# DU MONT

## CATHODE-RAY OSCILLOGRAPH
## TYPE 168

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### OPERATING INSTRUCTIONS

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

# *Operating Instructions*

*For*

# DU MONT TYPE 168 CATHODE-RAY OSCILLOGRAPH

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

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# TYPE 168 CATHODE-RAY OSCILLOGRAPH

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## 1.00 INTRODUCTION

### 1.10 GENERAL SPECIFICATIONS

Power Supply Ratings:

| | |
|---|---|
| Voltage | 115-230 Volts a.c.* |
| Frequency | 40-60 Cycles |
| Wattage | 50 Watts |
| Fuse Protection | 1 Ampere |

Operating Limits:

| | |
|---|---|
| Deflection Sensitivity (max. amplifier input) | .046 r.m.s. volts/inch |
| Deflection Sensitivity direct to plates | 20 r.m.s. volts/inch |
| Input Characteristics: | |
| Through vertical amplifier | 1 Megohm |
| Through horizonal amplifier | 0.8 Megohm |
| Approximate voltage gain, vertical amplifier, 1 stage | 70 Times |
| Approximate voltage gain, vertical amplifier, 2 stages | 450 Times |
| Approximate voltage gain, horizontal amplifier | 40 Times |
| Frequency range of amplifiers | 15 to 30,000 cycles/second |
| Frequency range of timing axis | 15 to 30,000 cycles/second |
| Max. allowable a.c. volts input to amplifiers | 300 Volts |
| Max. allowable d.c. volts input to amplifiers | 400 Volts |
| D. C. volts delivered by high voltage section of power supply | 1125 Volts |
| D. C. volts delivered by low voltage section of power supply | 415 Volts |

Tubes and Functions:

1—Type 80 half-wave rectifier
1—Type 80 full-wave rectifier
1—Type 6C6 Vertical amplifier
1—Type 76 Vertical amplifier
1—Type 6C6 Horizontal amplifier
1—Type 2B4 Saw tooth oscillator
1—Type 5MP1/2505A5 Cathode-ray Tube

Physical Specifications:

| | |
|---|---|
| Height | 14 Inches |
| Width | 8 Inches |
| Depth | 15¼ Inches |
| Weight | 31 Pounds |

* See Schematic for Transformer connections.



### 1.20 SET UP

The Type 168 Cathode-ray Oscillograph is shipped complete and ready for use and may be plugged into a power line of the proper frequency and voltage. It is suggested that these operating instructions be read thoroughly before operation is attempted.

### 1.30 CONTROLS

All controls of the Type 168 Oscillograph are on the front panel and are plainly marked. The following description gives the location and use of the various controls. Because all controls are on the front panel, it was deemed advisable to distinguish in some manner the controls frequently adjusted from those more permanently set. Hence the synchronizing, rough and fine frequency, and the horizontal and vertical gain controls have red bar-knobs.

In the upper left corner is the intensity control. At the upper right is the focus control. These two controls are adjusted simultaneously to give the best sharpness of pattern and the required brilliance. Just below the intensity control is the vertical positioning knob which controls the up and down movement of the spot or trace, while directly below the focus control is the horizontal positioning which controls the left to right movement of the pattern. The synchronizing control is in the center of the panel just below the cathode-ray tube. Directly below the position controls are the amplifier-gain controls, the vertical being on the left and the horizontal on the right. In the center of the panel under "Synchronizing" is the vernier, or fine, frequency control of the linear sweep, while directly below it is the rotary switch which controls the frequency in coarse steps. The approximate range of these steps is as follows:

1—Sweep Off
2—15 to 60 cycles
3—60 to 220 cycles
4—220 to 900 cycles
5—900 to 3,000 cycles
6—3,000 to 10,000 cycles
7—10,000 to 30,000 cycles

At the left of the instrument, at the bottom, is a switch controlling the signal to the vertical plates. This switch provides connection through coupling condensers direct to the deflection plates without amplification when in the counter-clockwise position. The middle position throws in one stage of amplification, while the clockwise position connects in two stages of amplification.

The right hand switch at the bottom controls the signal which is applied to the horizontal plates and also has three positions. Signals may be applied through the condenser direct to the deflection plate, or through a single stage of amplification. The third position connects the internal linear sweep circuit which passes through the horizontal amplifier.

At the bottom of the front panel are two toggle switches. The left one governs the synchronization, providing either external connection at the binding post for synchronization to a signal other than that under investigation, or internal synchronization to whatever signal is being applied to the vertical deflection plates, independent of whether or not it passes through an amplifier. The right hand toggle switch is a power switch.

The controls are arranged so that the minimum setting is obtained when the knobs are turned counter-clockwise and maximum when turned clockwise.

### 1.40 CONNECTIONS

The vertical input is to the binding posts on the left side of the panel, the lower post of the pair being the ground. The horizontal input is on the right side and, as in the previous pair, the bottom post is the ground.

At the left of the instrument, above the vertical input post, is an additional binding post to which a signal should be connected when external synchronization is desired. For convenience in testing and as a source of timing signals a 6.3 volt, 60 cycle connection is brought out on the front panel to a binding post above the horizontal terminals. This lead has a protective resistance inserted to prevent any dangerous results should a short circuit be formed.

On the back of the instrument is a plate with five screw-type binding posts. These permit the disconnecting of either or both circuits allowing direct connection to the deflection plates. This feature will be found a great convenience to amateurs or others working with d.c. or high frequency applications. The location of circuits on this plate will be found in Fig. 1, p. 14.

## 1.50 CAUTIONS AND WARNING

1. Do not operate this unit with the case removed as high voltages are employed.

2. Do not experiment with magnets around or near the case of the oscillograph, as the latter may be impaired or rendered useless.

3. Do not place the unit over, under, or near a power transformer or reactance carrying a.c. as the field set up will cause distortion of the patterns to such an extent that conclusions will be impossible.

4. Do not allow a small line or spot of high brilliancy to remain stationary on the screen for any length of time as the screen may be discolored or burned.

# 2.00 OPERATING INSTRUCTIONS AND APPLICATIONS

## 2.10 GENERAL

This procedure is included to acquaint the user with the operation of an oscillograph. It is suggested that the operator follow these instructions and familiarize himself with the controls and their location before attempting any use or measurements.

Turn the two positioning controls, the focus, the synchronizing, and the horizontal gain control to the half-way point. Then turn the synchronizing switch to internal and the horizontal switch to the sweep position. Place frequency control switch on position No. 2 and turn off the vertical amplifier. Insert plug in proper a.c. source and turn on the power switch. The intensity control should then be turned clockwise until a horizontal trace appears. The intensity and focus controls should be adjusted for a sharp and clear-cut trace. Do not use more brilliance than necessary to get a usable trace. The trace can now be positioned to the center of the screen. The vertical amplifier is turned on after the H and V input posts have been connected to the 60 cycle post. After advancing the vertical gain control, the power-supply wave-form will appear on the screen. If one wave is secured, it indicates that the sweep is of the same frequency as the 60 cycles applied, or if two waves appear the sweep is at one-half the frequency, or 30 cycles, and so on. The pattern can be made to stand still or drift by turning the synchronizing control. In some cases distortion can be caused by over-synchronizing, so use only enough to lock the pattern.

It is general practice to use several waves when examining wave form, especially on frequencies above 1,000 cycles.

While the pattern given by an oscillograph shows peak voltages, it is a simple matter for the operator to acquaint himself with the deflection in inches secured at various settings of the gain control with R. M. S. (meter readings) voltages applied. If considerable use is made of this feature it may be advisable to plot a curve of the voltages required to give certain deflections.

No attempt is being made to make this instruction book an exhaustive treatise on the oscillograph. It is supplied mainly to familiarize the user with this particular instrument. For a complete familiarity with miscellaneous applications of the oscillograph, the user is referred to the voluminous publications appearing from time to time in the literature. A few of the more comprehensive references are given here for your consideration. The following texts will be found of some value:

"The Cathode-Ray Tube at Work", by John Rider.

"The Low-Voltage Cathode-Ray Tube", by G. Parr.

"The Cathode-Ray Oscillograph in Radio Research", by R. A. Watson Watt.

Since this unit will be found especially useful for demonstration work for certain industrial applications, and for the radio service man, a brief set of instructions or suggestions for such uses will be given.

## 2.20 LECTURE DEMONSTRATIONS

The Type 168 Cathode-ray Oscillograph makes an excellent piece of demonstration apparatus for lecture work. It can be used in the analysis of wave forms from various electrical sources such as alternators, power lines, magnetos, or vibrators. The student who observes these signals with an oscillograph grasps the idea



of wave forms much more quickly than by the laborious method of plotting out sinusoidal and non-sinusoidal functions. Such patterns are most readily observed with the use of the linear time-base. However, for many purposes it is instructive to employ the Lissajous' patterns obtained when feeding two different signals in at the vertical and horizontal binding posts respectively.

Excellent studies of sound waves can be made with this Type 168 Oscillograph, as its vertical amplier is sufficiently sensitive so that the unit may be operated directly from a dynamic microphone of special type which can be obtained through the Allen B. Du Mont Laboratories. This microphone makes a very neat and useful supplement to the Type 168 instrument, because it gives excellent response over the audio frequency range and is extremely sensitive, so that full scale deflection may be obtained with average sound intensity. When ordering specify the Type 168-M microphone. Price may be obtained upon request.

The oscillograph makes an excellent frequency meter when using this microphone and some method of external synchronization. Approximate frequencies may be determined by direct use of the calibration of the sweep circuit. The sixty cycle source provided on the front panel also serves as an excellent standard of frequency, since most power lines are regulated to a high degree of accuracy.

This oscillograph is very useful in demonstrating the operation of public address systems and radio receiving sets. The vertical input posts should be connected somewhere in the audio amplifier circuits of the set. It is not necessary to connect it at the output, but frequently one can attach the oscillograph at the second detector or first audio stage and actually obtain less distorted signals than at the output of the instrument, showing that the receiver or PA system under test introduces considerable distortion.

## 2.30 ELECTRONIC SWITCH

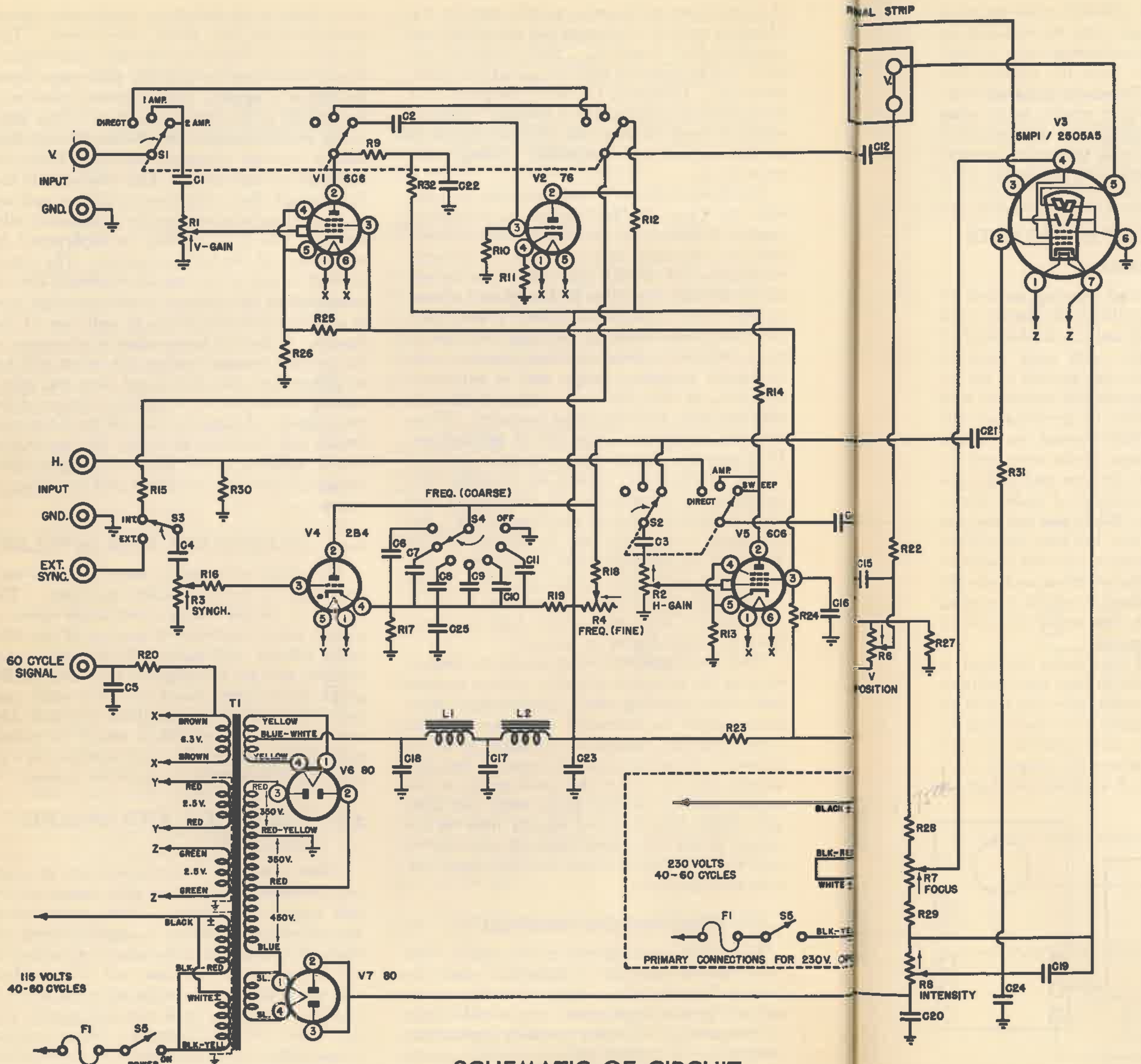
Since this oscillograph is practically free from inertia and has a deflection which increases linearity with voltage it makes an excellent signal-strength meter over a wide range of frequencies. In many research applications comparison is desired between various signals generated in certain pieces of apparatus. In some cases it is desired to apply two signals simultaneously for direct comparison. The Type 185-A Electronic Switch and Square Wave Generator is a great advantage here. Its output is applied to the vertical posts with the switch in the direct position. This electronic switch contains two balanced amplifiers and an internal electronic switching from one amplifier to the other. The two signals are fed through their respective amplifiers and are pictured simultaneously on the cathode-ray tube screen. The patterns may be superposed by adjustment of the balance control. The signal applied to one of the amplifiers should also be connected to the external synchronization post in order to lock the sweep to only one of the signals. If the synchronization is attempted in the normal internal manner the sweep will try to follow first one signal and then the other, causing uncertainty of the phase relation of the two signals. A suggested use of the Electronic Switch and Oscillograph is for the demonstration of splitting of the phase of a single phase voltage by use of a condenser and resistance in series.

## 2.40 TRANSIENTS AND IMPULSES

The shape of transient wave forms is very important in many research problems. The output of Geiger counters and other types of pickup units employed in studies of artificial radio activity and nuclear disintegration phenomena may be investigated with this oscillograph on its linear time-base. For many purposes the oscillograph amplifiers are quite adequate, but some applications where the pickup units develop extremely small voltages may require their customary pre-amplifier stages.

## 2.50 VIBRATION AND ENGINE TESTING

There are many research problems in which are produced certain detonation waves or certain typical vibrations. These characteristic wave forms are common in engine testing, the study of various fuels, the study of explosives, and the study of vibration and noise. Much valuable information can be obtained with the regular microphone used as a pickup unit with the Type 168 Oscillograph. Other applications, however, require much more localized study of the vibrations and consequently are




## SCHEMATIC OF CIRCUIT

**TYPE 168 CATHODE-RAY OSCILLOGRAPH**

**Ref: DW-40-C-2**

## COMPONENT PARTS LIST

| | |
|---|---|
| C1 | 1µf. 400v. |
| C2 | 0.1µf. 1000v. |
| C3 | 0.1µf. 1000v. |
| C4 | 0.05µf. 400v. |
| C5 | 0.1µf. 1000v. |
| C6 | 200µµf. 500v. |
| C7 | 600µµf. 500v. |
| C8 | 2500µµf. 500v. |
| C9 | 0.01µf. 400v. |
| C10 | 0.04µf. 400v. |
| C11 | 0.2µf. 400v. |
| C12 | 1µf. 400v. |
| C13 | 0.05µf. 400v. |
| C14 | 0.05µf. 400v. |
| C15 | 0.05µf. 400v. |
| C16 | 8µf. 150v. |
| C17 | 4µf. 450v. |
| C18 | 4µf. 450v. |
| C19 | 0.5µf. 600v. |
| C20 | 0.5µf. 1500v. |
| C21 | 50µµf. 1200v. |
| C22 | 4µf. 450v. |
| C23 | 4µf. 450v. |
| C24 | 0.1µf. 1600v. |
| C25 | 25µf. 50v. |
| F1 | 1 amp. 250v. |
| L1 | 8.5H. 35ma. 325 ohms d.c. |
| L2 | 8.5H. 35ma. 325 ohms d.c. |
| R1 | 1meg. pot. |
| R2 | 4meg. pot. |
| R3 | 15K pot. |
| R4 | 4meg. pot. |
| R5 | 4meg. pot. |
| R6 | 4meg. pot. |
| R7 | 500k pot. |
| R8 | 200K pot. |
| R9 | 100K 1 W. |
| R10 | 500K ½ W. |

| | |
|---|---|
| R11 | 6K ½ W. |
| R12 | 100K 1 W. |
| R13 | 1K ½ W. |
| R14 | 100K 1 W. |
| R15 | 1meg. ½ W. |
| R16 | 100K ½ W. |
| R17 | 750 ohms ½ W. |
| R18 | 750K. 1 W. |
| R19 | 100K. 3 W. |
| R20 | 10K. ½ W. |
| R21 | 5meg. ½ W. |
| R22 | 1meg. ½ W. |
| R23 | 25K. 10 W. |
| R24 | 10K. 3 W. |
| R25 | 10K. 3 W. |
| R26 | 220 ohms ½ W. |
| R27 | 250K. ½ W. |
| R28 | 750K. 1 W. |
| R29 | 100K. ½ W. |
| R30 | 1meg. ½ W. |
| R31 | 3K. ½ W. |
| R32 | 3K ½ W. |

K = 1000 ohms

| | |
|---|---|
| S1 | 3P. 3T. |
| S2 | 2P. 3T. |
| S3 | S.P. D.T. toggle |
| S4 | S.P. 7T. |
| S5 | S.P. S.T. toggle |
| T1 | Part No. 20-6 |
| V1 | Type 6C6 |
| V2 | Type 76 |
| V3 | Type 5MP1/2505A5 |
| V4 | Type 2B4 |
| V5 | Type 6C6 |
| V6 | Type 80 |
| V7 | Type 80 |

more readily studied with special pickup units. There is on the market a magnetic type of pick-up unit designed especially for attachment to internal combustion engines. The amplifiers of the Du Mont Type 168 Oscillograph are sufficiently sensitive to permit direct connection to the oscillograph with excellent results. Other types of pickup units which are available employ the condenser microphone principle, the variable resistance of a carbon stack, and the variable conductivity of a charged gap between which certain ionized gases may be passed. Small unbalances in radio frequency circuits caused by these vibrations may be observed readily on the Type 168 Oscillograph. The general principle employed is that of producing a beat frequency between the two high frequency carriers, one of which is changed slightly by the vibration under investigation. More complete details may be found in the references cited above.

## 2.60 PHOTOGRAPHY

Whenever patterns can be produced which are recurrent and can be maintained stably for a period of a second or so, excellent direct photography may be employed with the Type 168 Oscillograph. An ordinary camera, preferably with a low *f* value, is set up and focused in a normal manner on the screen and an exposure is made of the standing pattern. This procedure is a definite advantage in studying various musical wave-forms and in the harmonic analysis of power-line and amplifier waves. Certain very slow phenomena of single trace nature may be photographed satisfactorily, but where high speed, single trace photography is desired it is suggested that one of our high-voltage oscillographs be employed. With a wide aperture lens, say a *f*4.5, results may be obtained by photographs of patterns lasting only 1/60th of a second. In such cases the pattern size would be kept small. Generally speaking, however, the most satisfactory results, when using the Type 168 Oscillograph for photographic work, are obtained by using stationary patterns of recurrent phenomena with exposures of a second or more.

## 2.70 SERVICING OF RADIO SETS

### 2.71 Visual Alignment

This was the first and simplest method of alignment, and the oscillograph merely took the place of the output meter. It consisted of using a signal generator with some form of audio modulation which was applied to the receiver and the audio output was measured with an oscillograph. Unlike its predecessor, the output meter, it not only showed the voltage output but also the shape of the wave and enabled the study of the detector and audio systems permitting the locating of audio distortion, overloading, etc. While this method was not the most efficient and has been supplanted by the modern frequency-modulated oscillator of constant band-width, which is undoubtedly better for pure alignment work, it is coming again to the fore, this time under the title of "overall frequency response".

In this case the old type audio oscillator is replaced by an adjustable or beat type oscillator capable of producing essentially sine waves of the same voltage output, from five cycles to fifteen thousand cycles. It is apparent that this setup will determine where the response of a receiver starts to fall off at either the high or

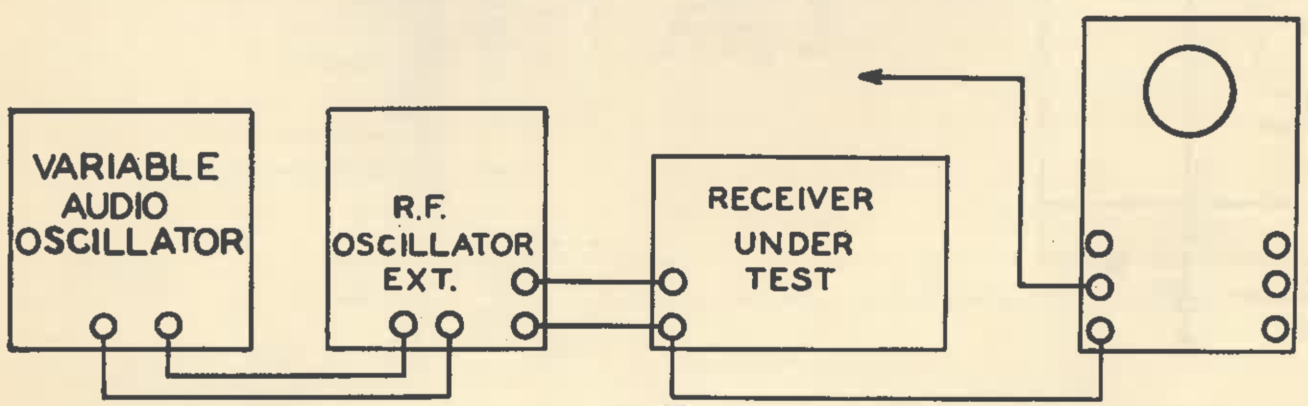



Fig. 1



low frequencies. Moving from the detector to the audio system and repeating the readings will show whether further loss is suffered.

### 2.72 Visual Response Curves

The general procedure involved is as follows: An R. F. oscillator is provided with some means that will serve to vary its frequency a few kilocycles either side of the frequency to which it is tuned. In the older units it consisted of a motor driven vernier variable-condenser connected across the main tuning condenser of the oscillator. This process, known as frequency modulation, is often called "wobbulation" to distinguish it from the audio modulation.

For I. F. alignment these older systems are nearly as good as the latest types, but a little thought will disclose the fact that the width of the band sweep will be determined by the posi-

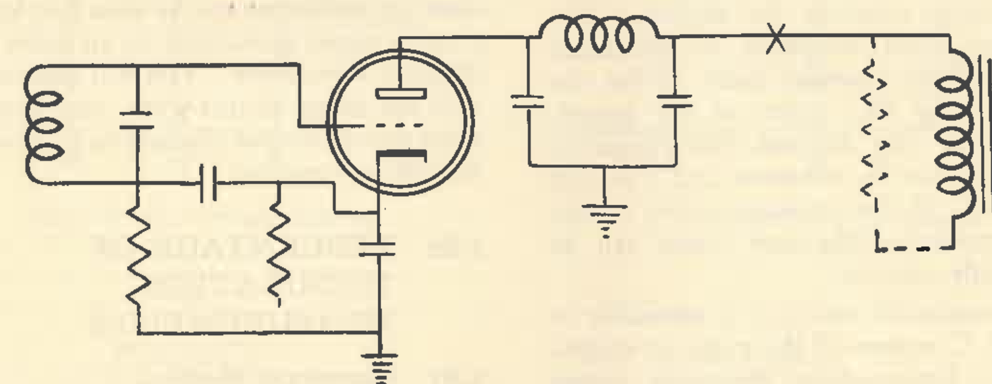


Fig. 2

In cases of resistive load this connection can be made as follows:

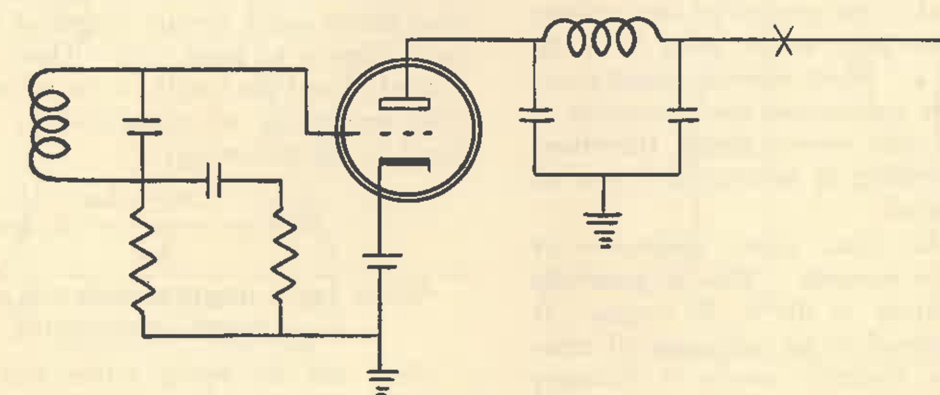


Fig. 3

In cases of diode connection across the diode load:

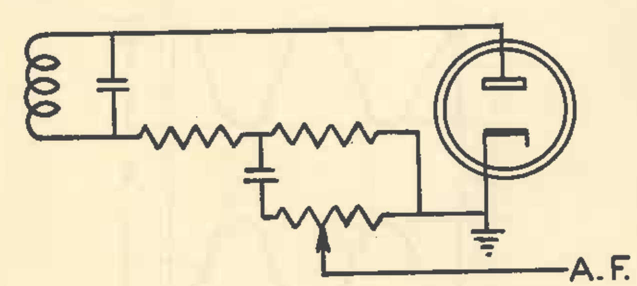



Fig. 4

tion of the main condenser, so the trend has been to beat-frequency oscillators which produce a constant band width.

There are numerous methods of producing a frequency modulated signal. It can be effected by a motor driven condenser, a motor driven disc, a vibrating reed, or electronic means, and, as previously stated, may or may not include the feature of constant band width. However, regardless of the method, the principle of operation is the same. The output of the generator in frequency plotted against time will appear as a pyramid for the 360 degrees of frequency-modulation rotation. If the sweep is adjusted to twice this frequency of rotation, the spot will sweep from one side of the screen to the other in the length of time required for the oscillator to go from minimum to maximum and will then sweep a second time while the oscillator frequency goes from maximum to minimum. Thus, during 180 degrees of frequency-modulation rotation, the oscillator frequency sweeps from minimum to maximum passing through the resonant point of the circuit tested tracing this curve on the screen. During the next 180 degrees, the frequency goes from maximum to minimum and a second curve is traced. If the resonance curve of the circuit is symmetrical the two traces can be made to actually coincide.

In taking resonance curves it is advisable to take the A. V. C. action off the stage, or stages, being tuned. Intermediate frequency stages should always be tuned to peak at the frequency for which the set is designed.

In general the ground circuit of the oscillograph is fastened to the ground of the receiver and the deflection plate to the point X in the figures 2, 3 and 4. Most receiver manufacturers give complete instructions for connection to oscillographs in their service sheets, therefore, it would be confusing to attempt to cover all cases in this manual.

There may be cases where symmetry of curves cannot be secured. This is generally due to regeneration in the I. F. stages. It should be considered as an indication of trouble. The most common source is ordinary coupling in the power supply due to open by-pass condensers or condensers of insufficient capacity. Of course, capacity coupling, poor shielding, etc., can cause the same effect.

The curves on page 13 are shown to acquaint the operator with their general appearance.

### 2.73 Hum Measurements

The sweep can be set to 60 cycles and, using internal synchronization, the pattern locked. A test then can be used for checking the entire circuit, the magnitude of the volume being indicated by the height of the waves. This enables the checking of the various points of the filter circuit and the effect of changes in chokes, condensers or alignment of parts is readily seen and compared.

### 2.74 Oscillation and Regeneration

With the oscillograph connected across the suspected circuit and no signal applied, only the straight horizontal trace of the sweep should appear. Oscillation will show by the widening of the sweep trace. Regeneration which is just short of oscillation can be seen best by applying a radio signal modulated by an audio oscillator of good wave form. You will become familiar with the shape of this wave, and since regeneration causes serious distortion, its presence will readily be apparent.

## 2.80 PERCENTAGE OF MODULATION MEASUREMENTS

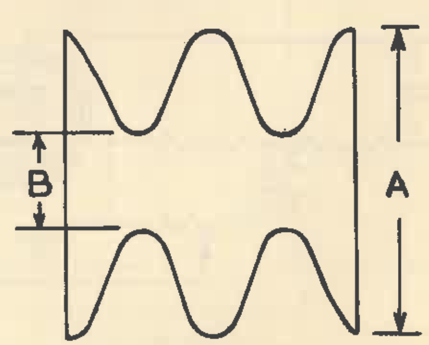
### 2.81 Envelope Method

The principle of this can be easily understood if we consider only one direction at a time. An unmodulated carrier is applied to the vertical plates and a certain length of trace measured (figure 2, page 14). Then modulation is applied and the length of the trace measured. The percentage of modulation is then calculated by the following:

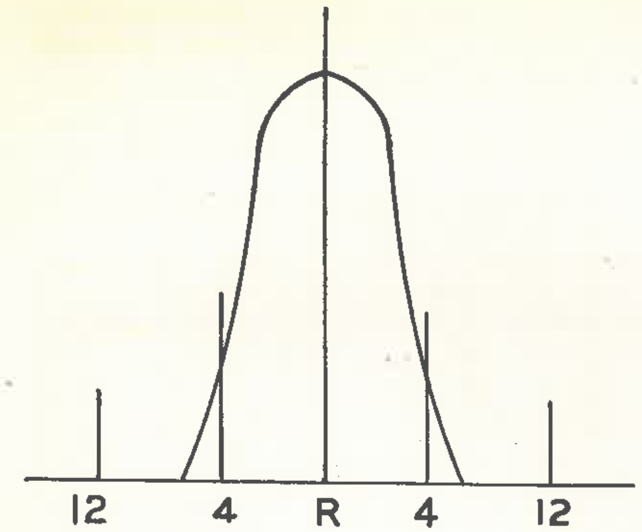
$$\%M = \frac{Lm - Lu}{Lu} \times 100$$

When Lm is length modulated, and
Lu is length unmodulated.

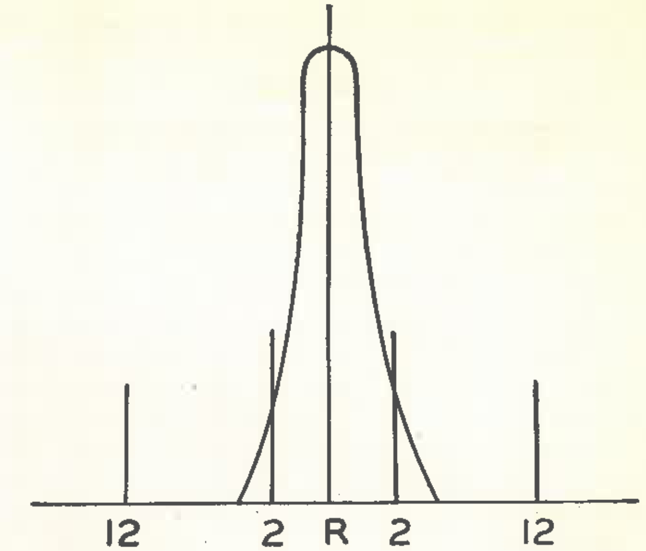
Now add the sweep action and you get a band or block pattern for the carrier which will be what is called an envelope when modulated, the appearance of which will be as shown:



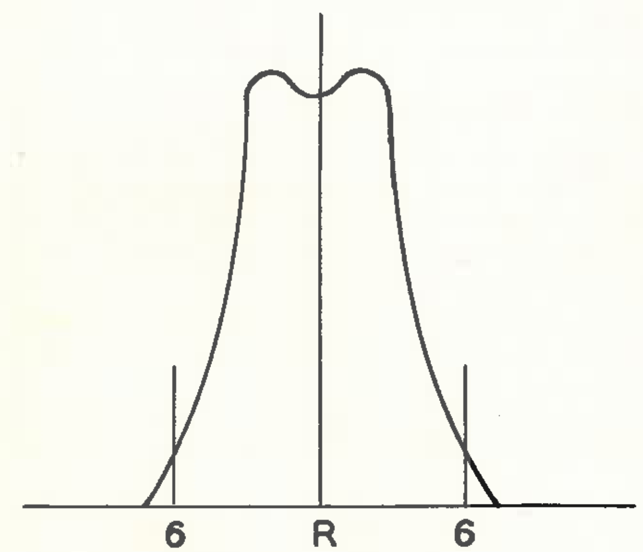


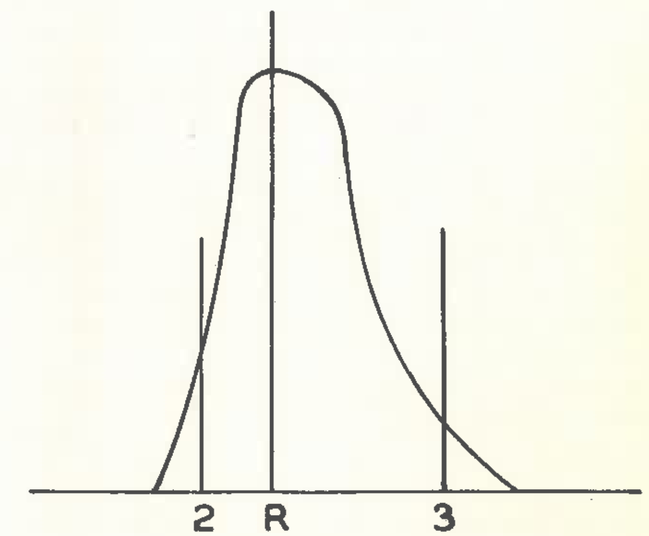

Good Curve, Average Receiver



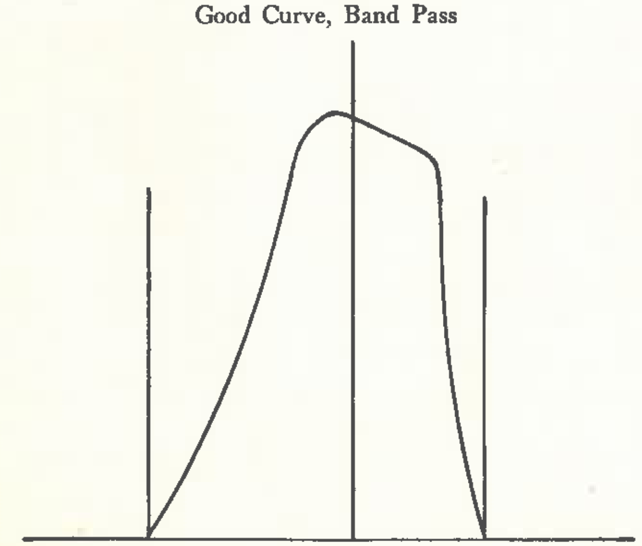

Good Curve, Old Receiver
Narrow Response



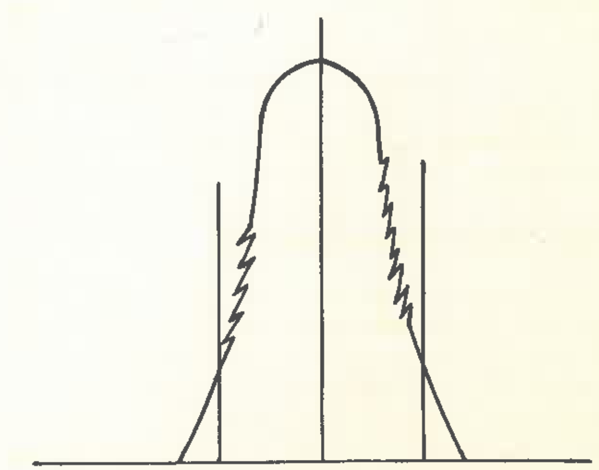

Good Curve, Band Pass




Misaligned Stage Cutoff One Side

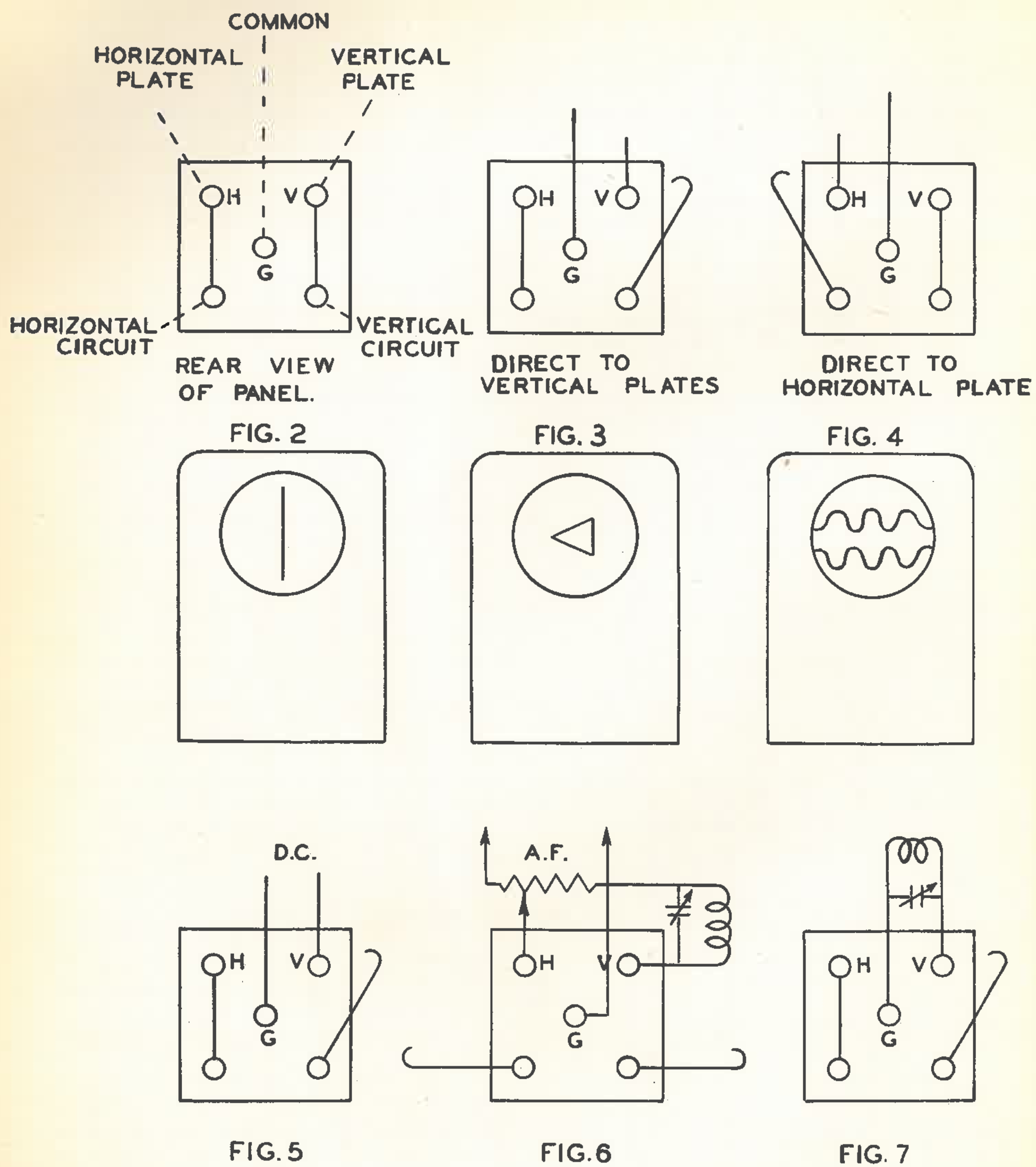


Misaligned Band Pass Stage
Cut Off on One Side



Oscillation Generally
Indicated by Jagged Slope

Fig. 1




Methods of Connecting Signals Directly to Horizontal and Vertical Deflection Plates



It is apparent that the sweep has merely followed the visualizing of the wave form and no change in the formula is effected. We would merely substitute the new terms A and B and get

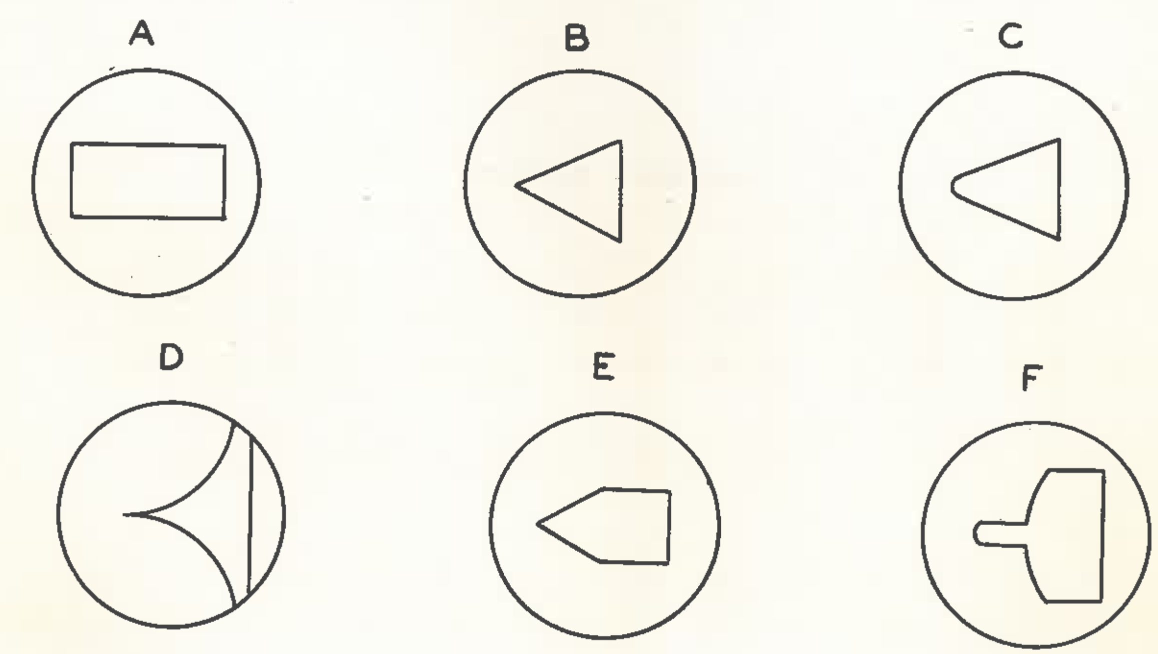
$$\%M = \frac{A - B}{A + B} \times 100$$

It is apparent that if sufficient voltage is available this could be applied to received signals as well as transmitters. On a transmitter it will usually be found that a few turns of wire connected to the vertical deflection plates and placed near the final tank circuit will pick up sufficient voltage. The size of the pattern will be controlled by varying the distance between the pickup coil and the transmitter. In case of very high frequencies or low power it may be found necessary to tune this pickup coil to the frequency of the transmitter. Methods of connection for observing modulation are shown in Figures 6 and 7, page 14.

### 2.82 Trapezoidal Method

This method is considered better than the envelope for transmitter adjustment. This is because it lends itself better to complete analysis of the transmitter and not because it is better as an indicator of percentage of modulation.

The articles on this particular application are so numerous that we will not go into details in this manual. The following drawings are self-explanatory:




## 3.00 MAINTENANCE

The components of the Type 168 Cathode-ray Oscillograph have been selected and tested to provide long, trouble-free operating life, and the only service necessary should be the replacement of vacuum tubes; the locations of the vacuum tubes are plainly marked on the chassis label.

### 3.10 REPAIRS

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

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

## PATENT NOTICE

The product described herein is manufactured under one or more of the following U. S. patents:

| | | | | | | |
|---|---|---|---|---|---|---|
| 1,844,117 | 1,960,333 | 1,999,407 | 2,000,014 | 2,014,106 | 2,067,382 | 2,082,327 |
| 2,085,576 | 2,087,280 | 2,098,231 | 2,153,800 | 2,157,749 | 2,162,009 | 2,163,256 |
| 2,164,176 | 2,185,705 | 2,186,634 | 2,186,635 | 2,190,020 | RE.21,326 | 2,201,309 |
| 2,207,048 | 2,208,254 | 2,209,507 | 2,221,398 | 2,225,099 | 2,227,822 | 2,229,556 |
| 2,245.409 | 2,245,428 | 2,249,942 | 2,249,943 | 2,269,115 | 2,269,129 | 2,280,700 |
| 2,280,738 | 2,290,592 | 2,297,742 | 2,297,752 | 2,299,471 | 2,299,510 | 2,315,848 |
| 2,319,691 | 2,321,149 | 2,328,259 | | Other patents pending | | |