may synchronize the sweep generator with the power line frequency.

Potentiometer P_5 is used for horizontal centering of the sweep trace on the screen. This adjustment is made after the X-POSITION and X-BALANCE have been set with the X-SELECTOR in position "100".

(2) Stability

In general the influence of line voltage fluctuations on the performance of the Oscilloscope are negligible. Under certain circumstances, however, the influence of the unstabilized filament voltage may give rise to inconvenient displacement of the image. Normally a line voltage variation of 5% will cause less than 5 mm displacement of the image at maximum amplification.

If a greater displacement occurs, try to replace the tubes No. ~~13 and 14~~, if the displacement is horizontal, and the tubes No. 7 and 8 if the displacement is vertical.

(3) Operating voltages and currents of the Oscilloscope

The voltage values (\sim denotes a-c) in the circuit diagram can be used as references when servicing the Oscilloscope. These values are mean values from a series of measurements, and deviations up to 20% may usually be neglected.

If nothing else is specified, voltages are measured with respect to common power supply minus (-). The voltmeter should have negligible consumption (vacuum-tube voltmeter).

Voltage measurements

	<u>d-c voltage</u>	<u>a-c voltage</u>
"Ground" or chassis	30 volts	30 mV
"+160" volts regulated	160 volts	1 mV
"+320" volts	345 volts	150 mV
A-C		15 volts
B-C		6.3 "
A-ground		10.5 "
C-ground		10.5 "

Current measurements

Total primary consumption at 220 volt power line voltage		900 mA a-c
current at "320" connection to Y amplifier		86 mA d-c
" " "320" " " X "		44 mA "
" " "160" " " Y "		33 mA "
" " "160" " " X "		16 mA "
" " "160" " " time base, chassis,		
sweep gen. off		18 mA "
sweep gen. at recurrent sweep		15 mA "
sweep gen. at triggered sweep		25 mA "

The fuses are accessible when the cover plate at the rear end of the Oscilloscope is removed. The fuse mounted on the voltage selector is the power line fuse. When replacing the fuses a 2 amp fuse should be used for line voltages higher than 200 volts. For lower line voltages the fuse should be able to carry a correspondingly higher current. The fuse for the "320" volt d-c supply should be 0.5 to 1 amp, and the fuse for the high voltage supply (CR-tube supply) should be 0.3 to 0.5 amp.

Section IV

Specifications

Cathode-ray tube:

Diameter of screen: 130 mm (5 inches)
Plate voltage: 2 kV + 2 kV intensifier voltage
Deflection sensitivity approx. 1 mm/volt rms

Vertical amplifier:

Maximum sensitivity: 1.5-2 mm/mV rms
Frequency range: d-c - 3 Mc (3 db) - 5 Mc (6 db)
Designed to provide optimum transient response.
Attenuator: 1:1, 1:10, 1:100, 1:1000 stepwise + 1:12 continuously.
Calibration: 2 voltages, line frequency
Input: single ended (with attenuator) or double ended without attenuator
Input impedance: $1\text{ M}\Omega \neq 30\text{ pF}$
Probe: Voltage division 1:20, input impedance $10\text{ M}\Omega \neq 6\text{ pF}$

Horizontal amplifier:

Maximum sensitivity: 0.7 - 1 mm/mV rms
Frequency range: d-c - 0.8 Mc (3 db) - 1.4 Mc (6 db)
Designed to provide optimum transient response.
Attenuator: 1:1, 1:10, 1:100 stepwise + 1:12 continuously
Calibration: 2 voltages, line frequency
Input: single ended (with attenuator) or double ended without attenuator.
Input impedance: $1\text{ M}\Omega \neq 40\text{ pF}$

Sweep system:

Recurrent sweep: 1 c/s - 100 kc/s, calibrated dial, uncalibrated to 300 kc/s
Triggered sweep: from single sweep to 100 kc/s repetition rate, max. sweep speed 50 mm/ μ sec

Synchronization:

- 1) Internal from signal being observed, either polarity
- 2) External from signals of either polarity.
0.1 volt or larger
- 3) Power line frequency, adjustable phase
- 4) By "Making" or "Breaking" an external connection

Blanking: effective on recurrent and triggered sweeps at sweep frequencies from 10 c/s to 100 kc/s

Sweep voltage at output terminal: 10 volts peak to peak

Light intensity modulation:

15 volts peak to peak for 100% light modulation.
Input impedance: $0.5 \text{ M}\Omega \neq 60 \text{ pF}$

Max. trace expansion: 3 times screen diameter in vertical and horizontal direction.

Power requirement:

110, 127, 150, 200, 220, or 240 volts, 50-60 cycles.
Consumption: 175 watts

Overall dimensions:

400 mm High
310 mm Wide
570 mm Deep

Weight:

29 kilos

OSG 41 SIMPLIFIED DIAGRAM

