Operating Instructions
for
DuMONT TYPE 248
CATHODE-RAY OSCILLOGRAPH

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Passaic, New Jersey, U. S. A.

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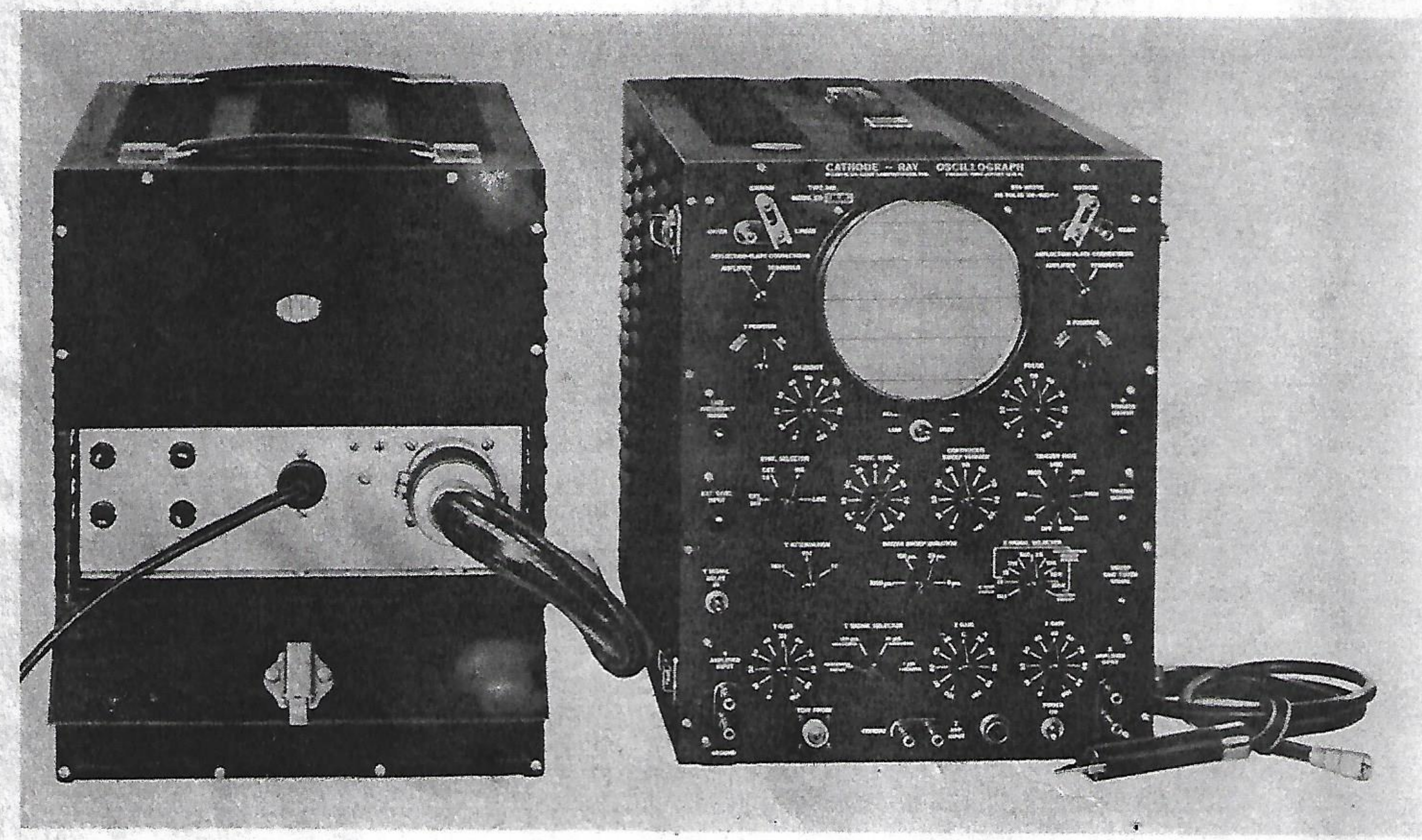

Du Mont Type 248 Cathode-Ray Oscillograph

1:00 INTRODUCTION

1.10 SUMMARY OF GENERAL SPECIFICATIONS

(Unless otherwise noted, minimum performance is given.)

Cathode-ray Tube:

Type	5JP1, 5JP2, or 5JP11
Accelerating Potential	4000 volts

Input Impedances:

TERMINALS	DIRECT (BALANCED)	DIRECT (UNBALANCED)	PROBE
Y-Axis 1 meg. 40 μμf.	10 meg. 15 μμf.	5 meg. 25 μμf.	5 meg. 10 μμf.
X-Axis 1 meg. 60 μμf.	10 meg. 15 μμf.	5 meg. 25 μμf.	
Z-Axis 1 meg. 25 μμf.			
Sync Amp. 2 meg. 45 μμf.			

Permissible Input Potentials: (Maximum denotes d-c plus peak a-c)

Y-Axis, Amplifier	600 volts maximum
Y-Axis, Direct	1000 volts maximum
Y-Axis, Probe	1000 volts maximum
X-Axis, Amplifier	210 volts peak a-c, 600 volts maximum
X-Axis, Direct	1000 volts maximum
Z-Axis, Amplifier	5 volts peak a-c, 600 volts maximum
Sync Amplifier	250 volts peak a-c, 600 volts maximum

Amplifier Response:

Y-Axis	Uniform within 30% from 20 cps to 5 mc.
X-Axis	Uniform within 30% from 20 cps to 2 mc.
Z-Axis	Blanks on 3 volts peak input from 30 cps to 5 mc.

Deflection Factors:

Y-Axis, max. amplifier gain	0.1 rms volts per inch total deflection (0.28 d-c volts per inch)
Y-Axis, direct to plates	Approx. 32 rms volts per inch total deflection (90 d-c volts per inch)
X-Axis, max. amplifier gain	2.75 rms volts per inch total deflection (7.75 d-c volts per inch)
X-Axis, direct to plates	Approx. 37 rms volts per inch total deflection (103 d-c volts per inch)

1G=320

1G=13

Linear Time Bases:

Continuous Sweep Frequency .... 15 cps to 150 kc.

Will synchronize with any repetitive signal having a frequency between 15 cps and 3 mc, a peak amplitude of one volt, and with peaks lasting more than 0.1 microsecond.

Driven Sweep Durations .... 5, 25, 100, 1000 microseconds

Can be initiated by any signal having a repetition rate up to 3 mc, a peak amplitude of 1.5 volts, and with peaks lasting more than 0.1 microsecond.

Markers

Interval .... 1, 10, 100 microseconds

Accuracy .... ±5%

Operative on driven sweeps only

Trigger Generator

Pulse Peak Amplitude .... Between 50 and 100 volts

Pulse Rate .... Approx. 200 to 3000 per second

Both polarities available

Power Requirements

Voltage .... 105-125 volts rms.

Frequency .... 50-400 cps.

Power Consumption .... 550 watts

Cabinet Sizes

Indicator Unit .... Approx. 21 7/16 x 16½ x 13 inches overall.

Weight .... Approx. 60 lbs.

Power Supply Unit .... Approx. 20 x 16½ x 13 inches overall.

Weight .... Approx. 110 lbs.

1.20 DESCRIPTION OF EQUIPMENT

The Type 248 Cathode-ray Oscillograph is an instrument for plotting a curve of one electrical potential as a function of another, on the screen of a cathode-ray tube.

It consists essentially of a cathode-ray tube, amplifiers for producing the deflection voltages, an amplifier for modulation of the beam intensity, a marker circuit which generates pulses at known time intervals, two types of time-base or sweep circuits, and the necessary power supplies. The foregoing is housed in two cases, the indicator cabinet containing the cathode-ray tube and associated circuits; the power-supply cabinet, all power components.

The great utility of the oscillograph lies in the fact that its function, that of automatic curve plotting, is of value in the solution of almost every scientific problem. Any physical variable from which a corresponding voltage can be obtained can be shown as a function of time or of some other quantity. Because of its extended frequency response, high-speed driven time-bases, and other features, the Type 248 is free of many of the limitations heretofore found in commercial instruments.

In the operating instructions which follow no attempt is made to describe application of the oscillograph to particular problems, or to discuss means of obtaining voltages proportional to the quantities they represent. General operation is covered in detail, however, and these instructions should be read carefully before placing the equipment in service.

2:00 OPERATING INSTRUCTIONS

2.10 INSTALLATION

2.11 Cathode-ray Tube

The Type 248 Cathode-ray Oscillograph is shipped ready to operate, all tubes being in place with the possible exception of the cathode-ray tube, which may be packed separately.

To install the cathode-ray tube the indicator chassis must be taken out of its cabinet. Stand the cabinet on its rear surface (first making certain the rear door over the connector is closed) and remove the two washer-head screws in the bottom. After replacing the cabinet in a horizontal position remove the ten slotted-head screws nearest to the edges of the front panel, and gently slide out the chassis assembly. Pull the sliding light shield out from the front panel until it is free of the supporting sleeve. The cathode-ray tube can now be carefully inserted base first through the front panel and magnetic shield until its face is approximately flush with the panel, the clamp tightened around the base, and the socket firmly seated. The intensifier cap should be pushed on the intensifier terminal, which must point downward.

The upper and lower deflection leads on the left, or Y-axis, side of the chassis go to the upper and lower deflection terminals, respectively, on the neck of the tube. The upper and lower caps on the right, or X-axis, side go on the right and left deflection terminals respectively. These four terminals should be well clear of the magnetic shield, and centered in the cut-outs. Their leads should be kept clear of the magnetic shield and of each other.

Before replacing the chassis in the cabinet it will be well to see that all tubes are firmly seated in their sockets.

2.12 Power Supply

This equipment is designed to operate from a 105 to 125 volt power line, at a frequency of from 50 to 400 cycles per second. As the power consumption is 550 watts, approximately five amperes will be taken from the line.

The power cord and connecting cable for the two units are stored in the lower part of the power supply cabinet, together with the test probe, instruction book, etc. The power supply, even though connected to the line, can not be turned on unless the cable is in place between it and the indicator unit, as the power switch is on the latter. The cable is quite durable and will withstand all ordinary wear, but it should be protected from stretching, crushing, continuous bending, and excessive heat.

Four fuses are available on the front of the power supply chassis. They are F101, in the primary of the 450 volt power transformer; F102, in the primary of the high-voltage transformer for the cathode-ray tube; F103, in the primaries of both filament transformers; and F104, in series with the power switch. Their values are marked near the fuse posts. Type 3AG tubular fuses are required.

A delayed-closure relay (V135) prevents high voltage surges in the d-c supplies by allowing approximately 20 seconds for tube warm-up before energizing the power transformer.

Ordinary line voltage fluctuations should cause little interference with the operation of this instrument. If disturbances are excessive a constant-voltage transformer of suitable rating may be placed in the supply line to the instrument. If such a regulator is used it should be located as far as possible from the indicator cabinet, in accordance with the precautions of Section 2.13.

2.13 Precautions

Although a magnetic shield has been provided for the cathode-ray tube in the Type 248, operation in the immediate vicinity of electrical power equipment may cause spurious deflections from stray magnetic fields. The power-supply cabinet should be at a distance of two feet or more from the indicator cabinet, and other a-c operated instruments may be placed beside or on top of the latter only after it has been determined that no interference will result.

Electromagnetic and electrostatic pick-up will be minimized by the use of shielded input leads and by good ground connections. Occasionally it may be found that reversing the power plug in the receptacle will reduce a line-frequency disturbance.

WARNING: It is inadvisable to operate this oscillograph with the case removed from either chassis. The presence of potential differences as high as 4000 volts in the instrument makes extreme caution necessary.

2.20 CATHODE-RAY TUBE OPERATION

2.21 Cathode-ray Tube

The Type 248 Oscillograph is normally supplied with a type 5JP1 cathode-ray tube, having a medium-persistance screen. The type 5JP2, with a long-persistance screen, or the type 5JP11, with a short-persistance screen especially good for photography, are furnished if desired.

When using the oscillograph in a brightly lighted room it may be helpful to let the cylindrical light shield project several inches, in order to shade the face of the tube.

2.22 Accelerating Potential

The cathode-ray tube may be operated with either of two values of overall accelerating potential. With the *Accelerating Potential* switch (located on the front panel just below the light shield) in the "HIGH" position the cathode-to-screen potential is 4000 volts; in the "LOW" position this is reduced to 2000 volts.

Operation of the tube at 4000 volts gives increased brilliance of trace and improved focusing characteristics, but decreases the deflection sensitivity to approximately one-half of that at 2000 volts. In general the higher potential should be used except where maximum sensitivity is required.

2.23 Beam Controls

The beam controls are those which govern the intensity, focus, and positioning of the electron beam. They are to be found on the upper half of the panel, adjacent to the cathode-ray tube.

The INTENSITY control adjusts the tube beam current, and thus the brightness of the trace. It is desirable to keep the intensity at the lowest value consistent with good visibility, in order to prolong the life of the tube.

The FOCUS control varies the size of the luminous spot formed where the electron beam strikes the screen. In general, focus and intensity settings are not independent of each other, as a change in intensity will usually necessitate refocusing.

A sharply focused spot or line of high intensity should not be permitted to remain stationary on the screen for any considerable period. Under such conditions the power input per unit area of the spot is very high, and the screen may be "burned" or discolored.

The Y POSITION and X POSITION controls serve to locate the spot or image in the vertical and horizontal directions.

2.30 Y AXIS DEFLECTION

2.31 Input to Deflection Plates

There are three ways in which a signal may be introduced into the Type 248 Oscillograph in order to cause deflection along the Y-axis. The first method is by applying the signal to the vertical deflection plates without going through the Y-axis amplifier. This may be done by throwing the switch marked DEFLECTION-PLATE CONNECTIONS (all Y-axis controls and terminals are to be found on the left side of the panel) to the TERMINALS position, and making connections to the two posts immediately above the switch. Each terminal is connected to its designated deflection plate through a 1000-volt capacitor, so that positioning is unaffected by applied d-c.

These coupling capacitors will cause distortion in signals having frequency components below 10 cps. The useful high-frequency limit of the tube when used in this way is in the hundreds of megacycles.

For a balanced input to both deflection-plate terminals the input impedance will be approximately equivalent to 10 megohms in parallel with 15 $\mu\mu$f. For single-ended input to either the upper or lower plate, with the other terminal grounded, the input impedance will be equivalent to 5 megohms shunted by 25 $\mu\mu$f.

With 4000 volts accelerating potential the deflection factor for the vertical plates will be approximately 90 volts (d-c or peak-to-peak) per inch. At 2000 volts the deflection factor will be about one half of this, or 45 volts per inch.

2.32 Input to Amplifier

The second type of Y-axis input is for smaller signals which must be amplified before being applied to the deflection plates. The Y-axis amplifier serves this purpose, if the DEFLECTION-PLATE CONNECTIONS switch is thrown to the AMPLIFIER position and input is made to the Y-AMPLIFIER INPUT terminal.

This terminal is immediately followed by a series capacitor. Permissible input is 600 volts maximum (d-c plus peak a-c) and the oscillograph input impedance is approximately equivalent to one megohm paralleled by 40 $\mu\mu$f. This is for a Y-ATTENUATION setting of 1:1 (See Section 2.34), and with the test probe cable not connected at its socket. Input capacity is decreased somewhat at other attenuation ratios.

At full gain, and with signal delay out, the deflection factor will be less than 0.1 rms (0.28 peak-to-peak) volts per inch total deflection. Characteristics of the Y-axis amplifier are covered in Section 2.34.

2.33 Input Through Probe

The third method, input through the test probe, should be used where minimum loading of the signal source is desired. The Y amplifier input terminal and the test probe socket are connected together at all times. Therefore it is advisable when using one to remove all external connections from the other, in order to prevent extraneous pick-up.

Probe impedance is approximately five megohms in parallel with 10 $\mu\mu$f. This capacitance may be increased by 50% or more if the probe is held in the hand, so while connected to high impedance circuits it should be secured only by its clips.

Clip insulation and high-voltage input capacitor permit safe use up to 1000 volts maximum. Due care should be exercised, however, when working with high voltages.

The signal is attenuated 20:1 in the test probe, so that the deflection factor of the oscillograph will be increased 20 times by its use. The input capacitor will introduce phase shift below 100 cps, otherwise the probe is essentially distortionless within the frequency range of the amplifier.

2.34 Y-axis Amplifier

Preceding the Y-axis amplifier is a three-position attenuator, indicated on the front panel by Y ATTENUATION, having ratios of 100:1, 10:1, and 1:1. Following the first stage of the amplifier is a continuously-variable attenuator, or Y GAIN control, covering a range of from 10:1 to 1:1. This latter control will not reduce the amplifier gain to zero, insuring that no overload will occur at less than three inches peak-to-peak deflection from a symmetrical signal, or one and one-half inches from a pulse signal.

Amplifier overload will appear as flattening of positive or negative signal peaks. It is always advisable to check for this condition by noting if a change in wave shape takes place when amplifier gain is reduced.

Both the stepped attenuator and the Y gain control are distortionless within the frequency range of the instrument. No signal distortion takes place as the gain is reduced from maximum to an intermediate setting.

The low-frequency phase characteristics of the Y-axis amplifier are such that a 40 cps square wave is transmitted with less than 10% sawtooth (that is, the decrease in amplitude along the top of any half-cycle will be less than one-tenth of the vertical front of the half-cycle). The sine-wave response will be approximately uniform to 20 cps.

The transient response of the amplifier gives no overshoot following steep wavefronts, and the high-frequency end of the response curve falls off gradually, being down less than 30% at 5 mc.

A positive signal at the Y amplifier input terminal will cause upward deflection of the beam.

2.35 Time-Delay Network

In connection with the driven sweep circuit, to be described later, it is often desirable to delay a signal slightly in its passage through the amplifier. This can be accomplished by switching in a time-delay network between stages, by means of the toggle switch denoted Y SIGNAL DELAY IN.

The network has a delay time of approximately 0.7 microsecond, with uniform characteristics up to six megacycles. It should cause negligible distortion in most waveforms, but a check can easily be made by comparison of images with and without the network in the amplifier. A change in size alone is not significant, as insertion of the network causes increased loading of the first stage, resulting in somewhat lower gain.

Transmission time of the Y-axis amplifier without the delay network is slightly greater than 0.1 microsecond.

2.40 X-AXIS DEFLECTION

2.41 Input to Deflection Plates

Deflection of the beam can be obtained by applying a signal directly to the horizontal deflection plates in a manner analogous to that described in Section 2.31 for the Y-axis. Performance will be approximately the same. All X-axis controls and terminals are located on the right hand side of the front panel.

2.42 Input to Amplifier

With the DEFLECTION-PLATE CONNECTIONS switch just below the LEFT and RIGHT input terminals in the AMPLIFIER position, the plates are connected to the output of the X-axis amplifier. External signals can be introduced into this amplifier by means of the X AMPLIFIER INPUT terminal if the X SIGNAL SELECTOR switch is in one of the two extreme counter-clockwise positions. These two switch positions are designated X AMPLIFIER INPUT, and give a choice of 10:1 or 1:1 attenuation of the signal before the first amplifier stage.

The input impedance of this amplifier, as well as that of the Z-axis and Sync amplifiers discussed later, is comparable to that given for the Y-axis in Section 2.32.

Permissible maximum (d-c plus peak a-c) input is 600 volts, but the a-c component should never be greater than 150 volts rms, as larger signals will overload the first amplifier stage even at 10:1 attenuation. At full gain the deflection factor will be less than 2.75 rms (7.75 peak-to-peak) volts per inch. The gain can be reduced to zero and the control is distortionless over the entire range. Amplifier response is uniform within 30% from 20 cps to 2 mc. At 4000 volts accelerating potential at least four inches of horizontal deflection is possible from a symmetrical signal before overload takes place in stages following the gain control.

Positive signals cause the beam to be deflected to the right.

2.43 Continuous Sweep

In most applications of the oscillograph it is desired to plot some variable on the Y-axis against time on the X-axis. A sweep circuit which moves the beam from left to right along the X-axis linearly with respect to time is included in the Type 248, and operates when the X SIGNAL SELECTOR switch is on any of the central positions marked "CONTINUOUS SWEEP RANGE." This movement is repeated continuously, the beam fly-back time from right to left being much shorter than that of the useful sweep in the opposite direction. The beam is automatically cut off during fly-back so that the return trace is not visible at usual intensities.

The rate at which the continuous sweep is repeated is determined by the range at which the X SIGNAL SELECTOR is set and by adjustment of the CONTINUOUS SWEEP VERNIER. The latter control will vary the sweep rate over roughly the range indicated by the two figures between which the pointer of the former control is positioned. Sweep rates are given in cycles per second, "K" being used for one thousand (e.g., 12 K means 12,000 cps). These figures are approximate only, as considerable over-lap is provided. Free-running sweep frequencies from 15 cps to more than 150 kc are obtainable.

2.44 Synchronization

If patterns are to be held stationary on the cathode-ray tube screen the continuous sweeps of the preceding section must be repeated exactly in step with the phenomenon being investigated. This synchronization can be brought about easily by feeding a very small part of the signal under observation (or other suitable signal) into the sweep circuit.

When it is desired to synchronize with the signal being amplified in the Y-axis the SYNC SELECTOR switch should be thrown to the INT. position. This connects the sync amplifier internally with the Y amplifier. The proper amount of synchronizing voltage can now be injected into the sweep circuit by moving the SYNC GAIN control away from zero position. To sync with positive signal peaks the control should be rotated to the right or "+" side. To sync with negative peaks it should be advanced in the "—" direction. In general, steep wavefronts give best synchronization.

The sweep circuits of the Type 248 will lock in with a very small signal input, therefore it is easy to over-sync on larger signals. The effect of this is to cut off the sweep length and distort the image. Always adjust the sweep to approximately the correct rate with zero sync gain, then move the control just far enough from the center position to hold the pattern steady. Often this will require only a few degrees rotation. Changes in signal level or of attenuator setting may necessitate readjustment of sync gain.

When a signal is placed directly on the Y deflection plates it will not be possible to synchronize the sweep internally. Instead, the SYNC SELECTOR switch must be thrown to one of the two external positions (EXT. 1:1 for signals smaller than 12.5 volts peak, or to EXT. 20:1 for 20:1 attenuation of larger signals) and a signal lead brought to the EXT. SYNC INPUT post. In the same way sweeps may be synchronized with any external signal, independently of Y-axis amplifier operation. Permissible input to this post is 250 volts peak a-c, or 600 volts maximum.

With the selector switch in the LINE position the sync circuits are supplied with a signal having a frequency of the power line.

The continuous sweep circuit will synchronize with any signal having a frequency between 15 cps and 3 mc, a peak amplitude of one volt or more, and with peaks lasting longer than 0.1 microsecond.

The sweep circuit will operate at considerably faster rates when synchronized with a higher frequency signal than when free-running with no sync.

2.45 Driven Sweep

Pulse signals of short duration and of low or inconstant repetition rate cannot be satisfactorily observed with a continuous type sweep. A circuit that quickly moves the beam across the screen once each time the pulse occurs is required. That is, the sweep must be triggered or driven by the external signal.

This type of sweep operation is obtained with the X SIGNAL SELECTOR in the DRIVEN SWEEP position.

Four fixed sweep durations are provided, 5, 25, 100, and 1000 microseconds. They are selected by the DRIVEN SWEEP DURATION switch, and can be initiated through the regular sync channels by any internal or external signal of at least 1.5 volts peak amplitude and of 0.1 microsecond or more duration. They can be triggered repeatedly with only a few microseconds recovery time between sweeps. Care should be taken not to over-sync by advancing the gain control too far. The minimum sync signal that will give steady triggering is advisable, although this type of sweep is not so sensitive to excessive synchronization as is the continuous sweep.

A beam control circuit serves to brighten the trace for the duration of the sweep period. This allows the normal tube intensity to be so reduced that the rest position of the beam is not visible. The absence of a bright spot at the beginning of the trace makes it much easier to photograph the patterns satisfactorily.

The brightness of the trace when using driven sweeps is of course directly dependent on the repetition rate.

About one-tenth microsecond is required for the driven sweeps to get under way after they have been triggered. It is therefore possible for most of the leading edge of a very steep pulse to be obliterated. To avoid this the time-delay network can be switched into the Y-axis amplifier. The resulting delay of approximately 0.7 microsecond is sufficient for the sweep to get well under way before the signal appears on the vertical deflection plates, and the entire wavefront is easily observed. See Section 2.35 for characteristics of the network.

2.50 Z-AXIS

2.51 External Input

The Z-axis amplifier of the Type 248 serves to modulate the beam intensity of the cathode-ray tube. With the Z SIGNAL SELECTOR switch in the EXTERNAL INPUT position, input can be made to the Z AMPLIFIER INPUT terminal near the bottom of the panel. The Z GAIN control functions also as a phase selector, causing a positive signal to brighten the trace when advanced in the "+" direction, and to blank or darken the trace when rotated to the "—" side.

At a normal beam intensity 2 rms (2.8 peak) volts input will blank the trace, from 30 cps to 5 mc. A signal larger than 5 volts peak will overload the input stage of the amplifier. Maximum d-c voltage input is 600.

There will be a phase difference of nearly 90° between Y and Z-axis at 20 cps. Transmission time of the Z-axis amplifier is slightly less than .15 microseconds.

2.52 Timing Markers

With the Z SIGNAL SELECTOR switch in one of the three marker positions the Z-axis amplifier is connected to an internal timing oscillator. Markers at intervals of 1, 10, or 100 microseconds can be blanked out along the driven sweep trace for measurement purposes. These markers are intended to be used on driven sweep only, and in general will not operate on continuous sweep.

Marker intervals are accurate within 5%.

2.60 TEST SIGNALS

2.61 Trigger Generator

A variable-rate pulse generator is included in the Type 248. It will be found convenient for triggering other equipment, as in synchroscope applications, and for checking operation of the driven sweeps.

The TRIGGER RATE control varies the pulse rate between roughly 200 and 3000 pulses per second. The graduations are approximate only. Similar pulses of opposite polarity can be taken from the + TRIGGER OUTPUT and — TRIGGER OUTPUT posts.

The peak amplitude is between 50 and 100 volts and the duration is less than one microsecond. Output impedance is less than 500 ohms. This generator should be turned off when not actually in use, as its sharp pulses may interfere with the operation of other circuits.

2.62 Sweep Sawtooth Signal

The binding post designated SWEEP SAWTOOTH SIGNAL is connected into the first X amplifier stage, so that when either sweep circuit is in operation the output is available at this point. The amplitude will be approximately 75 volts peak-to-peak. This is a low impedance source, but it should not be loaded appreciably as distortion of the sweep may result.

2.63 Line Frequency Signal

A sinusoidal line frequency test signal is available at the post marked LINE FREQUENCY SIGNAL. Its amplitude will be approximately five volts peak-to-peak at 60 cycles, and proportionally less at higher frequencies.

This terminal is connected to a high impedance filter, and so must be considered a potential supply only.

3:00 DESCRIPTION OF CIRCUITS

3.10 CATHODE-RAY TUBE

Figure 1 shows the functional layout of the oscilloscope in block diagram form. The horizontal deflection, vertical deflection, and beam modulation circuits are designated here, as they are on the front panel of the instrument, by the coordinate symbols X, Y, and Z. This nomenclature emphasizes the function of the cathode-ray oscilloscope as an extremely versatile curve-tracer, working in effect in three dimensions.

The cathode-ray tube selected is the Type 5JP- which has a five-inch diameter screen and is available with either short, long, or medium persistence characteristics. To improve the utility for high-frequency applications, the deflection plate connections are brought out directly to terminals on the neck of the tube, minimizing capacitance and cross-coupling effects. An intensifier electrode allows high over-all accelerating potentials without excessive beam deflection factors.

A double-primary transformer and high-voltage rectifiers normally supply a negative 2000 volts for the cathode and a positive 2000 volts for the intensifier, the second anode and deflection plates being near ground potential. When high deflection sensitivity is of greater importance than image brilliance, the second half of the power transformer primary can be switched in series with the first half. This change in connections reduces voltages by one-half, thus approximately doubling the deflection sensitivity.

If the waveform to be investigated has a peak-to-peak amplitude of 20 to 300 volts, it can be satisfactorily observed by feeding it directly to the deflection plates of the cathode-ray tube. There are terminals on the front panel for this purpose, and coupling capacitors in the deflection-plate leads allow the beam positioning controls to function without interference from applied d-c potentials. These coupling circuits introduce no distortion above ten cycles per second, and the upper limit of usefulness for the tube when used in this way is several hundred megacycles.

Ordinarily, the signal must be amplified before reaching the cathode-ray tube. Amplification is advisable if the input is single-ended, even though the original signal is of considerable amplitude, so that balanced signals may be applied to the deflection plates. Of course, amplifiers are of value only within their frequency response range. The Y-axis amplifier of this instrument is useful for sinusoidal signals between five cps and 10 mc.

3.20 SIGNAL INPUT CIRCUITS

Input can be effected through a test probe and five feet of coaxial cable, or to a terminal on the front panel. There is a twenty-to-one attenuation ratio in the probe as a result of a necessary compromise between probe input capacitance and cable length. A 0.01 μf, 1000 volt capacitor prevents d-c loading of the circuit under observation, and insulated clips permit safe use on peak voltages up to the rating of the input capacitor.

Immediately following the input terminal and probe socket is an isolating capacitor and a three-position *RC* attenuator having ratios of 1:1, 10:1, and 100:1. This attenuator, as well as the one in the test probe, is compensated for high frequencies and introduces negligible distortion within the frequency range of the amplifier.

A continuously variable attenuator is necessary in an instrument of this type, but here compensation is impossible because the resistances are not fixed. Stray capacitances must be rendered ineffective by a relatively low-resistance potentiometer (1000 ohms).

The problem of matching this low-impedance control to the high-impedance stepped attenuator is solved very conveniently by the insertion of a cathode follower as an impedance transformer, with the additional advantages of extremely low input capacitance and the ability to handle large signals. To take full advantage of the three-position decade-attenuator, the gain control is limited to a maximum attenuation of ten to one. This feature also prevents overloading of the input stage by strong signals, as long as the resulting deflection on the cathode-ray tube screen is less than three inches peak-to-peak.

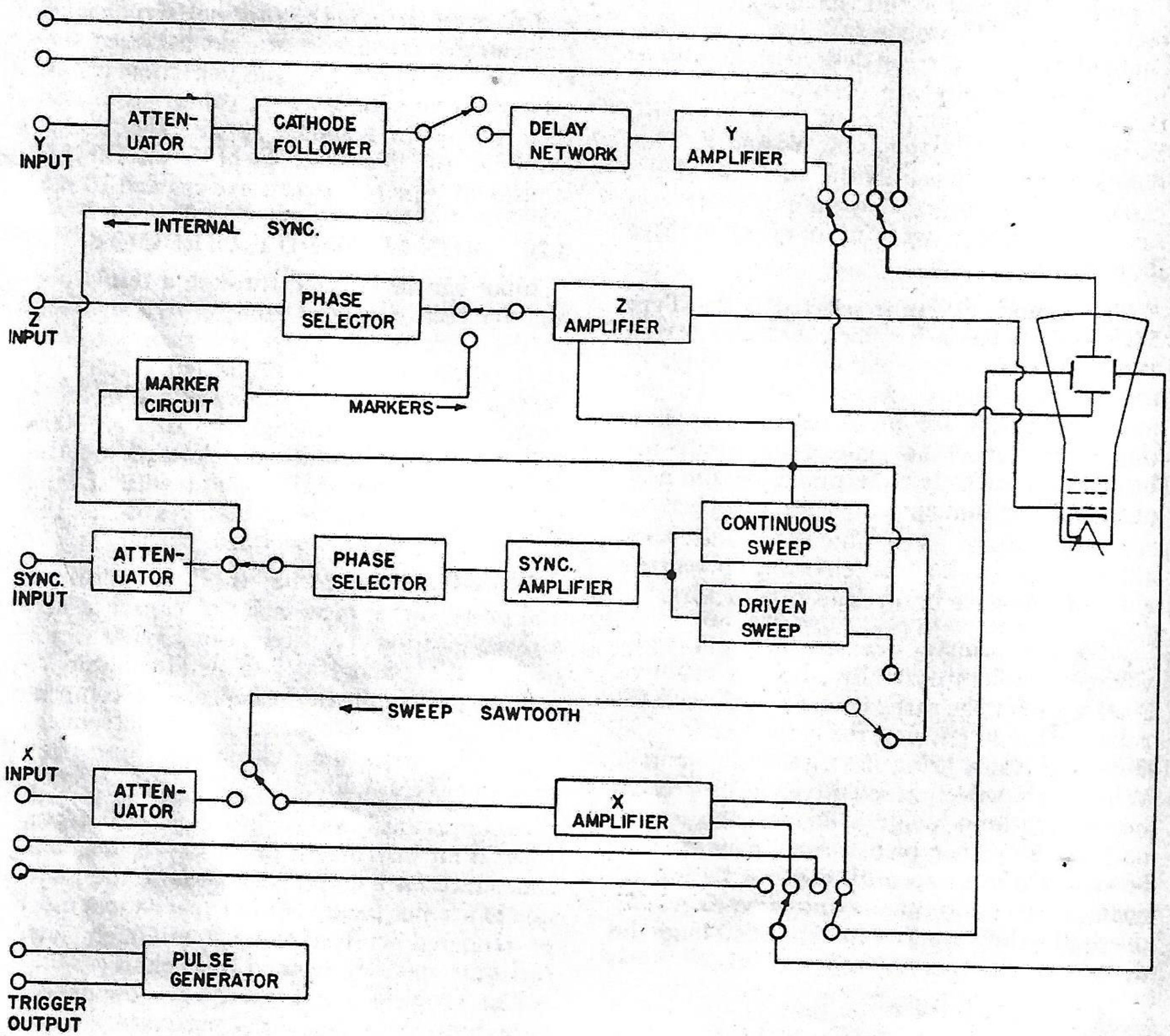

FIG. 1 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

BLOCK DIAGRAM

3.30 Y-AXIS AMPLIFIER

Immediately following the variable attenuator are two amplifying stages, the first employing a 6AC7 pentode, the second, a 6AG7. Both plate circuits include compensating filters for low frequencies which, with slight individual adjustment to take care of component variations, make it possible for the amplifier as a whole to pass a 30-cycle square wave with only slight distortion. High frequency compensation is also provided, shunt peaking being used with the 1000-ohm plate load of the Type 6AC7 stage and series peaking with the 1300-ohm load resistor of the Type 6AG7. A type of compensation allowing a larger plate load for the desired frequency range is used in the latter stage in order that the maximum possible output can be obtained from the deflection amplifier which it drives.

The deflection amplifier consists of two 807's, cathode-coupled to give a balanced output. Because of low output capacitance it was found possible to use 1500-ohm plate loads and shunt peaking without reducing frequency response below that of previous stages.

3.40 X-AXIS AMPLIFIER

High gain is not required in the X-axis or horizontal amplifier, so a cathode follower and gain control driving a balanced deflection amplifier similar to that of the Y-axis is all that is necessary.

3.50 SIGNAL TIME-DELAY

When using a driven or start-stop type of sweep, it is often necessary to trigger the time-base by means of the signal which is to be observed. Although sweep circuits such as the one used in this oscillograph get under way in a small fraction of a microsecond, part of the wavefront is obliterated unless there is a short time-interval before the signal appears at the vertical deflection plates.

A delay of about one-half microsecond can be obtained by switching in a delay network ahead of the variable attenuator. This network of the low-pass filter type has a characteristic impedance of 200 ohms to match the output of the cathode-follower, and a cutoff frequency of twelve megacycles in order that it will be essentially distortionless up to approximately six megacycles.

3.60 TIME BASES

Two linear time-bases are provided. One, the usual continuous sweep, has a range of 15 cps to 150 kc when running free and is exceptional in its ability to synchronize steadily at high signal-to-sweep frequency-ratios. Stable operation with more than 100 cycles of the signal on the screen can be obtained at medium frequencies. Operating frequencies as high as 300 kc or more are attained by moderate synchronizing with high frequency signals.

The second time-base is of the driven or start-stop type. Each stroke must be initiated by an external signal. Its great usefulness is in detailed inspection of waves occurring at relatively long and inconstant intervals, and having short durations. Any one of four sweep durations (5, 25, 100, or 1000 microseconds) may be selected by means of a switch on the front panel. This sweep can be triggered repeatedly at rates up to approximately the frequency corresponding to the sweep period. The previously mentioned delay network greatly increases the utility of this time-base.

A stage of amplification following a phase-selector stage in the synchronizing circuit insures that the foregoing time-bases can be synchronized or initiated by small signals of either polarity.

Generally, driven sweeps of short duration and low repetition rate are limited to one-half of the horizontal deflection distance that is available to the continuous saw-tooth sweeps or other symmetrical signals. However, when this instrument employs driven sweeps, the operating points of the X deflection amplifiers are shifted along their dynamic characteristics to allow full deflection.

3.70 Z-AXIS AMPLIFIER

The Z-axis or beam modulation amplifier makes use of a phase-selector as its input stage, thus making possible blanking or intensifying of the beam by either a positive or negative signal. This amplifier, together with the time-bases, acts as a beam control circuit serving to blank the return trace of continuous sweeps, and to drive the beam from cut-off during stand-by to full intensity during sweep when the driven time base is in use.

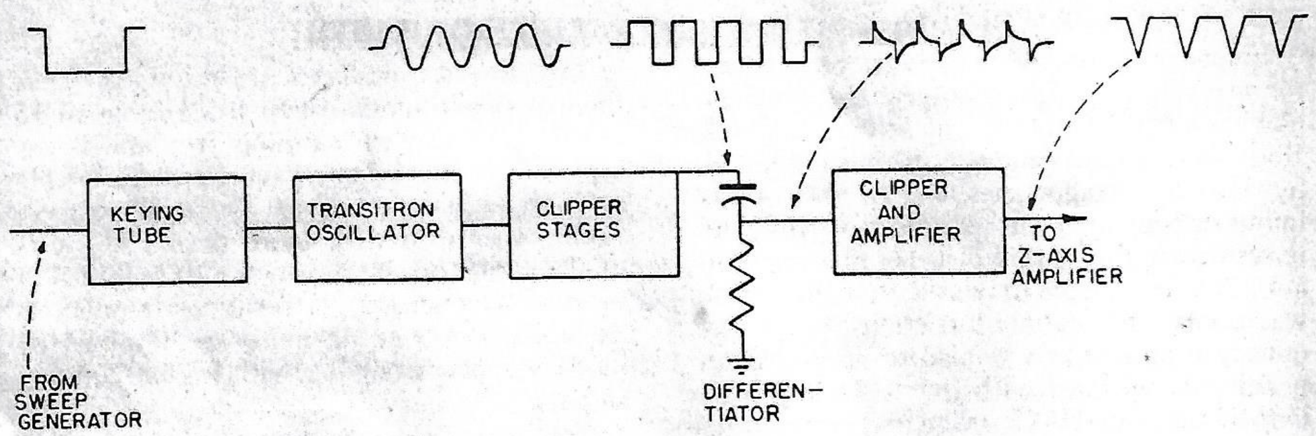

FIG. 2 — BLOCK DIAGRAM OF MARKER CIRCUIT

It is very necessary that adequate beam brightening be provided on short-duration strokes if the image is to be photographed, otherwise the beam intensity must be increased to a high level to make an infrequently repeated trace visible. As a result, the beam rest position will be so bright as to obscure the remainder of the trace. The cut-off of the beam during stand-by avoids this difficulty.

For use in conjunction with the Z-axis there is provided an oscillator and pulse-forming circuit which together furnish sharp pulses at intervals of one, ten, or 100 microseconds. Figure 2 is a block diagram of this marker circuit. The oscillator is synchronized with driven sweeps, and is used to indicate elapsed time along the X-axis by introducing blanking markers into the trace. Direct application of the signal to be investigated to the vertical deflection plates in no way affects the use of this timing circuit. The transitron oscillator is designed to be keyed on by the initiation of the driven sweep, but may also be useful over some of the continuous-sweep frequency ranges.

3.80 TRIGGER GENERATOR

A feature of this instrument is the inclusion of a pulse generator for use in triggering and testing other equipment. There are available at terminals on the front panel positive and negative pulses from a simple blocking oscillator and phase-invertor.

3.90 SIGNAL DISTORTION

Initial deformation of the signal takes place when it is reduced from its original value by the test probe or the stepped attenuator. Both of these voltage dividers are compensated at the high frequencies by means of adjustable capacitors shunting the fixed resistors. These capacitors are adjusted for minimum distortion of a 10 kc square wave, this frequency usually being the most sensitive to attenuator misadjustment. Even at the best possible setting, however, there will be a slight but noticeable rounding of the leading corners of square waves at 100 kc and higher. This distortion is due to a lagging voltage-coefficient of resistivity of the attenuator resistor that is connected to the input terminal of the attenuator. While generally negligible, this effect cannot be entirely eliminated. Equal attenuation at all frequencies is an engineering ideal that can be approached only at the expense of input impedance.

Additional distortion takes place in the delay network, mainly because of the more rapid transmission of the frequency components above approximately two megacycles, and because of resistive and dielectric losses. Fortunately, this deformation in a well designed and correctly matched lumped-constant delay network is of the same order as that occurring in the attenuators, and can usually be neglected at frequencies below one-half the theoretical cut-off of the delay network.

4:00 MAINTENANCE AND ADJUSTMENT

4.10 GENERAL

There follows a description of the adjustments by which optimum performance of the instrument may be obtained. A complete schematic diagram will be found at the back of this book. Voltages given on this diagram are those normally found by use of a meter having an internal resistance of 20,000 ohms per volt or more. At one point, however, measurement of the negative voltage on the control grid of V 102, a vacuum-tube voltmeter having a d-c input impedance of at least 10 megohms will be required. A greater load on this high impedance point will reduce the normal bias, giving an incorrect reading.

In case of faulty operation the Type 248 may be serviced with the aid of the schematic. Signal tracing methods are often helpful. A small signal from an audio oscillator can be introduced into any of the amplifiers and followed through successive stages by means of another oscillograph. Where a second oscillograph is not available, the Y-axis of the Type 248 can sometimes be used to observe waveforms in other circuits of the same instrument.

Settings of the several factory-adjusted potentiometers, capacitors, and inductors should not be disturbed unless readjustment is thought necessary.

4.20 REMOVAL FROM CABINET

Directions for removing the indicator chassis from the cabinet are given in Section 2.11. The power supply chassis is secured in its case by three bolts through the flange along the front edge and by four washer-head screws in the back. To remove the chassis it will be necessary to take off the panel across the front of the cabinet.

4.30 POWER SUPPLIES

4.31 Regulated Supply

Most of the tubes in the Type 248 obtain power from the 250 volt regulated supply. This consists of the transformer T 102, followed by the rectifiers, a capacitor input filter, and a conventional degenerative voltage regulator. The output voltage is controlled by R 253, which is to be found behind the small access hole in the front of the power supply chassis. Clockwise rotation of the slotted shaft increases the voltage. This supply should be adjusted to exactly 250 volts before checking other operating potentials. Regulator output is approximately 200 milliamperes.

The thermal type delay relay, V 135 (Amperex 6NO-20), in series with the primary of T 102 does not close for approximately 20 seconds after the instrument is switched on. This allows the regulator tubes to heat in advance, and to control any initial high voltage transients.

If V 135 fails, and a replacement is not available, pins 5 and 7 of its socket may be shorted together as an emergency measure. When in this condition the instrument should be switched on as seldom as possible. The previously mentioned voltage surges are detrimental to many circuit components, particularly the electrolytic capacitors.

4.32 Y-Deflection Amplifier Supply

Power for the Y-axis deflection amplifier (this term is applied to the final stage only) is taken from the output of the filter choke, L 115, just before the voltage regulator. The potential at this point is approximately 425 volts, and about 150 milliamperes are drawn by the two amplifier tubes.

4.33 X-Deflection Amplifier Supply

This supply is similar to that just described, except that additional filtering is provided by L 116 and C 196.

4.34 High-Voltage Supplies

The cathode-ray tube is supplied with +2000 volts (about 0.5 milliampere) and —2000 volts (about 1.5 milliampere) by two high-voltage rectifiers fed from transformer T 103. This transformer has a two-section primary. By switching in the second half of the winding the secondary voltage is reduced one-half, the output of the RC filters following the half-wave rectifiers becoming approximately 1000 volts positive and negative.

4.35 Filament Supplies

Transformer T 104 is insulated to safely furnish filament current for the cathode-ray tube and the high-voltage rectifiers V 133 and V 134.

Transformer T 105 has five secondary windings. Three of these supply current to the filaments of tubes V 126-131 and to the heating element of V 135. The other two supply the filaments of tubes in the indicator chassis, and are rated at slightly more than 6.3 volts in order to overcome the voltage drop in the connecting cable. The 5 ampere winding leads to tubes 101-105, 122, and 123; the 10 ampere winding to tubes 106-121 and 124.

4.40 AMPLIFIER ADJUSTMENTS

4.41 High-Frequency Compensation

The high-frequency response of the Y-axis amplifier is determined by the inductance of coils L 101, L 102, L 103, and L 104. They are most easily adjusted with the aid of a square-wave generator. Apply a 100 kc square wave to the grid of V 104 (through an isolating capacitor) and adjust the cores of L 103 and L 104 until the steepest wavefront possible without overshoot is obtained. The two coils should be adjusted alternately, keeping the screws out approximately the same distance.

The square wave generator should now be connected to the grid of V 103, and L 102 adjusted for best response. Following this, the square wave may be applied at the Y-AMPLIFIER INPUT terminal and the best setting of L 101 found. For this last adjustment Y gain should be at maximum, Y attenuation at 1:1, and Y signal delay out.

The X-Amplifier compensating inductances, L 112 and L 113 may be adjusted in a manner exactly similar to that for L 103 and L 104.

Settings of the two compensating coils, L 109 and L 110, in the plate circuits of V 113 and V 114, are not critical. These coils are adjusted to give the sharpest possible 1μsec. markers.

4.42 Attenuator Compensation

The small trimmer capacitors C 102, C 104, C 168, C 172, and C 203 should be adjusted for minimum distortion of a 10 kc square wave. Trimmers C102 and C104 are mounted on S101, C168 and C172 on S105 and S107 respectively. The probe trimmer, C203, can be reached through an access hole under the ferrule.

4.43 Network Termination

The Y-axis time-delay network, Z 101, has a characteristic impedance of 200 ohms. This is roughly the output impedance of the cathode-follower stage, V 101, so that the network is approximately matched at the sending end. Exact termination of the receiving end is necessary in order to avoid signal distortion. The terminating resistor, R 108, should be adjusted for minimum distortion of a 100 kc square wave. This adjustment can be made through a small access hole in the left side of the indicator chassis, about one inch back from the front panel.

4.44 Low-frequency Compensation

Low-frequency characteristics of the Y-axis amplifier are corrected by the decoupling filters C 110, R 114, and C 112, R 120. Three sections of each of these capacitors are connected in originally, then sections are clipped out one at a time until minimum distortion of a 40 cps square wave is obtained. Generally it will be found that two sections should remain connected in each filter.

4.50 SWEEP ADJUSTMENTS

4.51 Continuous Sweep

The lowest frequency at which the continuous sweep circuit will operate is controlled by R187. Linearity compensation for the first two sweep ranges is determined by the setting of R281. Access holes for the slotted shafts of these variable resistors are located on the right-hand side of the indicator chassis.

The minimum sweep frequency should be set to 15 cps by adjusting R187. (The X-SIGNAL SELECTOR should be set to the "15-125" range and the CONTINUOUS SWEEP VERNIER and the SYNC GAIN should be at their minimum settings during this adjustment). The sweep frequency can be conveniently determined by means of a Lissajous figure corresponding to a given ratio of a Y-axis signal frequency to the sweep frequency.

Correction for non-linearity by an adjustment of R281 must be made with a minimum of sync voltage. The lowest sweep frequency should be rechecked after any adjustment of R281; thus, correct minimum sweep frequency and linearity are achieved by alternate adjustment of R187 and R281.

The setting of the trimmer capacitor, C 151, mounted on the sweep terminal board, determines the highest rate at which the continuous sweep will operate on the 50 k to 150 k range. It should be adjusted to 150 kc with the CONTINUOUS SWEEP VERNIER at maximum and with no sync.

4.52 Driven Sweep

The amplitude of signal necessary to trigger or initiate the driven sweep is determined by R 237, mounted behind the access hole on the left side of the indicator chassis, 11 inches back from the front panel.

This sensitivity control should be so adjusted that a 1-volt, peak signal will trigger the 5 μsec sweep internally, at full sync. If the sensitivity is made too great the circuit will tend to oscillate continuously.

The exact duration of the 5 μsec driven sweep depends upon the setting of C 183, the trimmer capacitor mounted on the DRIVEN SWEEP DURATION switch. It should preferably be set to give a sweep slightly longer than five microseconds when triggered normally.

4.60 MARKER CIRCUIT ADJUSTMENTS

The marker intervals, or frequency may be varied by changing the inductances of the oscillator coils L 106, L 107, and L 108. The adjusting screws of these coils will be found projecting through the indicator chassis near the left rear corner, close to the 6SN7 and 6SJ7 tube sockets. The coil nearest the rear of the chassis is used for the 100 μsec markers, that in the center for the 10 μsec markers, and the coil toward the front of the chassis for the 1 μsec markers. Turning the screws clockwise decreases the frequency of the markers, or increases the interval between them.

Keying of the marker oscillator may be synchronized with the driven sweep by adjusting R154 (see Figures 3, 8, and 9) until definite blanking markers are visible. This adjustment should be made with the DRIVEN SWEEP DURATION switch set at "1000 μs" and the Z SIGNAL SELECTOR set at "100 μs MARKERS."

4.70 RETURNS TO FACTORY

In some cases, such as major repairs, it may be desirable to return the instrument to 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 must be given, together with a description of the trouble encountered.

When ordering replacement parts, always give the Type number and Serial number of the instrument and refer to the part by its symbol designation and its description on the schematic.

4.80 COMPONENT LOCATION PHOTOGRAPHS

Photographs showing the location of most of the Components are found in Figures 3-11, pages 35-43.

4.90 SCHEMATIC DIAGRAM

The schematic diagram for the equipment is shown in Figure 12, page 45.

ALLEN B. DU MONT LABORATORIES, INC.
PASSAIC, N. J., U. S. A.

5:00 Parts and Spare Parts by Symbol Designation

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION
	CAPACITORS
C101	Fixed: paper; .5 μf; 600 V; +20, −10%
C102	Variable: ceramic; 3-12 μμf; 500 V.
C103	Fixed: mica; 1000 μμf; 500 V; ±10%
C104	Same as C102
C105	Fixed: mica; 82 μμf; 500 V; ±10%
C106	Same as C103
C107	Fixed: electrolytic; 100 μf; 50 V; +150, −25%
C108	Fixed: paper; .5 μf; 600 V; +20, −10%
C109	Fixed: paper; .05 μf; 600 V; +20, −10%
C110	Fixed: electrolytic; four section; 10+10+10+10 μf; 450 V; +75, −10%
C111	Fixed: paper; .5 μf; 600 V; +20, −10%
C112	Same as C110
C113	Same as C108
C114	Same as C103
C115	Fixed: dry electrolytic; 25 μf; 50 V; +150, −25%
C116	Same as C110
C117	Fixed: paper; 1 μf; 1000 V; +20, −10%
C118	Same as C117
C119	Fixed: paper; 4 μf; 600 V; +20, −10%
C120	Fixed: paper; .25 μf; 600 V; +20, −10%
C121	Fixed: electrolytic; 8 μf; 450 V; +50, −25%
C122	Same as C103
C123	Same as C121
C124	Same as C103
C125	Same as C121
C126	Same as C108
C127	Same as C108
C128	Same as C107
C129	Fixed: paper; .1 μf; 3000 V; +20, −10%
C130	Same as C109
C131	Same as C115
C132	Fixed: paper; .01 μf; 600 V; +20, −10%
C133	Fixed: mica; 100 μμf; 500 V; ±20%
C134	Same as C103
C135	Same as C132
C136	Fixed: electrolytic; 16 μf; 450 V; +75, −25%
C137	Fixed: mica; 2,200 μμf; 500 V; ±20%
C138	Same as C136
C139	Same as C137
C140	Same as C109
C141	Same as C115
C142	Same as C109
C143	Fixed: mica; 24 μμf; 500 V; ±5%
C144	Fixed: mica; 51 μμf; 500 V; ±5%
C145	Fixed: mica; 680 μμf; 500 V; ±10%
C146	Same as C109
C147	Same as C137
C148	Same as C109
C149	Fixed: paper; .1 μf; 400 V; ±10%
C150	Same as C110
C151	Variable: ceramic; 4-30 μμf; 500 V.
C152	Same as C144
C153	Fixed: mica; 390 μμf; 500 V; ±10%
C154	Fixed: mica; 2200 μμf; 500 V; ±10%
C155	Fixed: paper; .01 μf; 400 V; ±10%
C156	Fixed: paper; .04 μf; 400 V; ±10%
C157	Fixed: paper; .2 μf; 400 V; ±10%
C158	Same as C120
C159	Same as C143
C160	Fixed: electrolytic; 100 μf; 150 V; +150, −10%
C161	Same as C103
C162	Same as C108
C163	Same as C103
C164	Same as C115
C165	Same as C117
C166	Same as C117
C167	Same as C120
C168	Same as C102
C169	Same as C133
C170	Fixed: paper; three section; 0.1+0.1+0.1 μf; 600 V; +20, −10%

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION
	CAPACITORS
C171	Same as C109
C172	Same as C102
C173	Same as C133
C174	Same as C121
C175	Same as C103
C176	Same as C103
C177	Same as C121
C178	Fixed: mica; 150 μμf; 500 V; ±5%
C179	Same as C103
C180	Fixed: mica; 3300 μμf; 500 V; ±20%
C181	Same as C156
C182	Same as C109
C183	Same as C151
C184	Same as C143
C185	Fixed: mica; 240 μμf; 500 V; ±5%
C186	Fixed: mica; 1500 μμf; 500 V; ±10%
C187	Fixed: mica; 5100 μμf; 500 V; ±5%
C188	Same as C137
C189	Same as C137
C190	Fixed: electrolytic; 4 μf; 450 V; +75, −25%
C191	Same as C132
C192	Fixed: paper; 8 μf; 600 V; ±10%
C193	Same as C111
C194	Same as C192
C195	Fixed: paper; 4 μf; 1000 V; ±10%
C196	Same as C119
C197	Fixed: paper; .25 μf; 3000 V; +20, −10%
C198	Same as C197
C199	Same as C197
C200	Same as C197
C201	Same as C197
C202	Fixed: paper; .01 μf; +20, −10%; 1000 V; dcw
C203	Variable: ceramic; 3-12 μμf; 1300 V; flash test
C204	Same as C121
C205	Same as C115
C206	Same as C121
	FUSES
F101	Cartridge: 5 amp; 250 V.
F102	Cartridge: ½ amp; 250 V.
F103	Cartridge: 3 amp; 250 V.
F104	Cartridge: 10 amp; 25 V.
I101	LAMP, incandescent: 0.25 amp; 6.3 V.
	INDUCTORS
L101	Variable: 7.0-27.6 μh.
L102	Variable: 13.8-53.2 μh.
L103	Same as L102
L104	Same as L102
L105	Fixed: 70 μh; ±5%
L106	Variable: 70-250 μh.
L107	Variable: 996 to 2916 μh.
L108	Variable: 15 to 42 mh.
L109	Same as L102
L110	Same as L101
L111	Fixed: 750 μh; ±5%
L112	Variable: 150-500 μh.
L113	Same as L112
L114	Fixed: 170 μh; ±5%
L115	Fixed: filter; 7 h. @ 500 ma.
L116	Fixed: filter; 19 h.
	RESISTORS
R101	Fixed: metallized; 2.2 megohm; ½ W; ±5%
R102	Fixed: composition; 22,000 ohm; ½ W; ±5%
R103	Same as R101
R104	Fixed: composition; 330,000 ohm; ½ W; ±5%
R105	Fixed: composition; 1 megohm; ½ W; ±10%
R106	Fixed: composition; 47 ohm; ½ W; ±10%
R107	Fixed: composition; 1000 ohm; 1 W; ±10%
R108	Variable: composition; 500 ohm; ½ W; ±20%

Parts and Spare Parts by Symbol Designation

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION
	RESISTORS
R109	Variable: composition; 1000 ohm; ½ W; ±20%
R110	Fixed: composition; 110 ohm; ½ W; ±5%
R111	Fixed: composition; 10 megohm; ½ W; ±10%
R112	Same as R106
R113	Fixed: composition; 1000 ohm; 1 W; ±5%
R114	Fixed: composition; 10,000 ohm; 3 W; ±10%; uninsulated
R115	Fixed: composition; 68,000 ohm; 1 W; ±10%
R116	Fixed: composition; 120,000 ohm; ½ W; ±10%
R117	Same as R106
R118	Fixed: composition; 51 ohm; ½ W; ±5%
R119	Fixed: composition; 1300 ohm; 2 W; ±5%
R120	Fixed: wire wound; 5000 ohm; 5 W; non-inductive; ±5%
R121	Fixed: composition; 22,000 ohm; 3 W; ±10%; uninsulated
R122	Fixed: composition; 220,000 ohm; 1 W; ±10%
R123	Fixed: composition; 15,000 ohm; ½ W; ±10%
R124	Same as R116
R125	Same as R106
R126	Same as R106
R127	Fixed: wire wound; 200 ohm; 10 W; ±5%; non-inductive
R128	Same as R106
R129	Same as R106
R130	Fixed: wire wound; 1500 ohm; 25 W; ±5%; non-inductive
R131	Same as R130
R132	Fixed: wire wound; 10,000 ohm; 10 W; ±5%
R133	Fixed: composition; 4.7 megohm; 1 W; ±10%
R134	Same as R133
R135	Variable: two section; composition; 4 megohm; 2 W; ±20%
R136	Same as R105
R137	Same as R107
R138	Same as R107
R139	Variable: composition; 2000 ohm; ½ W; ±20%; C. T.
R140	Same as R132
R141	Same as R105
R142	Fixed: composition; 330 ohm; ½ W; ±10%
R143	Fixed: composition; 1000 ohm; ½ W; ±10%
R144	Same as R143
R145	Fixed: composition; 1500 ohm; ½ W; ±10%
R146	Same as R105
R147	Fixed: composition; 3300 ohm; 2 W; ±10%
R148	Fixed: composition; 150 ohm; ½ W; ±10%
R149	Same as R105
R150	Fixed: composition; 68 ohm; ½ W; ±10%
R151	Fixed: composition; 33,000 ohm; 1 W; ±10%
R152	Fixed: composition; 100,000 ohm; 2 W; ±10%
R153	Same as R106
R154	Variable: composition; 1000 ohm; ½ W; ±20%
R155	Fixed: composition; 47,000 ohm; 3 W; ±10%; uninsulated
R156	Fixed: composition; 680 ohm; ½ W; ±10%
R157	Fixed: composition; 470,000 ohm; ½ W; ±10%
R158	Same as R105
R159	Same as R148
R160	Fixed: composition; 470,000 ohm; 1 W; ±10%
R161	Fixed: composition; 22,000 ohm; 1 W; ±10%
R162	Same as R106
R163	Fixed: composition; 220,000 ohm; ½ W; ±10%
R164	Same as R148
R165	Fixed: composition; 4700 ohm; 1 W; ±10%
R166	Fixed: composition; 47,000 ohm; 1 W; ±10%
R167	Same as R163
R168	Fixed: composition; 750 ohm; 1 W; ±5%
R169	Same as R148
R170	Same as R166
R171	Same as R143
R172	Fixed: composition; 4700 ohm; ½ W; ±10%
R173	Same as R123
R174	Same as R168
R175	Same as R166
R176	Same as R166
R177	Same as R157
R178	Same as R157
R179	Same as R157
R180	Variable, composition; 200,000 ohm; ½ W; ±20%
	RESISTORS
R181	Fixed: composition; 330,000 ohm; 1 W; ±10%
R182	Variable, composition; 500,000 ohm; ½ W; ±20%
R183	Same as R181
R184	Same as R181
R185	Same as R181
R186	Same as R166
R187	Variable: composition; 50,000 ohm; ½ W; ±20%
R188	Fixed: composition; 33,000 ohm; 1 W; ±5%
R189	Fixed: composition; 18,000 ohm; 1 W; ±5%
R190	Same as R148
R191	Same as R109
R192	Fixed: composition; 470 ohm; ½ W; ±10%
R193	Same as R147
R194	Fixed: composition; 180 ohm; ½ W; ±10%
R195	Fixed: composition; 15,000 ohm; 1 W; ±10%
R196	Same as R157
R197	Same as R101
R198	Fixed: wire wound; 40,000 ohm; 5 W; ±5%
R199	Fixed: composition; 100,000 ohm; 1 W; ±10%
R200	Same as R199
R201	Fixed: composition; 47,000 ohm; ½ W; ±10%
R202	Same as R166
R203	Same as R201
R204	Same as R106
R205	Same as R120
R206	Variable; composition; 5000 ohm; ½ W; ±20%
R207	Same as R106
R208	Same as R106
R209	Same as R122
R210	Same as R123
R211	Same as R123
R212	Same as R157
R213	Fixed: wire wound; 300 ohm; 10 W; ±5%; non-inductive
R214	Same as R106
R215	Same as R106
R216	Fixed: wire wound; 4000 ohm; 25 W; ±5%; non-inductive
R217	Same as R216
R218	Fixed: wire wound; 20,000 ohm; 10 W; ±5%
R219	Same as R133
R220	Same as R133
R221	Same as R135
R222	Fixed: metallized; 1 megohm; ½ W; ±5%
R223	Fixed: composition; 150,000 ohm; ½ W; ±5%
R224	Fixed: composition; 430,000 ohm; ½ W; ±5%
R225	Same as R166
R226	Same as R101
R227	Fixed: composition; 110,000 ohm; ½ W; ±5%
R228	Same as R107
R229	Same as R107
R230	Variable: composition; 2000 ohm; 2 W; ±20%; C. T. Spec. Taper
R231	Same as R106
R232	Same as R148
R233	Same as R114
R234	Same as R147
R235	Same as R151
R236	Same as R160
R237	Same as R187
R238	Same as R163
R239	Fixed: composition; 6800 ohm; 1 W; ±10%
R240	Fixed: composition; 33,000 ohm; 3 W; ±10% uninsulated
R241	Same as R114
R242	Same as R107
R243	Fixed: composition; 30,000 ohm; ½ W; ±5%
R244	Fixed: composition; 56,000 ohm; ½ W; ±5%
R245	Fixed: composition; 24,000 ohm; ½ W; ±5%
R246	Fixed: composition; 100,000 ohm; ½ W; ±5%
R247	Same as R192
R248	Same as R192
R249	Same as R107
R250	Variable: composition; 1 megohm; ½ W; ±20%; SPST Switch (S109)

Parts and Spare Parts by Symbol Designation

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION
	RESISTORS
R251	Same as R106
R252	Same as R115
R253	Same as R187
R254	Same as R166
R255	Same as R166
R256	Fixed: composition; 18,000 ohm; 2 W; ±10%
R257	Same as R106
R258	Same as R106
R259	Same as R106
R260	Same as R122
R261	Same as R199
R262	Same as R166
R263	Same as R166
R264	Same as R107
R265	Fixed: composition; 680,000 ohm; 1 W; ±10%
R266	Same as R265
R267	Same as R265
R268	Same as R265
R269	Same as R265
R270	Same as R265
R271	Same as R199
R272	Same as R265
R273	Same as R265
R274	Same as R265
R275	Same as R265
R276	Same as R265
R277	Same as R265
R278	Fixed: metallized (IRC); 4.7 megohm; ½ W; 5%
R279	Fixed: metallized (IRC); 240,000 ohm; ½ W; 5%
R280	Fixed: composition; 120,000 ohm; 1 W; ±10%
R281	Variable: wire wound; 2000 ohm; 2 W; ±10%
R282	Same as R165
R283	Same as R142
R284	Fixed: composition; 2200 ohm; ½ W; ±10%
	SWITCHES
S101	Rotary; 2P3T
S102	Toggle; DPDT
S103	Rotary; 2P2T
S104	Rotary; 4P4T
S105	Rotary; 8P9T
S106	Same as S103
S107	Rotary; SP4T
S108	Rotary; 3P4T
S109	Part of R250
S110	Toggle; SPDT
S111	Toggle; SPST
	TRANSFORMERS
T101	AF: pulse; unshielded; 1½" lg x 1-7/16" wd x 1½" h overall; three windings; turns ratio 1:1:1; max. pulse voltage = 1500 v; d-c resistance (1-2) 0.413 ohm, (3-4) 0.445 ohm, (5-6) 0.477 ohm.
T102	Plate: metal case; 6.120" lg x 5.260" wd x 7.067" h; pri 115 v, 50 cps; secd 500 v each side CT, 0.5 amp; shielded pri.
T103	Plate: metal case; 3.230" lg x 2.970" wd x 3.860" h; pri No. 1 115 v, 50 cps; pri No. 2 115 v, 50 cps; secd 800 v (both pri windings in series across line), 1600 v (one pri), 0.005 amp; shielded pri.

SYMBOL DESIG.	NAME OF PART AND DESCRIPTION
	TRANSFORMERS
T104	Filament: metal case; 3.650" lg x 3.280" wd x 4.290" h; pri 115 v, 50 cps; secd No. 1 6.3 v, CT, 1.0 amp; secd No. 2 2.5 v, 2 amp; secd No. 3 2.5 v, 2 amp; shielded pri & sec No. 1.
T105	Filament: metal case; 6.120" lg x 5.260" wd x 7.060" h; pri 115 v, 50 cps; secd No. 1 6.3 v, 3 amp, CT; secd No. 2 7.0 v, 5 amp, CT; secd No. 3 6.3 v, 5 amp, CT; secd No. 4 5.0 v, 6 amp, CT; secd No. 5 7.5 v, 10 amp, CT; shielded pri.
	TUBES
V101	Electron: type 6AG7
V102	Electron: type 6AC7
V103	Same as V101
V104	Electron: type 807
V105	Same as V104
V106	Electron: type 6SN7GT
V107	Same as V106
V108	Same as V102
V109	Same as V102
V110	Same as V106
V111	Electron: type 6SJ7
V112	Same as V102
V113	Same as V102
V114	Same as V102
V115	Same as V106
V116	Same as V111
V117	Same as V102
V118	Same as V101
V119	Same as V104
V120	Same as V104
V121	Same as V102
V122	Same as V101
V123	Same as V101
V124	Same as V106
V125	Electron: type 5JP1
V126	Electron: type 5R4GY
V127	Same as V126
V128	Electron: type 6B4G
V129	Same as V128
V130	Same as V128
V131	Same as V111
V132	Electron: type 003/VR105
V133	Electron: type 2X2
V134	Same as V133
V135	RELAY, time-delay, Amperite type 6NO-20; SPST normally open; 115 v - 3 amp contacts (a-c only); time delay: 20 sec ±7 sec; heater rating: 6.3 v - 0.3 amp.
W101	CABLE, inter-connecting: consisting of: a six-foot length of 17 conductor cable and connectors 9-185 (AN-3106-36-13P) and 9-211 (AN-3106-36-13S)
W102	POWER CORD
W103	PROBE, assembly: one 240K-½W resistor (R279); one 4.7 meg-½W resistor (R278); one 3-12 μμf ceramic trimmer (C203); one 0.01 μf 1000 vdc capacitor (C202)
Z101	TIME DELAY: type 267

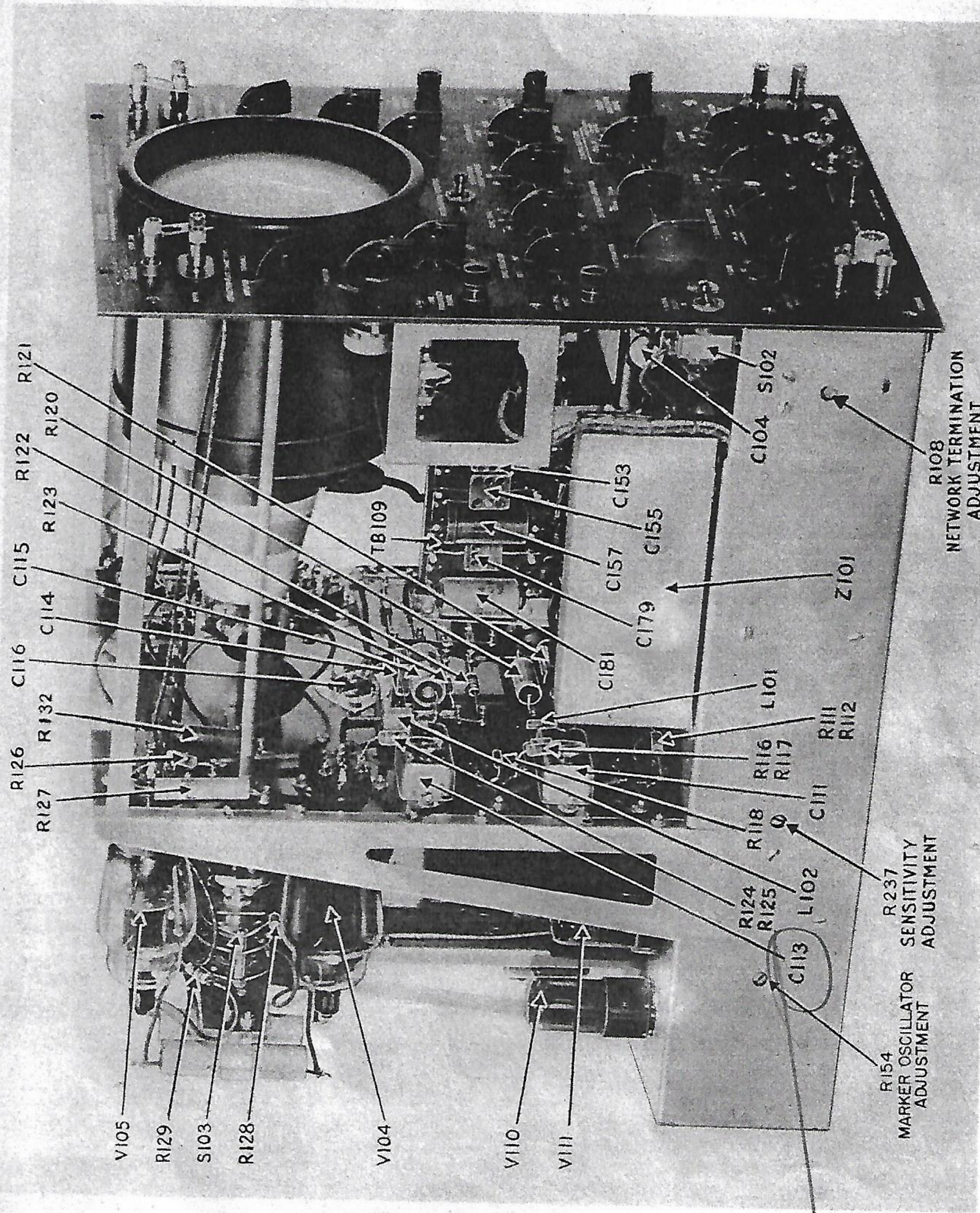

FIG. 3 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

INDICATOR CHASSIS — Left Side View

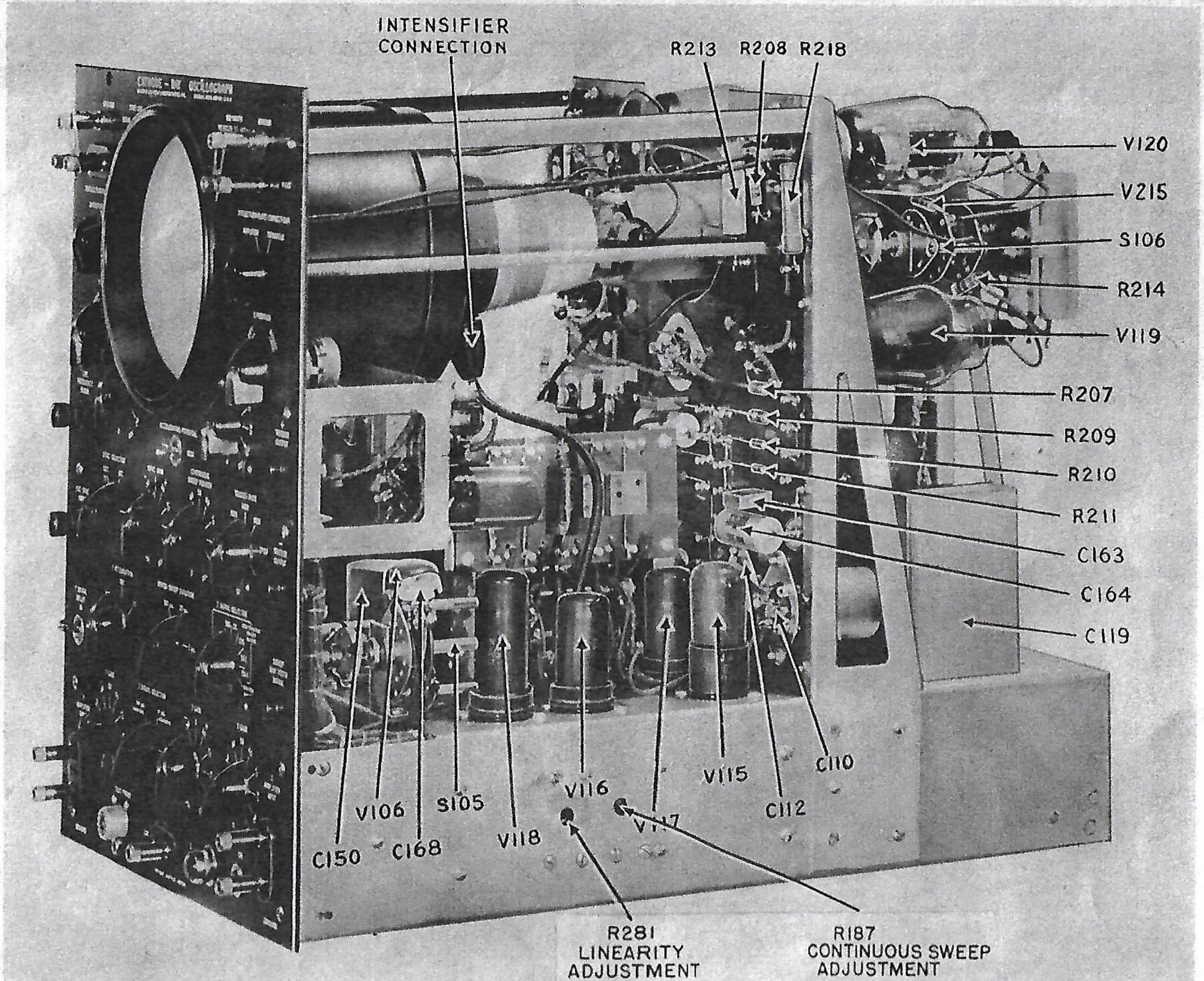

FIG. 4 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

INDICATOR CHASSIS — Right Side View — (See from Front)

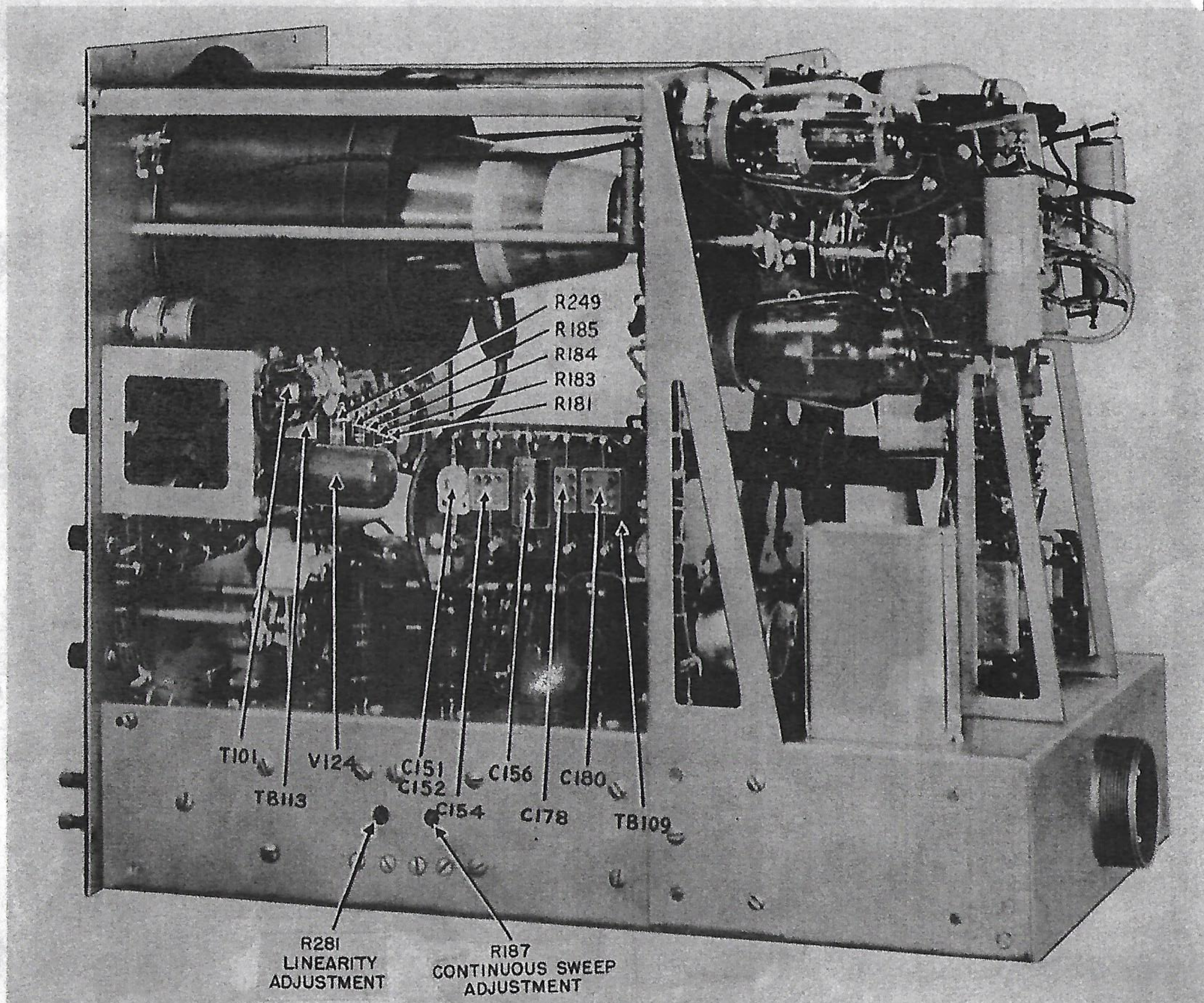

FIG. 5 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

INDICATOR CHASSIS — Right Side View — (Seen from Rear)

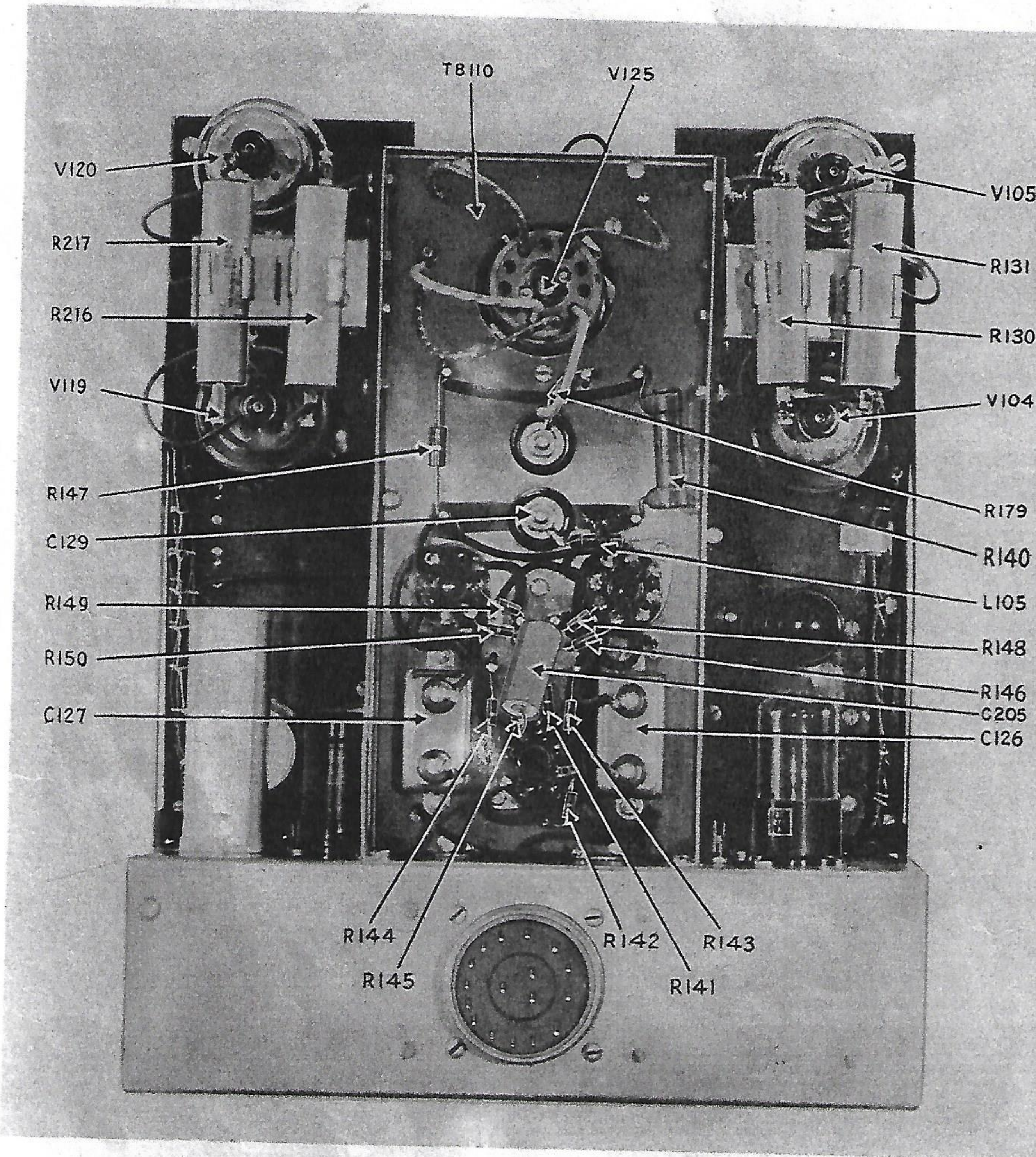

FIG. 6 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

INDICATOR CHASSIS — Rear View

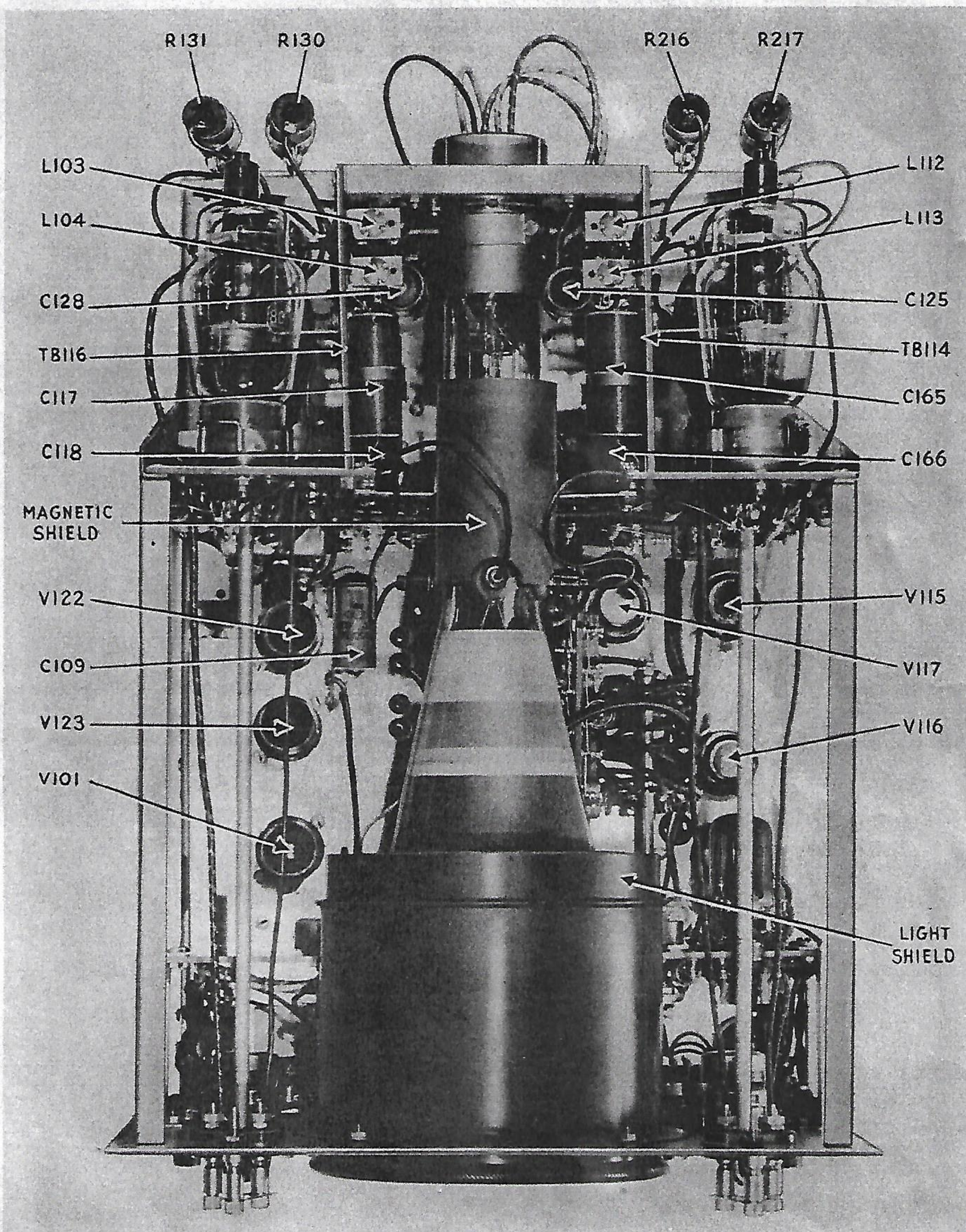

FIG. 7 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

INDICATOR CHASSIS — Top View

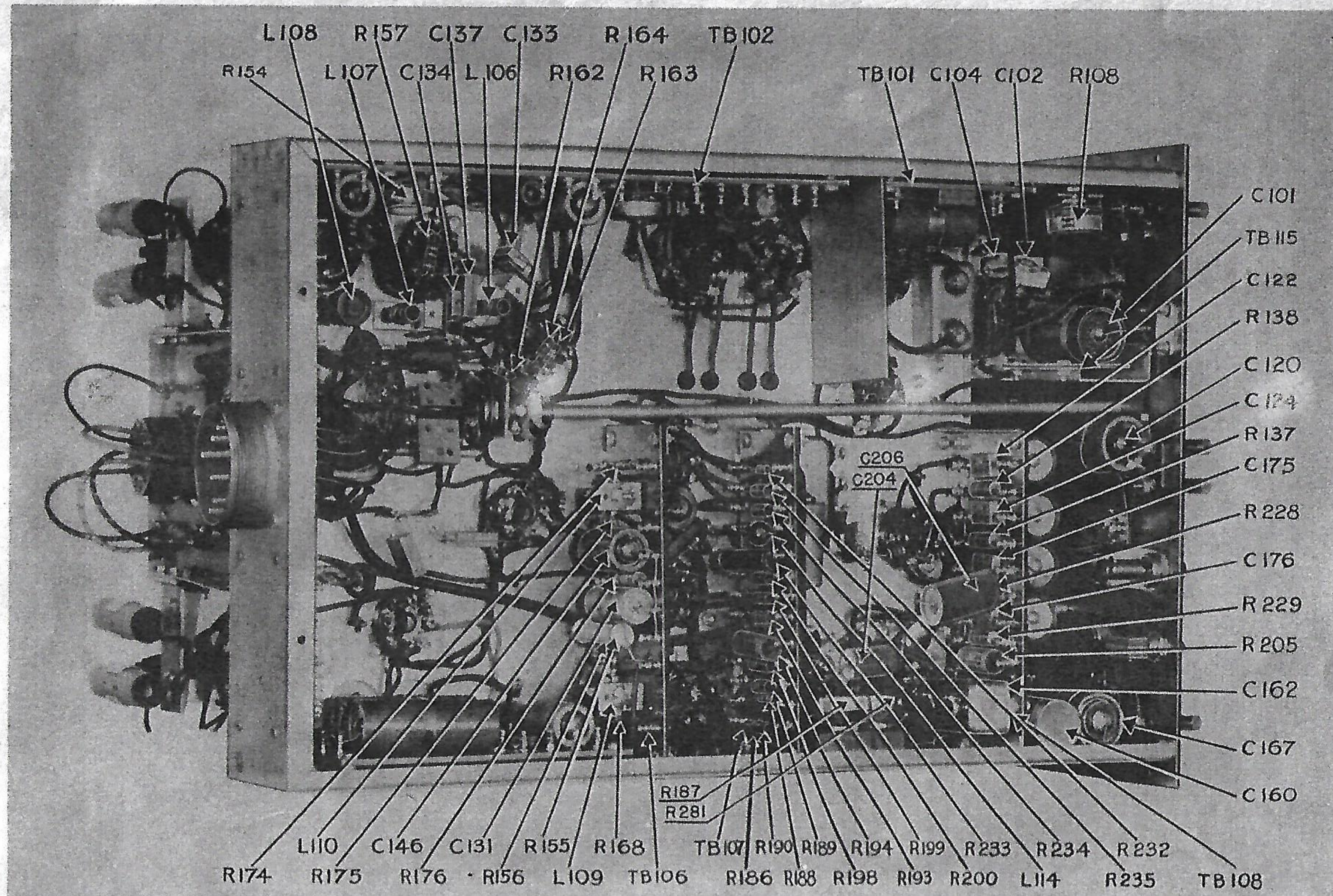

FIG. 8 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

INDICATOR CHASSIS — Bottom View — (Seen from Rear)

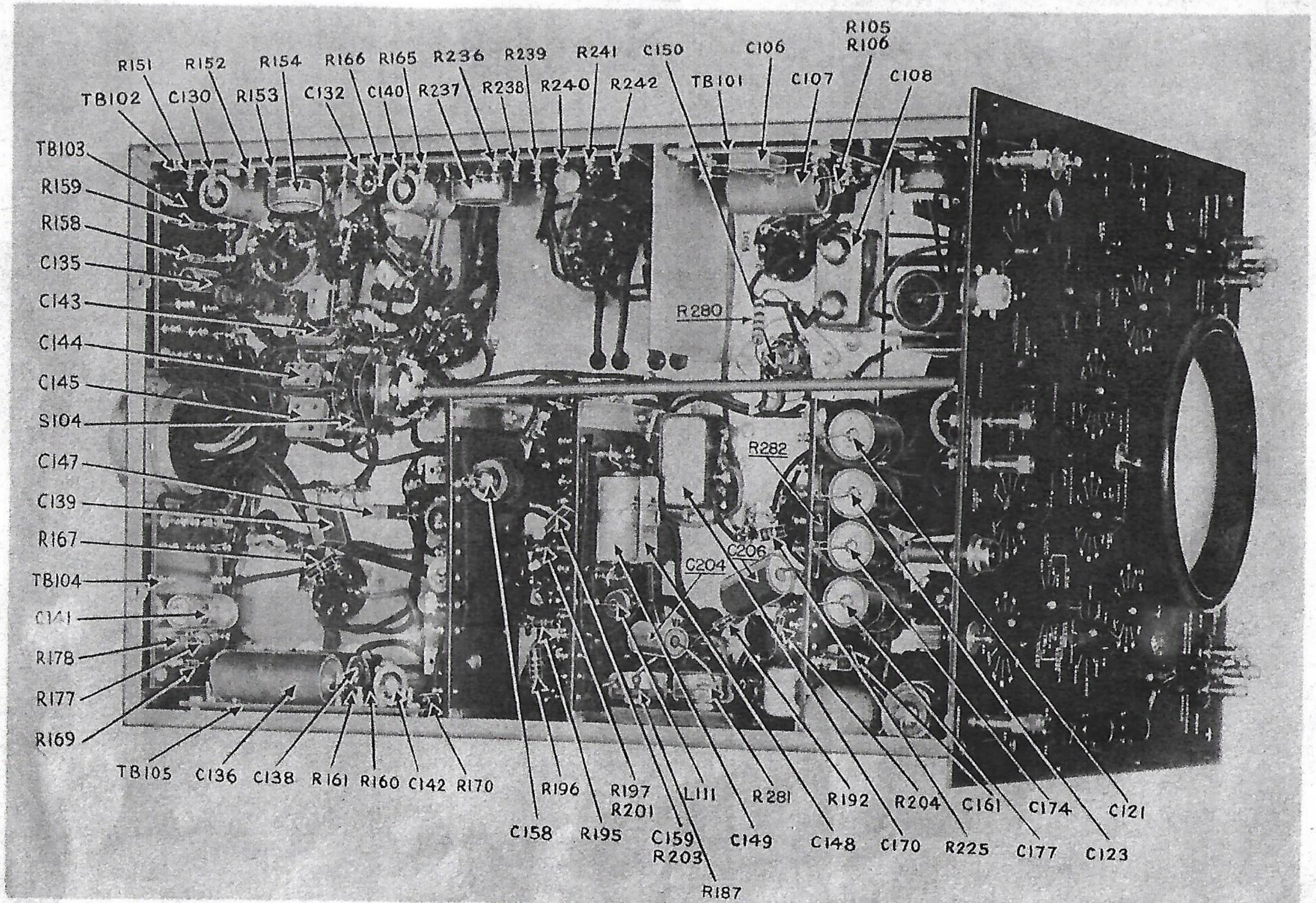

FIG. 9 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

INDICATOR CHASSIS — Bottom View — (Seen from Front)

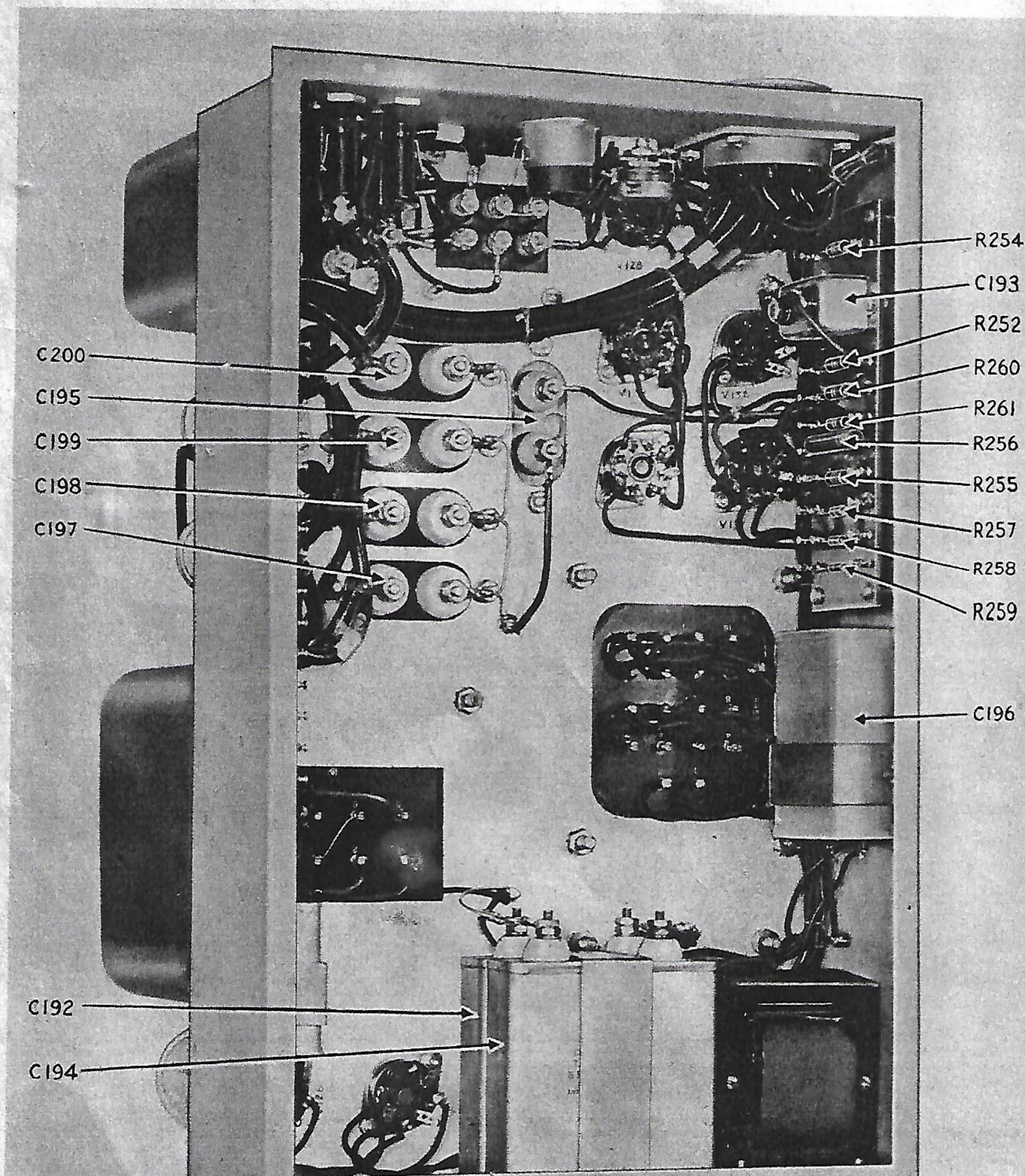

FIG. 10 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

POWER SUPPLY UNIT — Bottom, View A

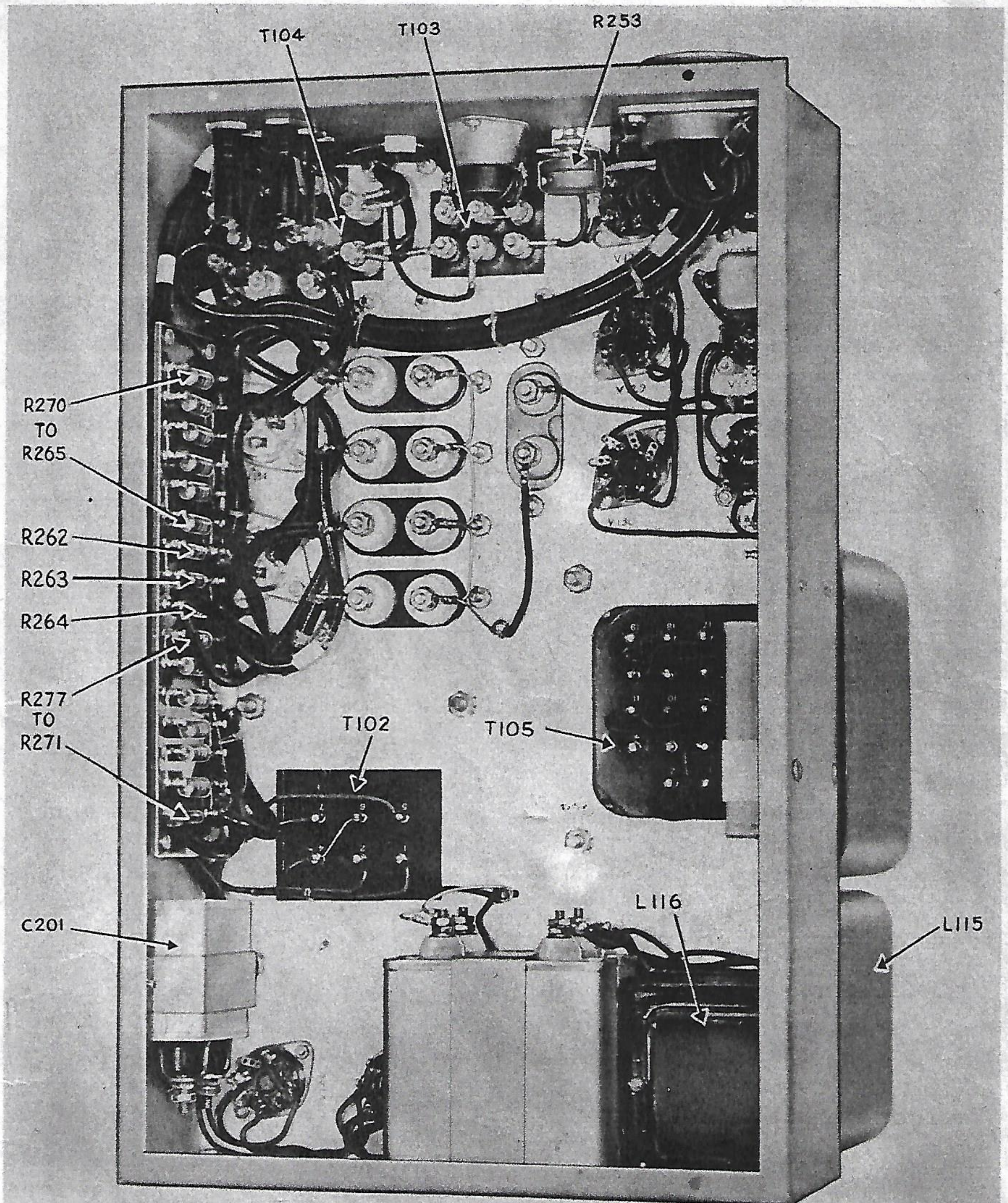

FIG. 11 — DU MONT TYPE 248 CATHODE-RAY OSCILLOGRAPH

POWER SUPPLY UNIT — Bottom, View B