

**LESSON
54 RA-1**

**COMPLETE CIRCUIT SYSTEM
OF A COMMERCIAL OSCILLOSCOPE**



RADIO-TELEVISION TRAINING SCHOOL, INC.

5100 SOUTH VERMONT AVENUE • LOS ANGELES 37, CALIFORNIA, U. S. A.

COMPLETE CIRCUIT SYSTEM OF A COMMERCIAL OSCILLOSCOPE

The entire circuit system of an oscilloscope is built around the cathode-ray tube - for providing the necessary electrical potentials, and for impressing the signals on the deflecting plates and spread the image across the screen of the tube so that the wave forms can be observed and analyzed to best advantage. The Supreme Model 546 discussed and illustrated here possesses all the features of a typical oscilloscope as used for radio analysis and alignment work.

The power supply contains two rectifier systems, one a half-wave high voltage system to supply the operating potentials to the cathode-ray tube, and the other a full-wave circuit for operating the two amplifiers and the sweep frequency generator. A single high-voltage secondary winding on the power transformer feeds both rectifiers. The half-wave rectifier employing tube T-1 (type 80) differs from the conventional arrangement in order that the high-potential side can be grounded. Current flow in this system is as indicated by the short heavy arrows. It leaves the tube at the filament terminal B and enters the transformer winding at 1, leaving at tap 2 and reaching the voltage divider at point 5, which is at maximum positive potential. It leaves the divider at point 3 (minimum negative potential) and re-enters the rectifier tube at the common plate terminal.

In the full-wave rectifier current flow is as indicated by the long thin arrows. From the center-tap C on the filament winding it flows through the filter choke L-1 and enters the upper voltage divider at 9, the point of maximum positive potential, and leaves at 5 which is at minimum negative potential. It enters the transformer at tap 2, and during one half of the cycle leaves at tap 3 and the other half at terminal 4. Point 5, which is the junction point,

is positive with respect to any part of the half-wave rectifier and negative for any portion of the full-wave rectifier. Also, in the line 2 to 5 current flows away from the transformer in the half-wave rectifier and into the transformer for the full-wave rectifier.

In the cathode-ray tube the cathode is tied to one side of the filament, and also connects to point 7 on the voltage divider. Potentiometer R-9 controls the negative potential on the grid and is the Intensity Control. R-7 regulates the positive potential on anode No. 1 and is the Focusing Control. Within the tube one of each pair of deflecting plates is tied to anode No. 2 and grounded. Since point 5 likewise is grounded, this is equivalent to making a direct connection from point 5 to anode No. 2, and anode No. 2 is at maximum positive potential.

To impress the signal on the vertical deflecting plates two tip jacks are provided, labeled VER. and GND. Potentiometer R-17 in series with fixed condenser C-7 is across these jacks, with the slider connected to the grid of a 6C6 tube. As the slider is moved left or right, more or less of the signal is supplied to this tube, and R-17 acts as a gain control. The signal is amplified in the tube and reappears across load resistor R-12 at point 13. It is then transmitted through condenser C-10 to the vertical deflecting plate at 14. But in this line is a S.P.D.T. switch S-1 which is operated by the shaft on potentiometer R-17. When R-17 is turned into the off position, switch S-1 is tripped breaking the line from 13 to 14, and cutting the amplifier tube out of the circuit. At the same time the vertical plate, point 14, is connected to the tip jack labeled V. This setting is used when a signal is to be impressed directly on the vertical plate without the intervening amplifier. When potentiometer R-17 is turned on, switch S-1 shifts to the left, and the amplifier tube is again connected into the vertical deflecting plate line and

jack VER must be used. R-17 determines the vertical height of the image and is called the Vertical Amplifier Control.

Similarly, for impressing a signal on the horizontal deflecting plates two tip jacks labeled HOR and GND are provided. Potentiometer R-18 is across these jacks with the slider leading to the grid of another 6C6 tube that serves as an intervening amplifier. Contact is made at terminal 15 to the cathode-ray tube. In series with the line is switch S-2. When R-18 is turned to the counter-clockwise Off position, S-2 breaks the line, takes the 6C6 tube out of the circuit, and connects the free horizontal plate to a tip jack labeled H. This arrangement is for making contact directly with the horizontal plate. Turning R-18 on, trips S-2 and connects the tube into the circuit. Since R-18 regulates the amount of signal voltage that reaches the grid of the tube, it determines the horizontal width of the image, and is called the Horizontal Amplifier Control.

At times it is desired to shift the image on the screen in a vertical or horizontal direction. This is done with the aid of potentiometers R-10 and R-11 that are connected from point 6 on the lower voltage divider to point 10 on the upper divider. The slider of R-10 is connected through resistor R-15 to the vertical deflecting plate line, while the slider of R-11 is connected through R-14 to the horizontal deflecting plate line. By moving the slider of either potentiometer up or down, the free vertical or horizontal plate is made more positive or negative than the tied-to-ground plates, and the image is consequently moved vertically or sidewise. Potentiometer R-10 is termed the Vertical Positioning Control on the instrument panel, and R-11 the Horizontal Positioning Control.

At the right in the diagram is the saw-tooth sweep frequency oscillator employing a type 885 gas discharge triode. S-3 is the Sweep Selector Switch that cuts in the necessary condenser (C-13 to C-18). Rheostat R-25 is the

Vernier Control that regulates the charging current and further selects the oscillator frequency. The plate supply is tapped off at point 9 on the voltage divider. The saw-tooth voltage developed by the sweep frequency oscillator is tapped off at point 16 and supplied to the horizontal plate through switch S-4, a S.P.D.T. switch labeled Ext.-Int. Sweep on the panel. The position shown is for employing an external sweep voltage. If the switch is thrown to the right, Int. Sweep, the sweep voltage generated within the 'scope by the saw-tooth oscillator is used for sweeping the image across the screen. As before, potentiometer R-18 regulates the strength of the sweep voltage that reaches the horizontal plate, and determines the horizontal width of the image whether an external or internal sweep voltage is employed.

The discharge frequency of the #885 triode is determined not only by the plate potential built up across the charging condenser (C-13 to C-18), but also by the potential on the grid. This latter fact makes it possible to tie together the action on the Vertical and the Horizontal deflecting plates so that a stationary image is secured on the screen. This synchronizing is accomplished with the aid of potentiometer R-20, the slider of which is connected directly to the grid of the #885 triode. Potentiometer R-20 is consequently called the Synchronizing Control on the panel. Since for certain types of work it is desirable to use an external synchronizing potential, while for others a part of the potential impressed on the vertical plates is needed, one side of the Synchronizing Control potentiometer is connected to and movable arm of another S.P.D.T. switch S-5, labeled Ext.-Syn. and Int.-Syn. on the panel.

In the Ext. position the switch contact connects to a special tip jack marked Ext.-Syn., and in this position any external voltage can be impressed on the grid of the #885 triode for regulating its discharge frequency. In the Int.-Syn. position the switch contact makes connection with the vertical de-

flecting plate circuit at point 17. By moving the slider of R-20 up or down, more or less of the vertical deflecting voltage is tapped off and impressed on the grid of the gas triode. This Synchronizing Control should never be turned on further than is necessary to fix the image in a stationary position.

THE TRIUMPH MODEL 830 OSCILLOGRAPH

The Triumph Model 830 Oscillograph, made by the Triumph Manufacturing Company, is equipped with a type 906 three-inch cathode-ray tube and is quite similar to other commercial instruments of this type, but has the additional feature of having a frequency modulator or Wobbulator, as it is called, incorporated in its structure. This makes it possible to use the Model 830 for visual alignment work in conjunction with any standard service oscillator that is not equipped for frequency modulation.

The power supply uses a 1-V rectifier tube in the usual half-wave rectifier system for supplying the high operating voltages to the cathode-ray tube. The Intensity Control potentiometer for regulating the negative potential on the grid of the tube is clearly illustrated, as is also the Focusing Control for regulating the positive potential on Anode #1. Anode #2 is shown tied to one of the vertical and horizontal deflecting plates and also to ground. As usual, this ground connection is the point of maximum positive potential on the rectifier system.

There is also a type 84 tube operated in a full-wave rectifier system for furnishing the required voltages to the vertical and horizontal amplifiers, as well as to the sweep frequency generator and to the wobbulator unit. This rectifier is connected in series with the half-wave system mentioned above, and the ground connection here is the point of minimum negative potential on its voltage divider.

The Vertical Beam and Horizontal Beam controls shown in the diagram serve

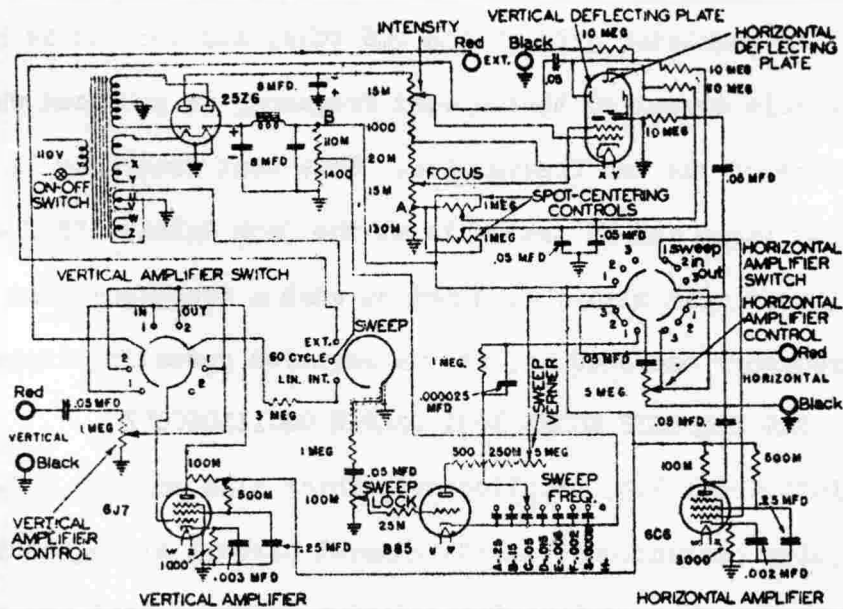
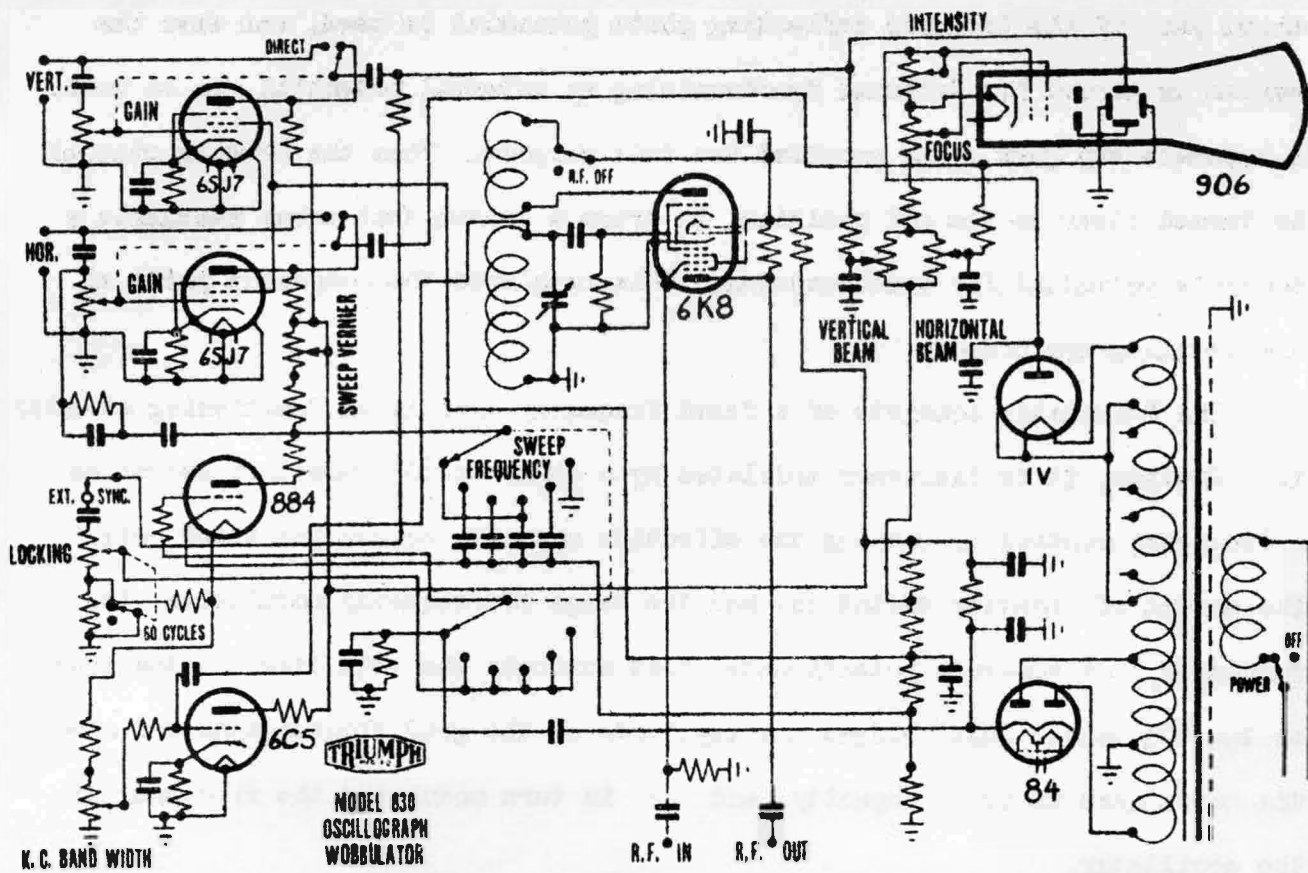
to shift the image vertically or horizontally, and to locate it in the desired position on the screen of the tube. All these controls are clearly marked on the instrument panel.

The Vertical Input jacks are shown in the upper left-hand corner of the diagram, and across these is connected the Vertical Gain control potentiometer that regulates the signal supplied to the 6SJ7 amplifier tube and determines the vertical height of the image on the screen. Attached to this potentiometer shaft is also a S.P.D.T. switch by means of which the amplifier tube is cut out of the circuit so that the signal can be impressed directly on the vertical plate through a suitable blocking condenser.

Below these are shown the Horizontal Input jacks and the Horizontal Gain control for regulating another 6SJ7 tube that determines the horizontal width of the image. This amplifier tube can also be cut out of the circuit with a S.P.D.T. switch mounted on the shaft of the potentiometer, so that the signals can be impressed directly on the horizontal deflecting plate through the proper protecting condenser.

The Sweep Frequency generator employs a type 884 gas discharge triode, and has a 6-position selector switch, four points for determining the sweep frequency range, one for automatically synchronizing the generator circuit with the wobulator system, and the last an Off position. The switch must be in this off position when a signal voltage is to be impressed directly on the horizontal deflecting plates. The sweep Vernier control is a potentiometer in series with the 884 plate line. The output of the generator is tapped off at the plate line and impressed on the Horizontal input control.

The Locking or Synchronizing control is also a potentiometer with the slider connected through the lower deck of the selector switch to the grid of the 884 tube. Two synchronizing positions are provided - in the position



Schematic circuit diagram of the Triplet Model 1690 Oscilloscope, which uses a two-inch diameter cathode ray tube. This diagram also applies to the Model 1691 Oscilloscope, which has a three-inch cathode ray tube.

shown part of the Vertical deflecting plate potential is used, and when the switch is thrown for External Synchronizing an external potential can be used, a separate tip jack being provided for this purpose. When the Locking control is turned clear to the off position, it trips a switch that makes available a 60-cycle potential for synchronizing. This completes the component parts of the Oscillograph proper.

The Wobbulator consists of a fixed frequency oscillator functioning at 1000 kc. However, it is frequency modulated by a separate 605 tube that serves as a frequency control by varying the effective capacity across the tuned coil. The amount of capacity variation, and the range of frequency modulation, is regulated by a separate potentiometer that controls the grid bias fluctuations on the 605 tube. This changes the amplitude of the grid fluctuations and also the variations in input capacity, and this in turn modulates the frequency of the oscillator.

To use this wobbulator, the output of the signal generator on hand is connected to the jack marked "R.F.-In" on the oscillograph panel. This impresses the signal on the modulator grid of the 6K8 tube, and here it is heterodyned with the 1000-cycle signal so that a beat frequency is produced which is the sum or difference of the two frequencies. This beat frequency is also wobbled over the desired range and is available at the jack labeled "R.F.-Out". The external oscillator must always be tuned to such a frequency that the difference between its frequency and 1000 Kc. is the required operating frequency.

THE TRIPLETT MODEL 1691 DELUXE OSCILLOSCOPE

The Triplett Model 1691 Oscilloscope, which also employs a 3-inch cathode-ray tube, is quite conventional in its general circuit arrangement, but has incorporated in it a number of individual design features that are rather attractive.

The power supply employs a type 25Z6 tube that is operated as two separate

half-wave rectifiers, one through the lower half of the high-voltage transformer winding for supplying the operating voltages to the cathode-ray tube, and the other through the upper half of the winding for feeding the vertical and horizontal amplifier tubes and the sweep frequency generator. The center tap on this winding is grounded, and is the point of high positive potential for the first rectifier system as well as the negative return point on the other system. That is, the two rectifiers are in series with their common point grounded to the chassis.

In the cathode-ray tube the cathode is internally tied to one side of the filament or heater and externally connected to the voltage divider between the Intensity Control and Focusing Control potentiometers, which are clearly indicated in the diagram. Anode No. 2 as usual is tied to one of the vertical and horizontal deflecting plates within the tube, and externally it is grounded. It is, therefore, at maximum positive potential. The two Spot-Centering or positioning controls are shown connected across the high-potential grounded point on the voltage divider.

The Vertical input jacks are shown at the left in the diagram, and the slider of the Vertical Amplifier Control is connected to a 3-point 2-position rotary switch. With this switch in the "In" position, points numbered 1 touch the contact arcs, and the output of the amplifier tube, a type 6J7, is impressed on the vertical deflecting plate. In the "Out" position, switch points numbered 2 touch the contact arcs, the amplifier tube is cut out of the circuit, and the control slider is connected directly to the vertical plate through an .05 condenser. In either position part of the signal potential going to the vertical plate is also available at the Sweep Selector switch for synchronizing or locking in.

The Horizontal input jacks are shown at the right, and here the Horizontal

Amplifier Control is connected to a 3-point 3-position selector switch. In the position labeled "Out", points numbered 3 touch the control arcs. This connects the red Horizontal jack to the Amplifier Control and the slider of this control through an .05 condenser directly to the Horizontal deflecting plate. In other words, the amplifier tube, a type 6C6, is cut out of the circuit.

In the position labeled "In", points numbered 2 touch the contact arcs, and the red Horizontal jack is again connected to the Amplifier Control, but the slider now joins to the grid of the 6C6 horizontal amplifier tube. Also, the plate of this tube is connected through the .05 condenser to the Horizontal deflecting plate. The amplifier tube is, therefore, in operation between the Horizontal input jack and the Horizontal plate in the cathode-ray tube.

In the position labeled "Sweep", points numbered 1 touch the contact arcs. This cuts out the Red Horizontal jack and instead connects the output of the Sweep Frequency Generator to the Amplifier Control. The slider is still joined to the grid of the amplifier tube and the plate is coupled to the Horizontal deflecting plates. In other words, the output of the Sweep Frequency Generator is now impressed on the Horizontal deflecting plate with the amplifier in series.

In the Sweep Frequency oscillator system a type 885 gas triode is used, and across the plate circuit of the tube is a 7-position selector switch for cutting in the desired frequency range. In series with the plate circuit is the Sweep Vernier for further adjusting the frequency to the exact value. The high voltage operating potential is supplied to the plate circuit through one of the contact arcs on the Horizontal Amplifier switch.

For synchronizing the Sweep Frequency generator a Sweep Lock control is provided, the upper end of which is connected to a 3-position Sweep Selector Switch. In one position labeled Lin. Int. (Linear Internal) this switch supplies part of the signal voltage sent to the Vertical Deflecting plate for

synchronizing. In the second position it provides a 60-cycle A.C. potential which is tapped off from one of the secondary windings on the power transformer, and in the third labeled Ext. it connects to a tip jack at the top of the instrument panel so that any desired external potential can be used for synchronizing or controlling the Sweep Frequency generator.

This completes the circuit system of the entire oscilloscope, and although the arrangement is quite standard, the switching controls are somewhat different from those used in other 'scopes.

HOW TO OPERATE AN OSCILLOSCOPE

To obtain optimum performance from an oscilloscope and prolong the useful life of the tube as much as possible, certain operating principles should be observed and other practices guarded against. The following outline gives the proper method of procedure for putting an oscilloscope into operation. A number of experimental exercises are also given to enable those unacquainted with the instrument to gain some experience in the manipulation of the various controls.

Putting An Oscilloscope Into Operation

Before an oscilloscope is turned on, these control settings should be made: The Sweep Frequency control put in the off position, the External-Internal Sweep switch in the External position, the Vertical and Horizontal Gain controls turned in a clockwise direction just far enough to trip their switches, the Synchronizing control turned to zero, and the Vertical and Horizontal Shift knobs rotated about half-way. The Intensity Control is then advanced far enough to trip the On-Off switch, and the Focus Control is rotated through about ninety degrees.

After the tube has warmed up for a minute or more, the Intensity Control is advanced slowly until the green spot of light becomes visible on the screen. Both the Focusing and Intensity controls are then adjusted together until a clean

sharp spot is obtained, but not any brighter than is necessary to be visible. Caution! - Never let the spot remain in a fixed position for any length of time, for otherwise it will burn the screen and render it inoperative at that place. If the spot of light does not appear at the center of the screen, it can readily be positioned by adjusting the Vertical Shift and Horizontal Shift controls.

The oscilloscope is now ready for use, and merely needs to be connected to the receiver itself and to whatever accessories are required. The service to which it is to be put, of course, will determine the additional control adjustments that are necessary. Important! - Whenever a 'scope is to stand idle for a few minutes or longer time, the Intensity Control should be turned back (not to trip the switch, however) so as to conserve the active material on the screen.

Practice Exercises

TO MOVE OR SHIFT THE SPOT VERTICALLY. To shift the spot of light in a vertical direction, a suitable potential must be impressed on the vertical plates. The A.C. line voltage is used at this time. Without changing the control settings arranged above, insert one end of a pair of test leads into the "Vert." and "Gnd" tip jacks on the oscilloscope, and the other end into a convenient A.C. outlet. Be careful that they do not short or that you do not touch them.

Slowly advance the Vertical Gain control, and gradually the spot of light will elongate into a vertical line. Further adjust the control until the line is about two inches long. This line now represents the movement of the spot of light as the electron ray is influenced by the alternating potential on the vertical plates. As the potential increases from zero to a positive maximum, it shifts the spot upward; and as it drops back to zero, it returns the spot to its position of rest. But at this instant the voltage reverses and increases to a negative maximum, carrying the spot of light downward; and as it decreased

to zero again, it brings the spot of light back also.

Since the A.C. voltage passes through 60 such cycles per second, the spot of light also makes 60 complete up and down swings in a second. Although there is only a single spot of light that moves through these successive positions, the fact that the motion occurs so rapidly and that the impression in the eye lingers for a fractional part of a second, causes the motion to appear as one continuous line. In a similar manner an A.C. voltage of any frequency up to the limit of the amplifier can be impressed on the deflecting plates and cause a vertical swing of the spot of light.

As the gain control is increased or decreased, the length of the vertical line changes accordingly due to the amplifying action of the amplifier between the input to the 'scope and the vertical deflecting plates. By adjusting this gain control it is possible to regulate the size of the image on the screen according to the value of the input voltage. When disconnecting the test leads first remove them from the A.C. outlet and then from the oscilloscope.

TO SWING THE SPOT HORIZONTALLY

The spot of light can be shifted horizontally by impressing an external voltage on the horizontal plates, or by using the internal saw tooth oscillator. The external voltage will be applied first, but before this is done the vertical gain control should be returned to its original position and all other controls left as they were set previously.

Insert one end of the test leads into the "Hor" and "Gnd" tip jacks and the other end into the A.C. outlet. Gradually advance the Horizontal Gain Control, and soon the spot of light will elongate into a horizontal line. This line is again the result of the influence of the A.C. potential on the ray of electrons, except that now the potential is impressed on the horizontal plates and the spot swings in a horizontal direction. The intensity control should be set just high enough to produce a clear visible line.

This horizontal line is frequently used as a reference line and is then called the Zero Axis. Distances above this line are considered positive and distances below as negative. It is also known as the Timing Axis or Time Base, for the horizontal movements are sometimes used as a standard against which the frequency of the voltage impressed on the vertical plates is measured.

CONNECTIONS MADE DIRECTLY TO DEFLECTING PLATES

Provisions are also made on oscilloscopes for connecting directly to the deflecting plates, with the amplifiers cut out of the circuit. The instructions accompanying an instrument then indicate how the controls must be set. Generally a separate tip jack is provided. On the Supreme Model 546, for example, a tip jack labeled "V" connects directly to the Vertical plates and another labeled "H" connects to the horizontal plates. When direct connections are made, the Vertical Gain and Horizontal Gain controls are returned clear to the off position to cut the amplifiers out of the circuit entirely.

There are not many occasions when such direct connections are used. But since there are no series condensers, this makes it possible to use the 'scope as a D.C. voltmeter. Voltages up to about 90 or 100 volts can be applied directly to the plates without carrying the image off the screen. To use the oscilloscope as a D.C. voltmeter, the Vertical and Horizontal Gain controls are turned to the off position and connections are made directly to the "V" and "Gnd" plate. Under these conditions, the Vertical and Horizontal positioning controls are inoperative. A graduated screen is generally provided with an oscilloscope to be placed in front of the tube. By noting to what height the vertical line rises when D.C. voltages of known value are impressed on the vertical plate, the screen can be calibrated directly in volts. Unknown voltages can then be measured against this scale.