Vol. 8, No. 2 March-April, 1946

THE OSCILLOGRAPHER

Published Bi-Monthly by the Allen B. Du Mont Laboratories, Inc.

Some Extended Uses of The Cathode-ray Oscillograph

By E. G. Nichols

This article attempts to describe a few of the many interesting and rather unusual applications to which a versatile, laboratory cathode-ray oscillograph may be put. It is hoped that this discussion will assist engineers in placing their equipment to the greatest possible use and that in so doing useful results will be obtained in the form of more information in the least possible time. While this discussion is not intended to be exhaustive, it is nevertheless hoped that it will point the way to many new applications for the ordinary laboratory cathode-ray oscillograph.

INTRODUCTION

Occasionally it is more advantageous to depart from the regular oscillographic methods and make signal connections directly to the deflection plates of the cathode-ray tube instead of through the amplifiers, or to interchange the horizontal and vertical channels of the oscillograph. In general, the two conditions which warrant direct connections are: (1) if the signal has sufficient amplitude but contains frequency components incapable of being handled without distortion by the amplifiers; (2) if the signal is of such amplitude that a voltage divider is necessary to reduce it to a usable value. The condition calling for interchanging the horizontal and vertical channels arises when it is desired to present the time variable in the vertical plane and the amplitude variable in the horizontal plane.

The considerations involved in connecting directly to the deflection plates are: (1) whenever possible, to make the input impedance to the deflection plates at least 5 to 10 times as high as the output impedance of the source under observation to avoid loading the source; (2) always to be sure that there is d-c continuity between the deflection plates and ground (in general, this d-c path should be limited to a maximum resistance of 5 megohms); (3) to determine whether one or two free deflection plates are available in each channel of the oscillograph.

The third consideration just mentioned demands some expanding. An example of oscillograph having only one free deflection plate in each channel, the other deflection plate being connected within the instrument to the second anode (which is generally at ground potential), is the Du Mont Type 164-E. This type of oscillograph is capable of handling the outputs of any unbalanced circuit or half the output of a balanced circuit. The more versatile instruments such as the Du Mont Types 208-B, 224-A, 241, 247, 248 and 274 cathode-ray oscillographs have both deflection plates in each channel available for signal connections. These latter types of oscillographs can handle either unbalanced or balanced outputs.

In all these considerations for direct connections to oscillographs it is assumed that the external signal connections are made to the vertical channel and the horizontal channel remains intact. Of course, if the occasion should arise when it would be convenient to use direct deflection in the horizontal channel the same would apply as are herein discussed for the vertical channel.

DIRECT CONNECTION: ONE FREE DEFLECTION PLATE

The Du Mont Type 164-E Cathode-ray Oscillograph serves as an example for illustration purposes of an oscillograph with one free vertical deflection plate.

The simplest case* involving direct connection to the deflection plates arises when: (1) the signal amplitude is below 150v peak; (2) a d-c return is available through the source; (3) no vertical positioning is required. Figure 1 shows the circuit used when making direct connections in the simplest case. Of course, the circuit applies if the source contains either or both d-c or a-c components.

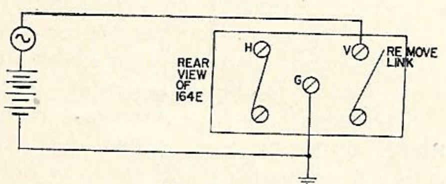
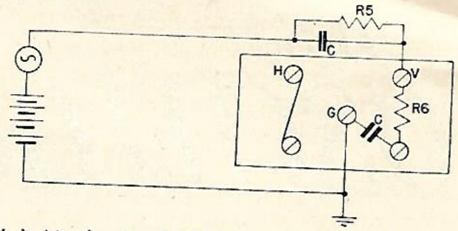


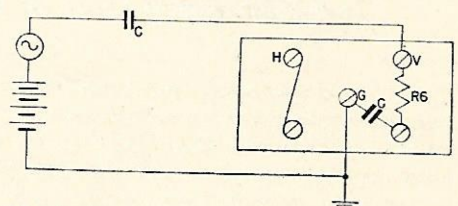
FIGURE 1

Method of Making Direct Connections to the Deflection Plate in the Simplest Case

Under certain conditions, vertical positioning control is necessary. Figure 2a shows the connections which would be required in order to make use of the vertical positioning circuits of the oscillograph. With the connections shown, all of the a-c components and a portion of the d-c component will be displayed and a limited amount of vertical positioning control will be available. The larger R_5 is made, compared to R_6, the more positioning and the less d-c signal will be available. Of course, at the limit when R_5 becomes infinite or an open circuit as shown in Figure 2b, only the a-c components of the signal will appear on the screen and the entire positioning range will be available.



(a) Method of Making Direct Connections to the Oscillograph While Maintaining Limited Control of Vertical Positioning



(b) Method of Making Direct Connections to the Oscillograph While Maintaining Full Control of Vertical Positioning

FIGURE 2

Under this condition, R_6 should have a value between 1 and 5 megohms to act as the d-c return from the deflection plate. Both capacitors "C" should have a capacitance large enough to pass the a-c signals without attenuation.

Then, again, it may be required to see the entire signal (both d-c and a-c components) but still have vertical positioning control available. A schematic circuit of an arrangement for meeting such requirements is shown in Figure 3. The balanced power supply required for positioning should have a higher voltage to ground than the d-c signal component. It is assumed that the d-c resistance of the source in this case will be under 5 megohms and, therefore, this path through the source will be the d-c return for the deflection plate. In this case, the positioning potentiometer could be calibrated to measure the d-c component of the signal. The measuring procedure is to connect directly from the center arm of the calibrated potentiometer to the vertical deflection plate, then to adjust the spot on the screen to some reference line, and finally to connect the signal source as shown in Figure 3 and to note how much the potentiometer has to be adjusted to bring the base line back to the same reference point.

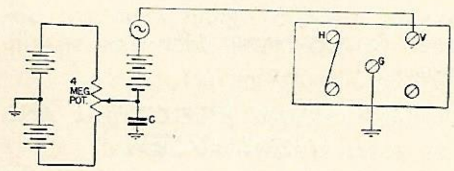


FIGURE 3

Method of Making Direct Connections to the Oscillograph While Maintaining Full Positioning Control and Retaining Both A-C and D-C Signals

When the a-c signal exceeds 150 volts peak, a circuit resembling Figure 4 is used since voltage division is necessary in order to have the signal small enough to fit on the screen. The ratio of resistors R_1 and R_2 determines the fraction of the available signal which is placed on the deflection plates. Both capacitors "C" are large enough in capacitance to afford adequate a-c by-pass at the signal frequency. The small capacitors C_1 and C_2 are optional and would only be required if the signal contains extremely high frequency components and a frequency-compensated voltage divider is needed to avoid distortion. Cases such as short pulses or spark discharges will require frequency compensation. A good approximation for such compensation is to make the time constant $R_1 C_1$ equal to the time constant $R_2 C_2$.

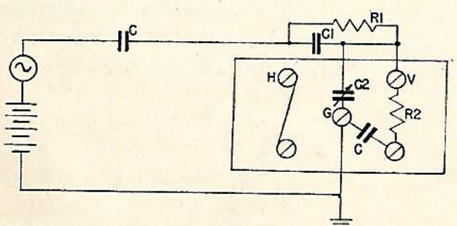


FIGURE 4

Method of Making Direct Connections to the Oscillograph When the A-C Signal is too Large in Amplitude

The method of attack employed when the output of a balanced source is to be observed on an instrument such as the Type 164-E is shown in Figure 5. The requirements are that R_3 and R_4 be equal, and very large compared to the circuit impedances Z_1 and Z_2. All the previous variations in connecting to the oscillographs still apply in this case. Capacitor C_4 is optional. Its function is to compensate for the wiring and input capacitance of the cathode-ray tube connected to the other half of the balanced circuit. As far as total output of the source is concerned, only half of it is being seen on the screen.

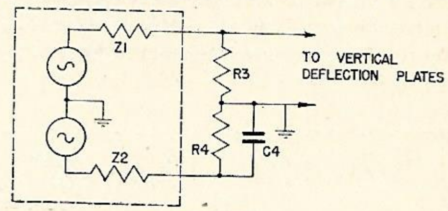


FIGURE 5

Method of Making Direct Connections to the Oscillograph from the Output of a Balanced Source

In all cases where synchronization is required, an external synchronizing signal for the horizontal sweep must be used. A signal which is large enough to be directly connected to the vertical deflection plates is usually too large to use as a synchronizing signal without voltage division. Furthermore, the low input impedance to the synchronizing circuit (15K in most cathode-ray oscillographs) would be a very serious load to a high impedance signal source. Referring back to Figure 2, the resistor R_6 could be split into two components as shown in Figure 6. The resistor specified as 100K

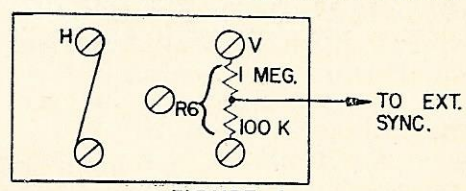


FIGURE 6

Method of Making Direct Connections to the Oscillograph When a Sync Signal is Needed arise when it would be convenient to use direct deflection in the horizontal channel the same would apply as are herein discussed for the vertical channel.

DIRECT CONNECTION: ONE FREE DEFLECTION PLATE

The Du Mont Type 164-E Cathode-ray Oscillograph serves as an example for illustration purposes of an oscillograph with one free vertical deflection plate.

The simplest case involving direct connection to the deflection plates arises when: (1) the signal amplitude is below 150v peak; (2) a d-c return is available through the source; (3) no vertical positioning is required. Figure 1 shows the circuit used when making direct connections in the simplest case. Of course, the circuit applies if the source contains either or both d-c or a-c components.

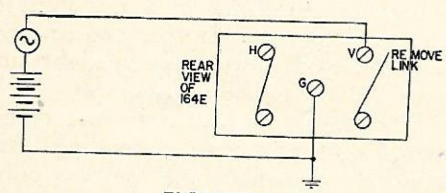
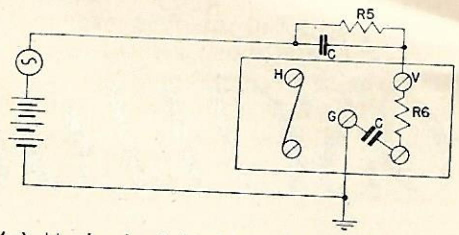
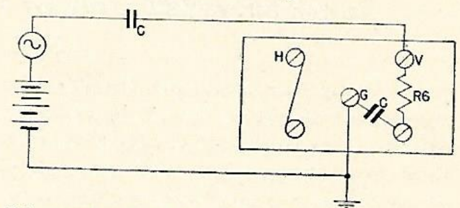


FIGURE 1
Method of Making Direct Connections to the Deflection Plate in the Simplest Case

Under certain conditions, vertical positioning control is necessary. Figure 2a shows the connections which would be required in order to make use of the vertical positioning circuits of the oscillograph. With the connections shown, all of the a-c components and a portion of the d-c component will be displayed and a limited amount of vertical positioning control will be available. The larger R_5 is made, compared to R_6, the more positioning and the less d-c signal will be available. Of course, at the limit when R_5 becomes infinite or an open circuit as shown in Figure 2b, only the a-c components of the signal will appear on the screen and the entire positioning range will be available.



(a) Method of Making Direct Connections to the Oscillograph While Maintaining Limited Control of Vertical Positioning



(b) Method of Making Direct Connections to the Oscillograph While Maintaining Full Control of Vertical Positioning

FIGURE 2

Under this condition, R_6 should have a value between 1 and 5 megohms to act as the d-c return from the deflection plate. Both capacitors "C" should have a capacitance large enough to pass the a-c signals without attenuation.

Then, again, it may be required to see the entire signal (both d-c and a-c components) but still have vertical positioning control available. A schematic circuit of an arrangement for meeting such requirements is shown in Figure 3. The balanced power supply required for positioning should have a higher voltage to ground than the d-c signal component. It is assumed that the d-c resistance of the source in this case will be under 5 megohms and, therefore, this path through the source will be the d-c return for the deflection plate. In this case, the positioning potentiometer could be calibrated to measure the d-c component of the signal. The measuring procedure is to connect directly from the center arm of the calibrated potentiometer to the vertical deflection plate, then to adjust the spot on the screen to some