the GENERAL RADIO Experimenter

Since 1915 — Manufacturers of Electronic Apparatus for Science and Industry

VOLUME XXIX No. 11 APRIL, 1955

A NEW SYSTEM FOR AUTOMATIC DATA DISPLAY

Today's shortage of new engineers points up the increasing importance of more efficient use of our available engineering man-hours. Just as improvements in tooling have extended the productivity of the factory worker, so will improvement in the tools of the research worker enable him to do more work in less time. Automation in production has its counterpart in new techniques for automatic data presentation designed to save time for the engineer and to augment his productivity.

One of the simplest and most useful improvements in measuring techniques is the replacement of point-by-point measurements by data displayed as continuous functions of the independent variable. Very commonly, the independent variable is frequency, and sweep oscillators to serve as generators for these measurements are coming into widespread use. These sweep techniques are helping the development engineer to simplify measurements, are suggesting new solutions to complicated problems, and are speeding up adjustment and testing of components and circuits in production. Sweep oscillators for these uses change frequency as a function of time and provide a voltage that is a known function of that frequency

Figure 1. View of the new General Radio Sweep Drive and Amplitude-Regulating Power Supply set up to sweep a Type 1209-B Unit Oscillator.

See also "Automatic Sweep Drive for the Slotted Line," page 10.

Also

IN THIS ISSUE

to serve as a horizontal deflection voltage for a graphic recorder or cathode-ray oscilloscope.

Electronic or mechanical sweep oscillators covering various frequency ranges are available on the market. To avoid flicker when used with CRO display, they employ relatively fast repetition rates, usually related to the power-line frequency. The frequency of the electronic type is varied by a voltage-sensitive element in the frequency-determining circuit. In mechanical types, the frequency is similarly varied by a displacement-sensitive element. Large fractional variation in frequency is difficult to obtain with either of these systems. Although the electronic types are quiet, and insensitive to shock and vibration, they are limited in sweep range and are not suitable for high frequencies. Mechanical types, on the other hand, can be made to cover all frequencies, although the types using small vibrator-driven circuit elements usually suffer from similarly restricted sweep ranges. At audio frequencies, where very wide ranges must be considered, slow mechanical dial drives are sometimes used in connection with synchronized recorders. A speed of 3 decades in $2\frac{1}{2}$ minutes is common. General Radio's previously announced synchronous dial drives[1] are suitable for this service and provide speeds as fast as $6\frac{2}{3}$ seconds per octave to permit oscilloscope displays of data at audio frequencies.

At high frequencies, where the required sweep range is usually smaller, speeds should be high enough to give a continuous trace on an oscilloscope with a long-persistence screen, but not so high that extraneous transient effects occur when the performance of a high-Q circuit is being observed.

Intermediate between the speeds of 30 or 60 cycles per second, which do not produce flicker on a 'scope, and the lower speeds of the audio recorder, are the speeds around 1 cycle per second, which are fast enough to produce a satisfactory trace on a cathode-ray tube

[1] Littlejohn, H. C., "Motor Drives for Precision Dials and Beat-Frequency Oscillators", *General Radio EXPERIMENTER*, Vol. XXIX, No. 6, November 1954, pp. 1–3.

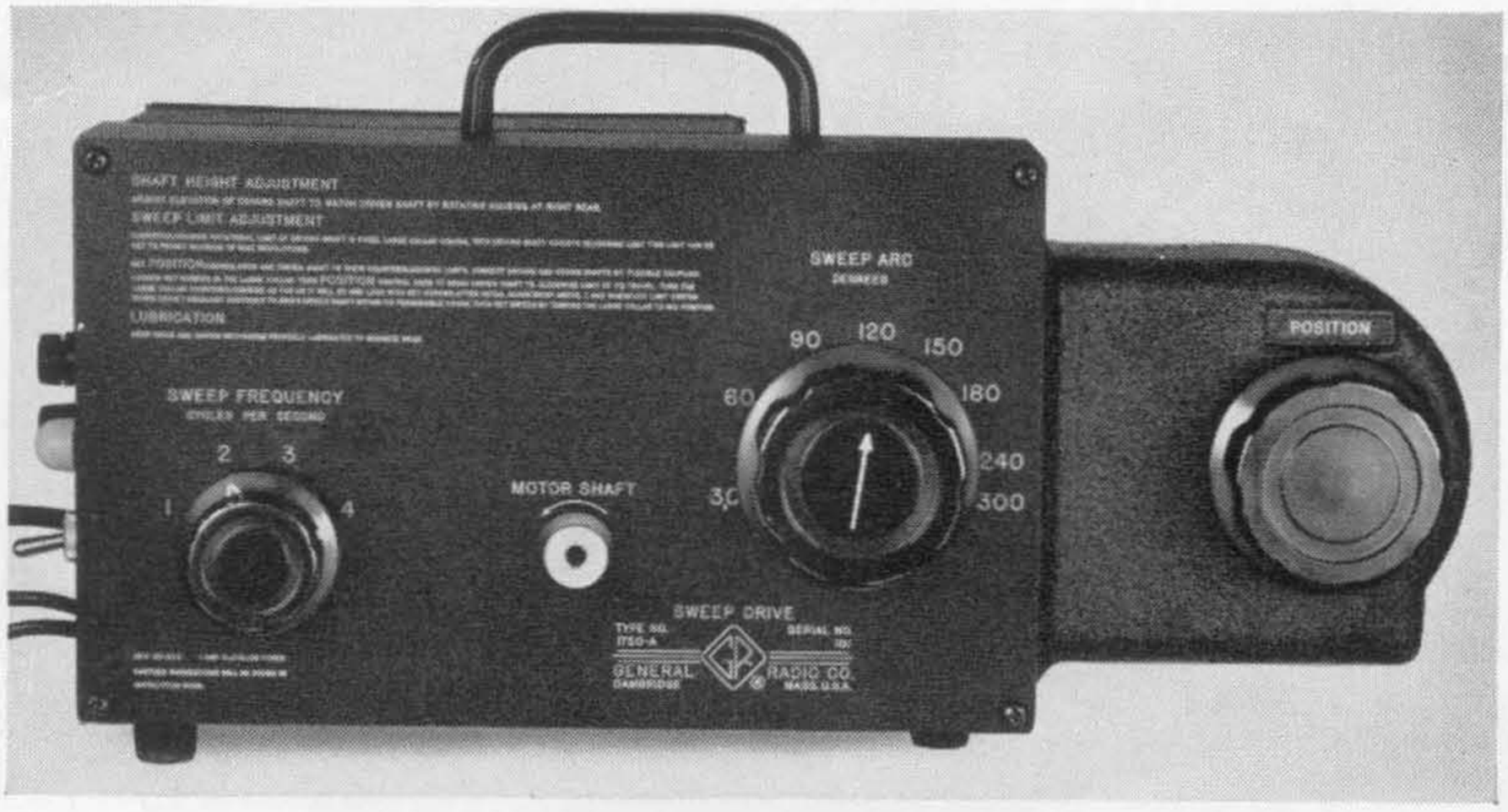


Figure 2. Front panel view of the Type 1750-A Sweep Drive, showing the SWEEP FREQUENCY, SWEEP ARC, and POSITION controls.

with a long-persistence screen and to permit observation of pattern changes without excessive delay. Most conventional oscillator dials can be turned back and forth at these speeds without damage to the oscillator. The new General Radio Sweep Drive shown in Figure 1 is designed to perform this function.

The new drive is unique because it adapts manually operated equipment to automatic sweep applications. It can be attached to the tuning knob of any oscillator to operate as an artificial hand, turning the oscillator dial back and forth over the desired frequency range and supplying a horizontal sweeping voltage proportional to shaft angle.

A very important requirement of any sweep generator is that the output voltage be constant with frequency, since any variation shows up as a part of the displayed curve. The problem of maintaining an adequate degree of flatness of output increases with the range to be covered, and, for wide sweep ranges, output regulation is usually necessary. General Radio Unit Oscillators cover very wide frequency ranges and are therefore particularly suitable for use with the Sweep Drive. Since they use separate power supplies, they are easily adaptable to output regulation. The new TYPE 1263-A Amplitude-Regulating Power Supply is designed primarily for use with these oscillators to maintain constant output.

TYPE 1750-A SWEEP DRIVE

The new sweep drive shown in Figure 2 can be attached to shafts, knobs or dials to drive them in reciprocating motion at speeds between 0.5 and 5 cycles per second. Two independent controls are provided to adjust the sweep arc and the center position of the sweep while the drive shaft is in motion. The sweep arc is adjustable between 30 and 300 degrees, and the position control has a range of nine full turns of the drive shaft between adjustable stops.

The height of the drive shaft is adjustable from $2\frac{1}{2}$ to $4\frac{7}{8}$ inches above the bench. The drive shaft can be coupled directly to shafts whose diameters are $\frac{1}{4}$ inch and $\frac{3}{8}$ inch, and a universal clutch is provided for attachment to knobs and dials up to 4 inches in diameter.

Mechanical System

The diagram of Figure 3 shows the operation of the drive. The Sweep Drive is powered by a 5000-rpm universal motor, operated with fixed field supply and adjustable armature supply, (SWEEP FREQUENCY control) as in the General Radio Type 1701-AU Variac® Speed Control. A crank is driven through two belts to provide

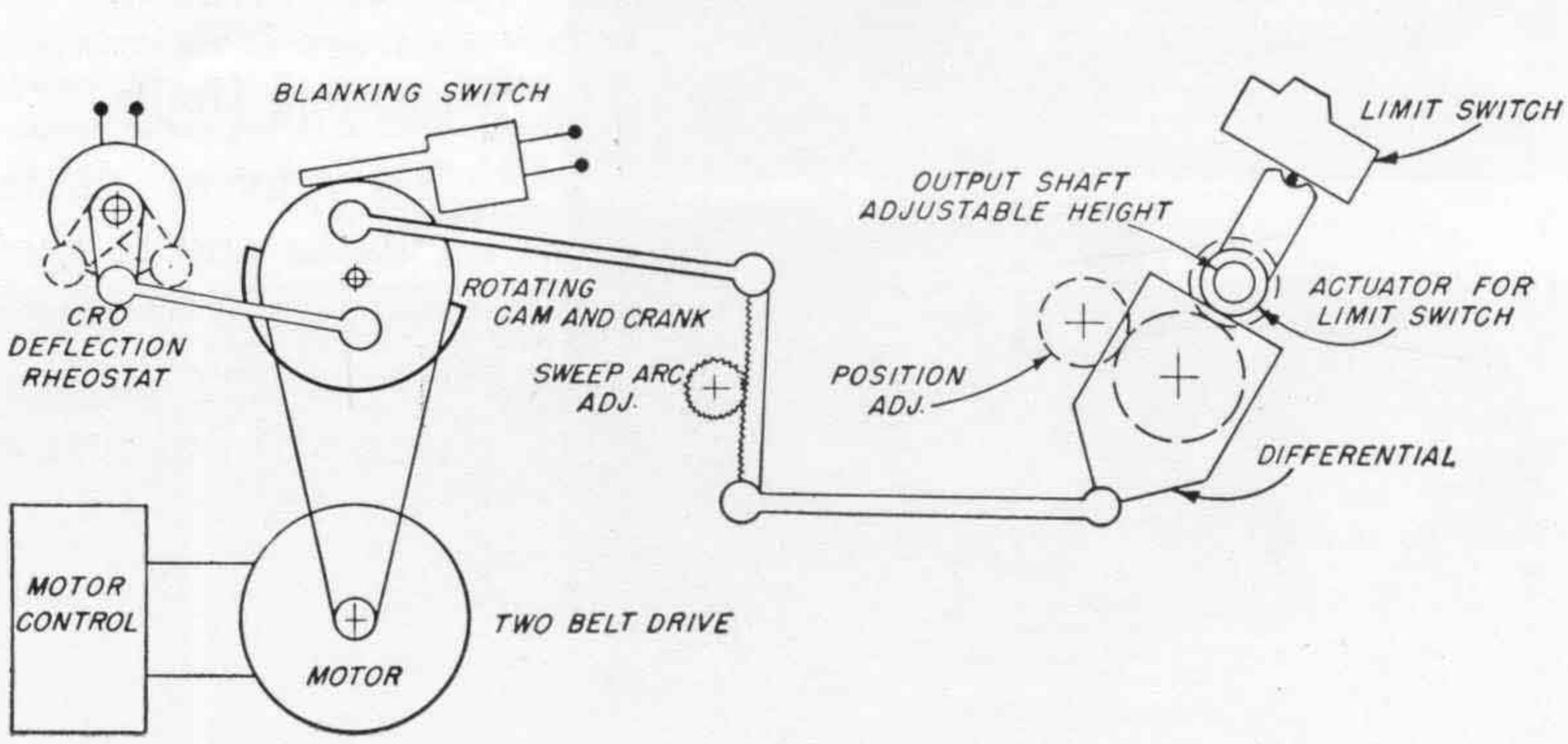


Figure 3. Elementary mechanical diagram of the Sweep Drive.

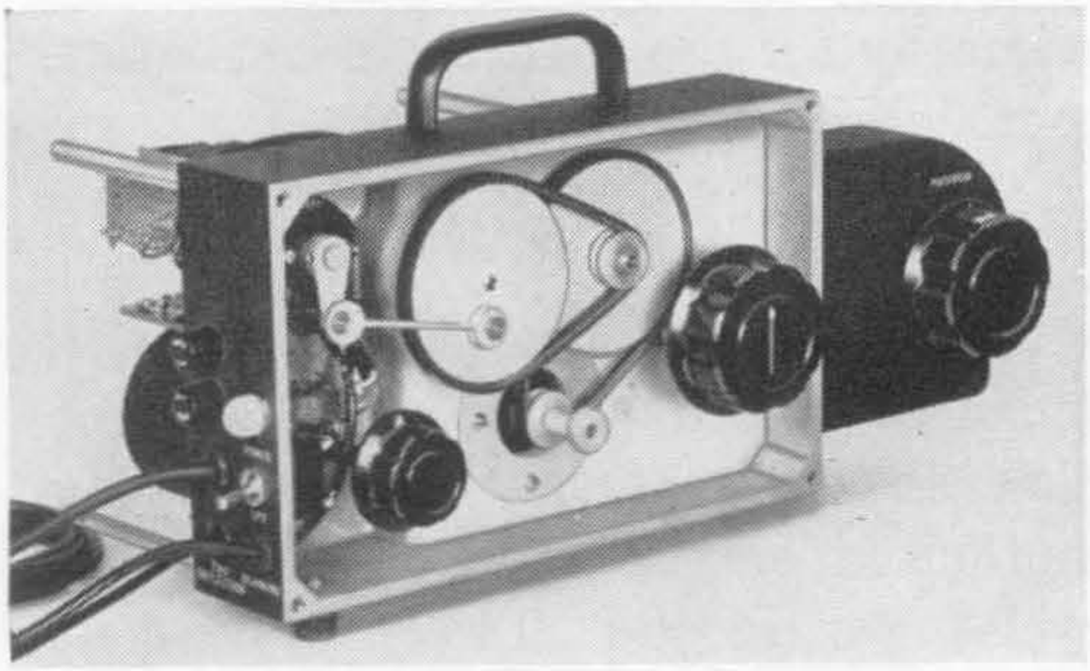


Figure 4. View from front with panel removed. The potentiometer that supplies the horizontal sweep voltage can be seen in the upper left-hand corner.

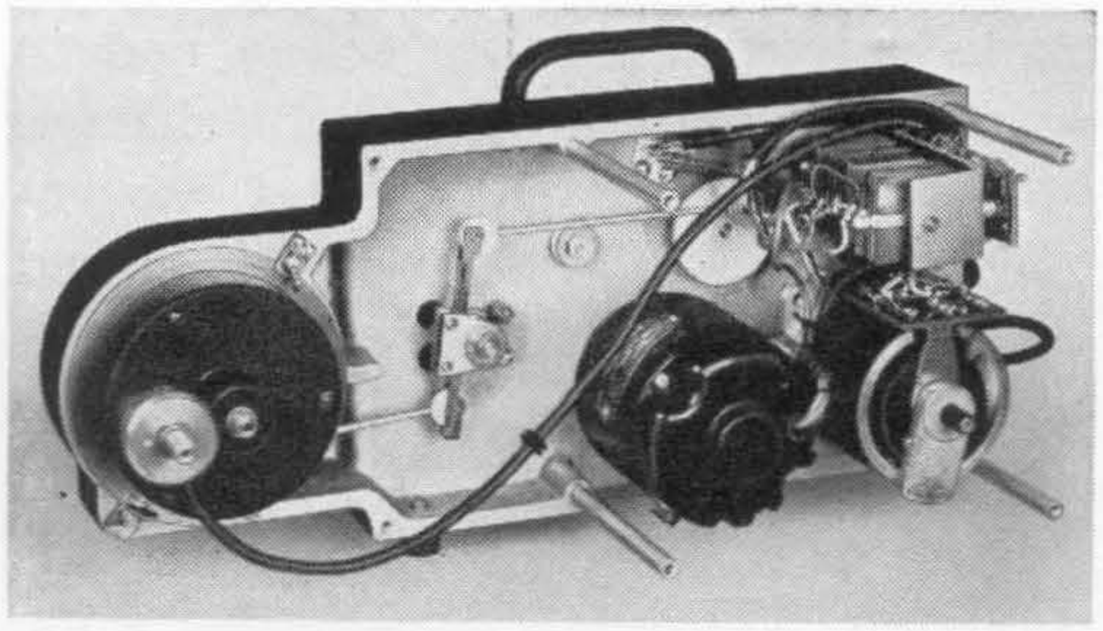
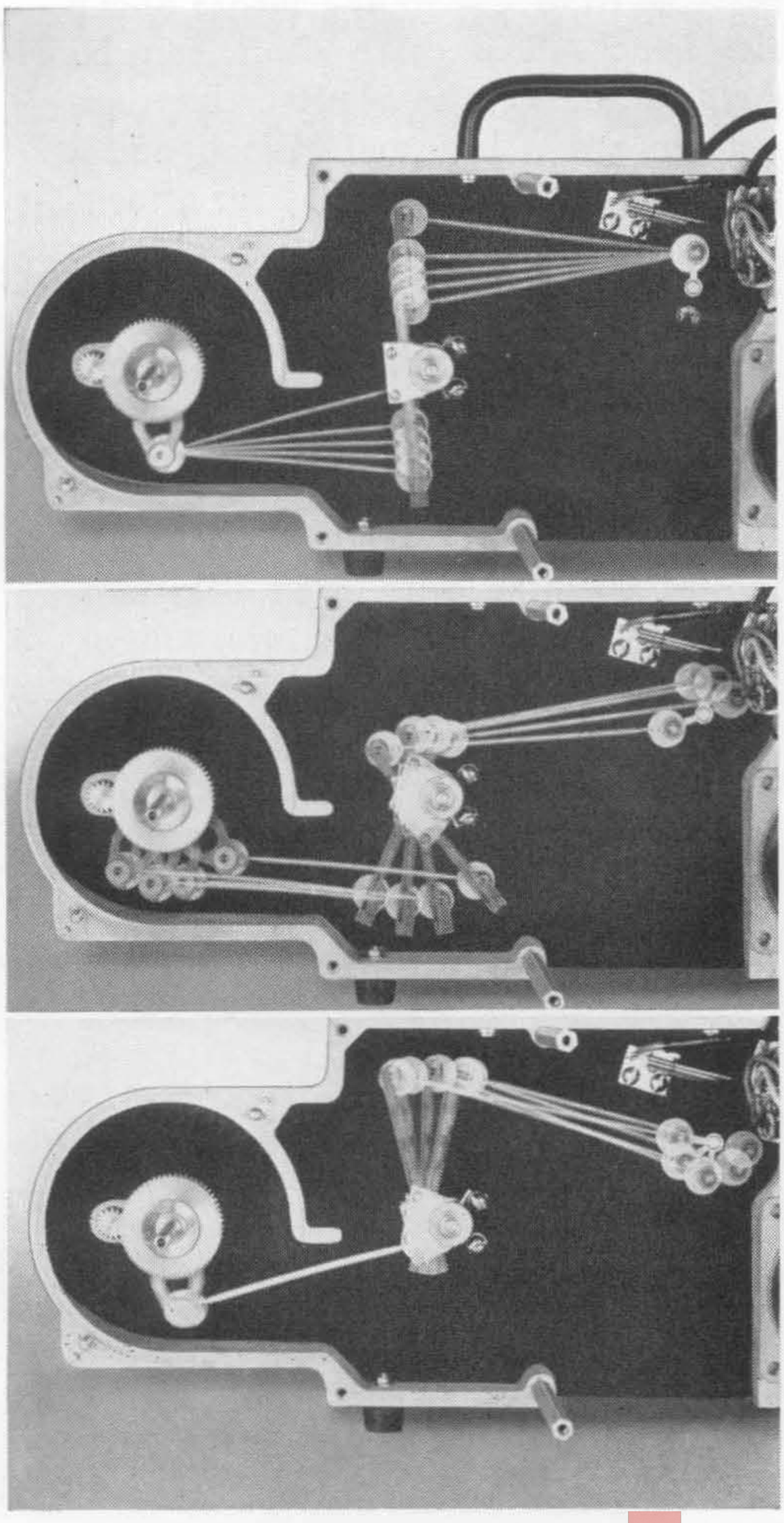


Figure 5. Rear view with cover removed, showing motor, motor control circuits, driving crank, and adjustable rack.

Figure 6. Multiple exposure views showing the action of the sliding rack. The upper view shows the driving mechanism at rest in the center of its stroke, and the range over which the rack can be adjusted by means of the position control. The center view shows the drive in motion at maximum sweep arc, and the lower view similarly shows the operation at minimum arc.



the necessary speed reduction. Operated from the crank through a connecting rod is a rack, adjustable in position by the SWEEP ARC control. At the opposite end of the adjustable rack is a second connecting rod, which operates through a differential (the POSITION control) to turn the output shaft.

Figure 4 shows the motor shaft, pulleys, and belts through which the speed reduction is obtained. In Figure 5, a view from the rear of the assembly, the motor, main driving crank, and sliding rack are visible. Figure 6, a series of multiple exposure photographs, shows the sliding rack in different positions and illustrates how the sweep arc is changed by adjustment of the point at which the rack pivots. At the left is the differential. In Figure 7, are shown the output coupling shaft, with its two flexible couplings, and details of the universal clutch.

Operating Limits

To prevent damage to the driven oscillator and to the sweep drive itself, speeds must be kept at safe values. The forces acting on the driven device increase with the moment of inertia of the

moving parts and with their angular acceleration. The accelerating forces increase 1000:1 when the controls are changed from 30° and 0.5 cycles per second to 300° and 5 cycles per second. In any specific application, the sweep arc is determined by the requirements of the measurement to be made. The highest speeds should be used only with small-angle sweeps, with the speed being decreased correspondingly as the arc increases.

In reciprocating motion, forces vary harmonically and reverse gradually two times each cycle. In practice, small clearances between the shafts and bearings prevent a gradual reversal. This small play, which can never be eliminated, is the cause of backlash in manual operation and of pounding in the motor drive. The rated maximum torque of the drive shaft is 24 ounce-inches. No definite limit can be specified for the accelerating forces. Their effect can be estimated by the amount of pounding they cause. As a protection of the driven device, excessive force (about five times rated torque) will cause slipping in the POSITION control.

For additional protection, a built-in limit switch disconnects and brakes the motor when the preset limits of shaft travel are accidentally exceeded. The two limits can be set apart by nine full turns of the output shaft, which is useful

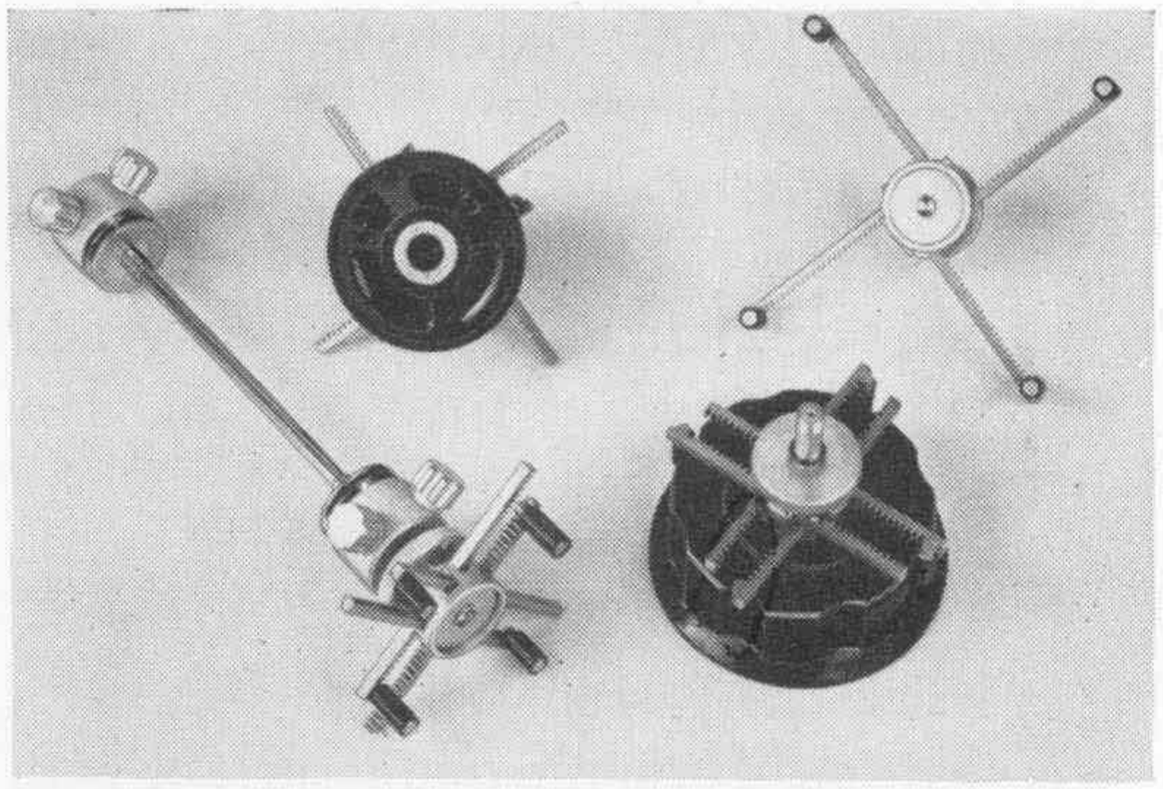


Figure 7. View of the coupling attachments furnished with the Sweep Drive. At left is the coupling shaft, to which has been attached the universal clutch. The other views show the clutch and the clutch attached to a knob.

when the drive is coupled to the slow-motion drive shaft of an oscillator.

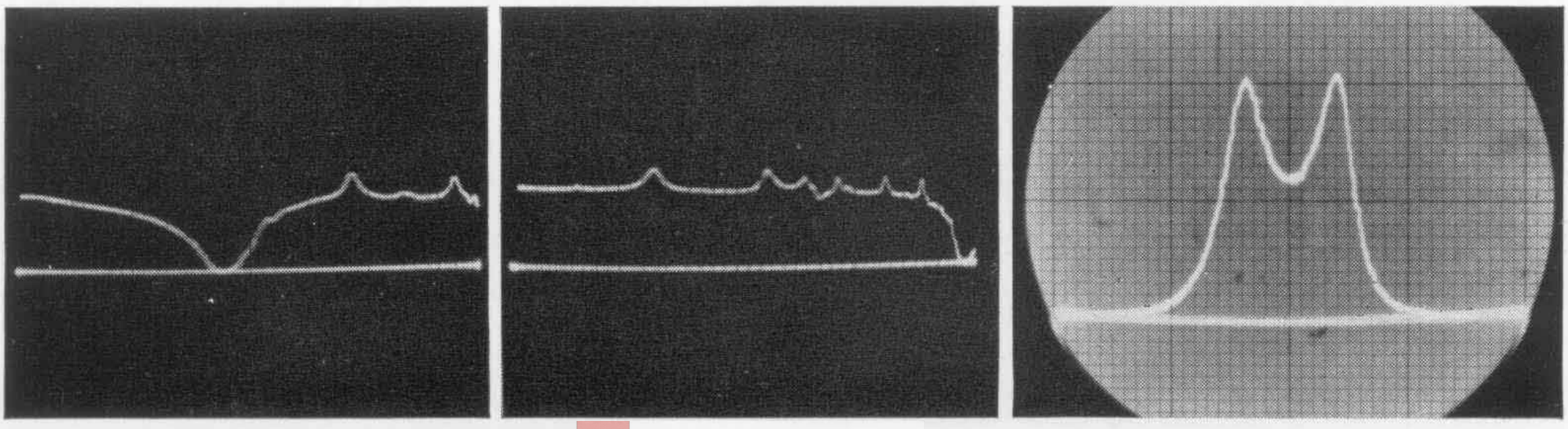
Use With Unit Oscillators

Current models of General Radio Unit Oscillators can all be used with the Sweep Drive. These oscillators are:

Type No.	*Frequency Range*
1211-A	0.5 to 5 Mc and 5 Mc to 50 Mc
1215-B	50–250 Mc
1209-B	250–920 Mc
1208-B	65–500 Mc
1218-A	900–2000 Mc

The last two models, TYPES 1208-B and 1218-A have sliding contacts in the tuned circuit, and, while not recommended for high-speed sweeping over long periods, they are satisfactory for use at low speeds with the Sweep Drive. The TYPE 1208-B, however, cannot be

Figure 8. Oscillograms of typical amplitude-frequency characteristics as displayed by the Sweep Drive. Left, Characteristic of a Type 874-FR Rejection Filter tuned to 76 Mc; sweep range is 48 to 260 Mc. Center, characteristic of same filter for the 250- to 900Mc range. Right, characteristic of a television front-end tuner set to channel 7; sweep range is 160 to 200 Mc. Vertical scale is square law for all of these oscillograms.



regulated by the Amplitude-Regulating Power Supply.

The older models, the TYPES 1208-A, 1209-A and 1215-A, were originally designed for manual operation only and therefore should be used only at slow speeds.

Use With Other Oscillators

When the Sweep Drive is used with oscillators of other manufacture, or with other General Radio oscillators, the same precautions should be taken. Sweep arcs should be held within safe limits, and speeds should be adjusted to conform to the mechanical limitations of the oscillator.

Calibration

The horizontal deflection voltage for the oscilloscope is obtained from a potentiometer, driven by a fixed crank, which can be seen in Figure 4. This voltage is proportional to the angle through which the oscillator shaft is turned. Owing to the geometry of the various linkages involved, the relation is closely linear in one direction but does not repeat on the return trace. A blanking contact is provided to suppress the return trace and to replace it by a zero reference axis.

The frequency distribution on the oscilloscope screen repeats the frequency distribution of the swept oscillator, but the actual frequencies corresponding to ordinate lines on the screen depend upon the settings of the arc and position controls. Accuracies comparable to the calibration accuracy of the swept oscillator are readily obtained by transferring the oscillator calibration to the screen. To facilitate this transfer, the end of the motor shaft has been extended through the panel of the sweep drive. With power on, and with the speed control at zero, an oscillator coupled to the output shaft can be set manually to a desired frequency by rotation of the motor shaft. The spot on the oscilloscope indicates the ordinate at which this frequency appears.

Applications

The flexibility of this new sweep drive, the fact that it can be used with manual-drive oscillators, and the consequent wide sweep ranges that can be obtained open up many new applications for sweep techniques. While the obvious uses are those involving the sweeping of an oscillator to display amplitude-frequency characteristics, the drive is not limited to these. It can be used in the display of any electrical quantity as a function of shaft angle, or of any other quantity, mechanical, for instance, that can be converted to an electrical voltage.

— EDUARD KARPLUS

TYPE 1263-A AMPLITUDE-REGULATING POWER SUPPLY

In sweep techniques, it is essential that the amplitude of the applied signal remain constant as a function of frequency. Since General Radio Unit Oscillators, like most high-frequency oscillators do not meet this condition when operated from a power supply with fixed-plate voltage, the Amplitude-Regulating Power Supply has been designed to maintain constant oscillator output.

The Type 1263-A Amplitude-Regulating Power Supply compares the d-c potential developed by the oscillator output rectifier with a d-c reference potential and applies a correction to the oscillator plate supply to minimize the difference. A maximum of 300 volts at 30 milliamperes is available for the oscillator plate. The d-c reference poten-

tial is adjustable from zero to 2.5 volts, which corresponds to an r-f output of zero to 2 volts with the Type 874-VR Voltmeter Rectifier. With an oscillator capable of producing at least 2 volts output with a 300-volt, 30-milliampere plate supply at all frequencies within its range, this power supply will maintain any preset level within 2 per cent over the entire frequency range.

Speed of Response

In sweep applications, rapid variations of the oscillator output are likely to occur, particularly in the u-h-f range. The Type 1263 Amplitude-Regulating Power Supply will change the plate current supplied at a rate of 3 milliamperes per millisecond or faster. For an oscillator requiring 30 milliamperes at 300 volts, this corresponds to a change of 30 volts per millisecond. Such an oscillator must not be swept at a speed that requires a rate of plate-supply variation exceeding this value. General Radio Unit Oscillators can be swept through their entire ranges in a sinusoidal manner at rates up to one cycle per second. With the Type 1750-A Sweep Drive, the maximum speed recommended for mechanical reasons is, incidentally, also one cycle per second for full-range sweeping. Fractional parts of the oscillator ranges can, of course, be swept at correspondingly more rapid rates.

Blanking

Phone-tip jacks on the panel permit connection to be made to an external contactor to cut off the oscillator plate supply. This connection is useful for blanking the oscillator output in sweep applications to eliminate the return sweep and to provide a reference base line on the cathode-ray oscilloscope. The Type 1750-A Sweep Drive is provided with a blanking contactor.

Calibration

An internal d-c vacuum-tube voltmeter, calibrated in terms of r-f output voltage, indicates the voltage at the output rectifier. The meter scale is quasi-logarithmic and covers an output voltage range of 0.1 to 2. An internal calibration means permits the meter to be standardized with a particular output rectifier. The calibration and zero adjustments are convenient, thumb-set controls on the panel of the instrument.

Circuit

The elementary schematic diagram (Figure 10) illustrates the principle of operation of the Type 1263-A Amplitude-Regulating Power Supply. The output rectifier develops a negative d-c potential proportional to the r-f amplitude at the oscillator output. This potential is applied to the voltmeter amplifier and to one grid of the first dif-

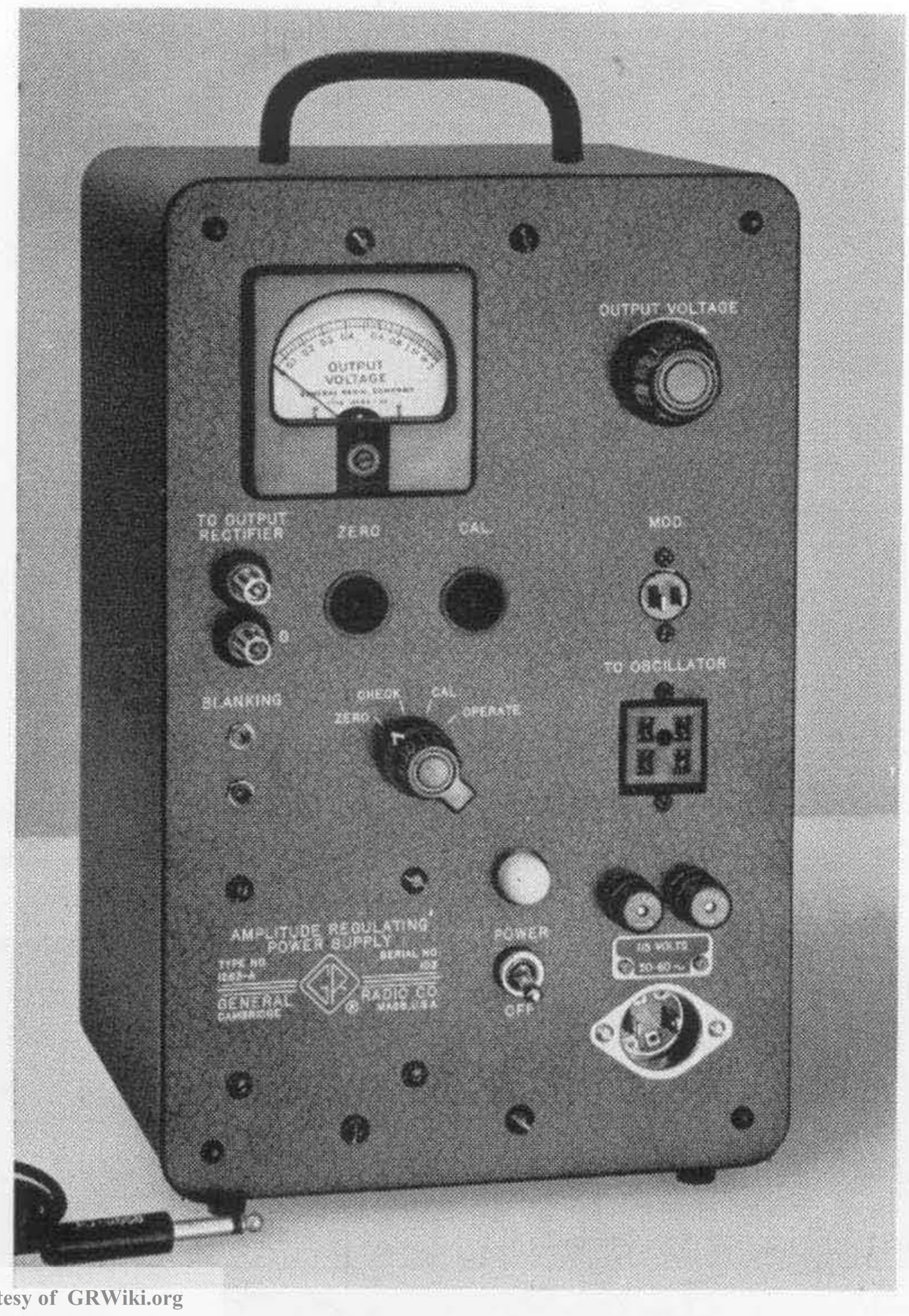


Figure 9. Panel view of the Type 1263-A Amplitude-Regulating Power Supply.

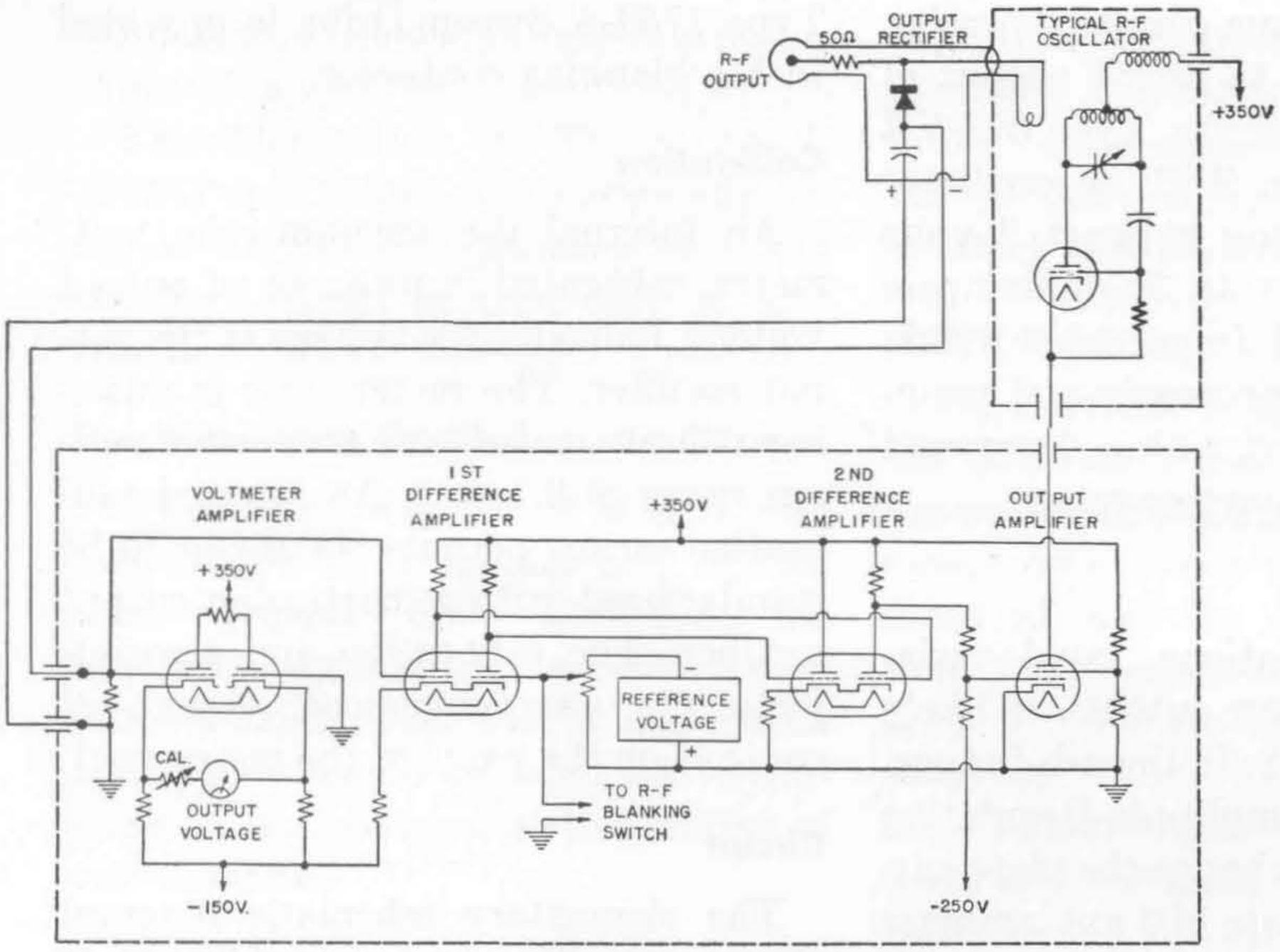


Figure 10. Elementary schematic circuit diagram of the Power Supply connected to an oscillator.

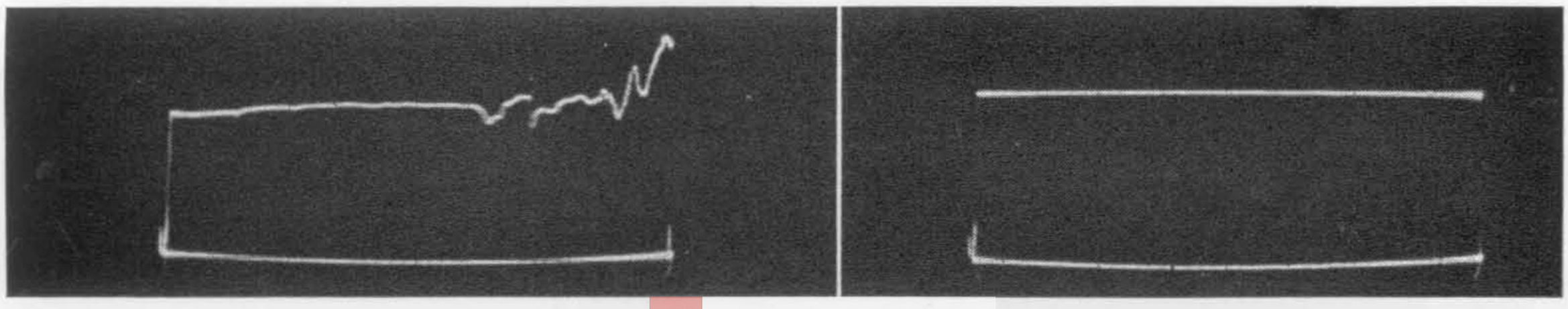
ference amplifier. A negative adjustable reference potential is applied to the other grid of the first difference amplifier. An increase in the negative potential with respect to the reference potential is amplified by the two difference amplifiers and appears as a negative-going potential at the output amplifier grid. This reduces the plate current supply to the oscillator. Conversely, a decrease in output produces an increase in plate current supplied. A closed-circuit feed-back system is thereby established, which holds the output closely to a preset level.

The Amplitude-Regulating Power Supply also furnishes power for the plate and cathode heater of the oscillator. Direct current is used for the heater supply, in order to minimize frequency modulation from hum. The Type 1263-A Amplitude-Regulating Power Supply is designed primarily for use with General Radio Unit Oscillators. Other oscillators can be operated from this instrument if their power requirements are within the allowable range and if a d-c connection can be made to the cathode circuit for applying plate current control. The following oscillators are suitable for use with this power supply:

Type No.	*Frequency Range*
1211-A	0.5–5 and 5–50 Mc
1215-B	50–250 Mc
1209-B	250–920 Mc
1218-A	900–2000 Mc

The earlier "A" models of the TYPES 1215 and 1209 oscillators will operate satisfactorily with the Amplitude-Regulating Power Supply if the modulation phone plug provided is removed or adapted to connect to the screw-type

Figure 11. Output amplitude characteristic as a function of frequency for the Type 1209-B Unit Oscillator (250–920 Mc), unregulated (left), and (right) when operated from the Amplitude-Regulating Power Supply.



terminals provided on these instruments. The TYPES 1208-A and 1208-B, however, cannot be used with this power supply.

The General Radio TYPE 874-VR Voltmeter Rectifier is the recommended output rectifier. It is equipped to plug directly into the output connector of General Radio Unit Oscillators and provides a matched source for 50-ohm coaxial cable.

— W. F. BYERS

SPECIFICATIONS

Type 1750-A Sweep Drive

Reciprocating Output Shaft

Center Position: Adjustable within 9 turns.
Sweep Arc: Adjustable 30–300 degrees.
Torque: Rated max. 24-ounce inches.
Sweep Speed: Adjustable 0.5–5 cycles per second. Moment of inertia limits the speed at which a load can be driven.
Height of Shaft: Adjustable from 2½–4⅞ inches over bench.
Flexible Coupling: 5¾ inches long.
Provision for Coupling: Shaft diameters, ¼ and ⅜ inches; knobs and dials, 1 to 4 inches.

Limit Switch: One limit fixed, second limit adjustable within 9 turns.

Sweep Voltage: 2.5 volts peak to peak, ungrounded.

Blanking: Shorting contact closed during clockwise rotation of driven shaft, ungrounded.

Input Power: 115 volts, 50–60 cycles, 60 watts.

Dimensions: 17½″ wide, 9″ high, 8¼″ deep.

Weight: 22½ pounds.

Type 1263-A Amplitude-Regulating Power Supply

General: For use with an oscillator whose output can be controlled by varying plate voltage applied. D-C connection to oscillator cathode must be available for applying modulation.

Plate Supply: 0–250 volts at 25 milliamperes with 105 to 125 line volts (or 210 to 250), as required to maintain preset output level. Up to 300 volts at 30 milliamperes is available above 115-volt line (or 230).

Heater Supply: 6 volts dc at 0.5 amperes at 115/230 volt line (5.4 volts at 0.7 ampere).

R-F Output Regulation: An output control permits the regulating level to be set from 0.2 to 2 volts. The output of an oscillator that is capable of delivering a minimum of 2 volts into 50 ohms within stated plate supply limitation will be regulated within ± 2 per cent of the preset level over its frequency range. Output change with rated line-voltage variation is less than 20 millivolts.

Response Time: Plate voltage is changed at a rate of 30 volts per millisecond.

Output Meter: An internal d-c vacuum-tube volt-meter is provided, which is calibrated in terms of the r-f voltage at the external output rectifier. An internal calibration means is provided for standardization of this meter with the rectifier.

Power Input: 55 watts maximum at 115/230 volts, 50–60 cycles.

Blanking: Phone-tip jacks are provided to which connection to a contactor in the TYPE 1750-A Sweep Drive can be made for cutting off the oscillator plate supply. This connection is useful for blanking the oscillator output, to eliminate the return sweep and to provide a reference base line on the CRO display.

Terminals: A Jones-type socket is provided for direct plug connection to General Radio Unit Oscillators. A detachable cable terminating in a phone plug is provided for connection to the modulation jack on a Unit Oscillator. Binding posts provide connection for external output rectifier and provide monitoring points for checking the dynamic regulation, in sweep applications, by means of a CRO.

Vacuum Tubes: The following tubes are supplied: 3 12AX7; 1 6V6-GT; 1 0A2; 1 6X4.

Accessories Supplied: Power cord, cable for connecting to modulation jack on unit oscillators, multipoint connector plug, spare fuses.

Other Accessories Required: TYPE 874-VR Voltmeter Rectifier, TYPE 274-NF Patch Cord and TYPE 874-Q6 Adaptor for connecting output rectifier.

Dimensions: Panel, (height) 13¼ x (width) 8¼ inches; depth behind panel, 7¼ inches.

Net Weight: 18½ pounds.

Type 874-VR Voltmeter Rectifier

Maximum Voltage: 2 volts.

Resonant Frequency: Approximately 3800 Mc.

By-Pass Capacitance: Approximately 300 $\mu\mu$f; shunt capacitance of crystal, approximately 1 $\mu\mu$f.

Dimensions: 3¾ x 2½ inches.

Net Weight: 5 ounces.