

April 27, 1948.

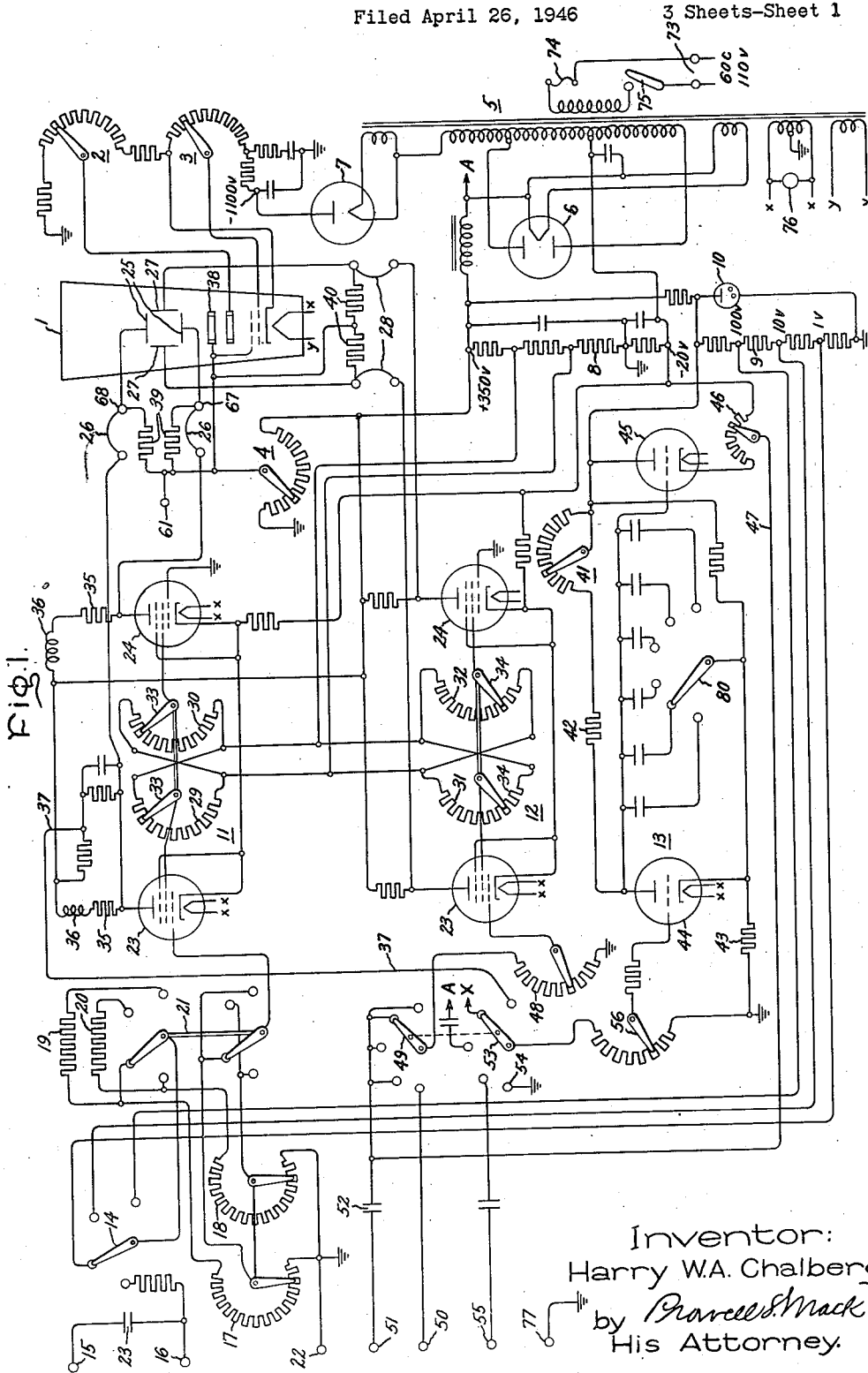
H. W. A. CHALBERG

2,440,538

PORTABLE CATHODE RAY OSCILLOSCOPE

Filed April 26, 1946

3 Sheets-Sheet 1



Inventor:
Harry W.A. Chalberg,
by *Harold S. Mack*
His Attorney.

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H. W. A. CHALBERG

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3 Sheets-Sheet 2

Fig. 2.

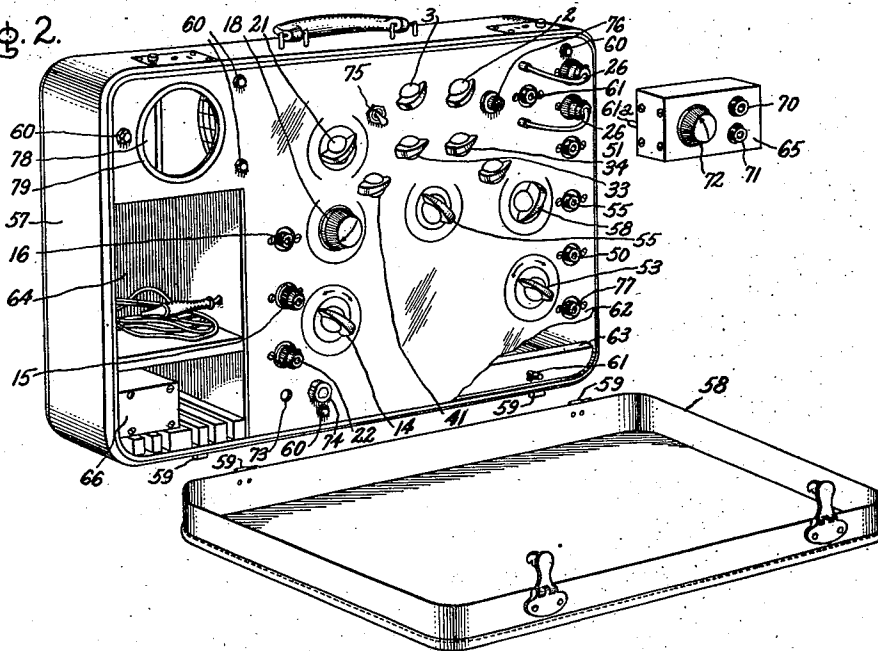
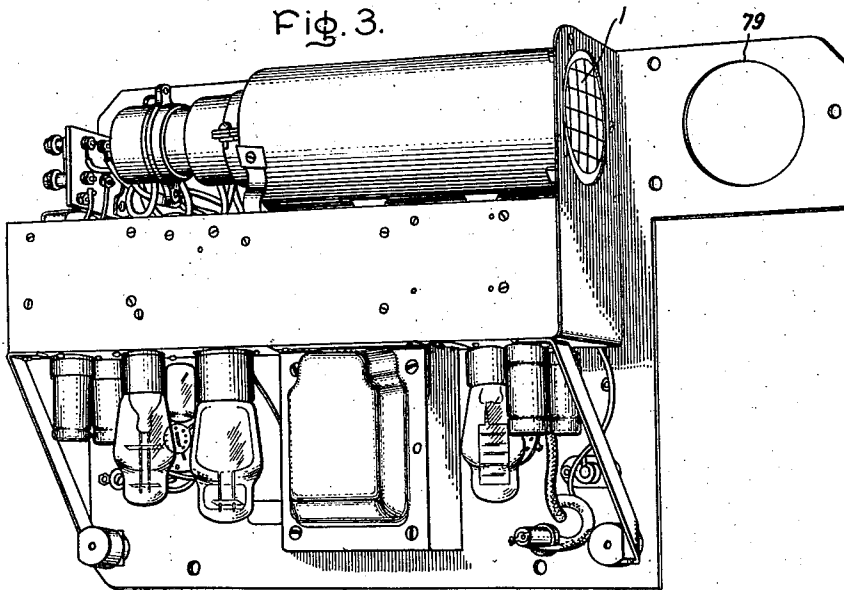


Fig. 3.



Inventor:
Harry W.A. Chalberg,
by *Rowell & Mack*
His Attorney.

April 27, 1948.

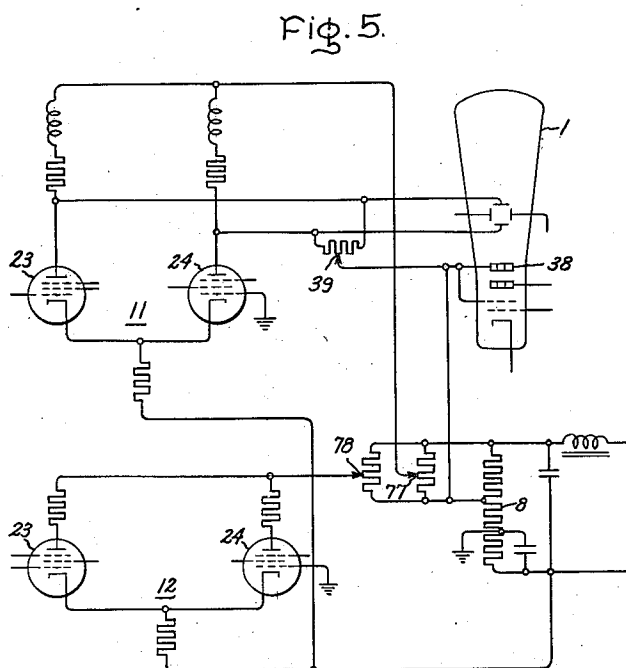
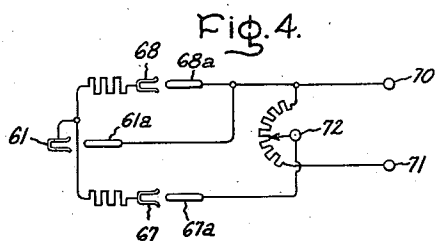
H. W. A. CHALBERG

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PORTABLE CATHODE RAY OSCILLOSCOPE

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3 Sheets-Sheet 3



Inventor:
Harry W. A. Chalberg,
by *Rowell & Mack*
His Attorney.

UNITED STATES PATENT OFFICE

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PORTABLE CATHODE-RAY OSCILLOSCOPE

Harry W. A. Chalberg, Berne, N. Y., assignor to
General Electric Company, a corporation of
New York

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2 Claims. (Cl. 315—26)

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My invention relates to cathode-ray oscilloscopes and one object is to provide a portable oscilloscope that may be housed in a portable container comprising an ordinary luggage or suitcase. Other objects relate to certain improvements in the control circuits employed to obtain simplicity, ease and accuracy of calibration and operation, and independence of line voltage variation, without sacrificing reliability for general industrial use. Certain aspects of my invention disclosed but not claimed herein are claimed in divisional applications Ser. No. 3804, filed February 17, 1948; and Ser. No. 3805, filed February 17, 1948.

The features of my invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. For a better understanding of my invention, reference is made in the following description to the accompanying drawings in which Fig. 1 is a wiring diagram of the oscilloscope apparatus; Fig. 2 is a front view of the oscilloscope as assembled in its carrying case with the cover of the case removed preparatory to using the oscilloscope; Fig. 3 shows a rear view of the oscilloscope chassis as removed from its carrying case; Fig. 4 shows connections of a plug-in attenuator and Fig. 5 is a modified image distortion control.

In Fig. 1 of the drawing there is represented the wiring diagram of the oscilloscope. The oscilloscope cathode-ray tube 1 with its focus control 2, sensitivity control 3, and astigmatism control 4, is represented in the upper right of Fig. 1. The power supply pack for the oscilloscope and its circuits is conventional and is represented in the lower right of Fig. 1, and consists of a transformer 5 having the necessary secondary windings for supplying the filament heater circuits designated *x* and *y*, the full wave rectifier tube 6, the half wave rectifier tube 7 for supplying the high voltage cathode circuit of the oscilloscope, voltage dividers 8 and 9, and voltage regulator tube 10. Typical D.-C. voltages employed are indicated at important points in the power supply. The vertical amplifier for the oscilloscope is generally designated at 11, the horizontal amplifier at 12, and the sweep voltage generator at 13. At 14 is a switch which is used to connect the vertical amplifier input signal terminals 15 and 16 or calibrating voltages from voltage divider 9 to the input of the vertical amplifier 11. The vertical amplifier input is made through one of the gain control variable resistance circuits having high and low variable resistances 17 and 18 and high and low fixed resistances 19 and 20.

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The particular gain control resistance circuit used is selected by means of switch 21. Four different ranges of resistance control are provided for and in each case one or the other of the variable controls 17 or 18 is included. It is noted that such variable resistance gain control is available both when the input is connected to the signal terminals 15 and 16 or to the calibrating voltages from voltage divider 9. When A.-C. signal voltages are being investigated, the input terminals 15 and 22 are used. Terminal 22 is a ground or common terminal and is connected to the metal chassis of the apparatus. For the A.-C. signal connection the condenser 23 blocks out any D.-C. component present. When investigating D.-C. signals or D.-C. components of signals, the input is connected between terminals 16 and 22. The incoming signal is thus direct connected to the vertical amplifier without any blocking condenser, and hence, D.-C. signal values can be measured directly on the screen of the oscilloscope after calibration by the known D.-C. voltages from voltage divider 9. This is considered to be an improvement over the usual arrangement where a blocking condenser is employed in the input circuit of the vertical amplifier.

The vertical and horizontal amplifiers are supplied from the -20 and +350 volt terminals of voltage divider 8. These amplifiers are similar and each comprises a pair of screen grid vacuum tubes 23 and 24, and they are cathode connected phase inverters and produce output voltages of opposite polarity of a magnitude proportional to input. The output of the vertical amplifier is or may be impressed across the vertical deflection plates 25 of the cathode-ray tube 1 through jumper connections at 26, and the output of the horizontal or sweep amplifier is or may be impressed across the horizontal deflection plates 27 of the oscilloscope through jumpers at 28. The jumpers 26 and 27 are removable for purposes to be explained later. The representation of the deflection plates is schematic.

Positioning control

I provide a novel positioning control method for the vertical and horizontal amplifiers by inversely varying the screen grid voltages. In this control a voltage from a suitable intermediate section of voltage divider 8 is impressed across four slide wire resistances 29, 30, 31, and 32. Contacts 33 and 34 associated with the vertical and horizontal amplifiers, respectively, which are adjustable along these resistances connect with the screen grids of the respective tubes and since the

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cathodes of these tubes are all connected to a more negative point of the same resistance divider 8, the screen grid voltages will be varied when the contacts are adjusted, thereby varying the currents through the tubes and their plate voltages accordingly. It is further noted that the two contacts 33 at the vertical amplifier are connected together for simultaneous adjustment. Likewise, the two contacts 34 at the horizontal amplifier are connected together for simultaneous adjustment. The slide wires 29 and 30 are cross connected to the voltage source such that as the voltage on the screen grid of one of the tubes 23 is increased, the screen grid voltage of its companion tube 24 is reduced. Hence, moving contacts 33 in one direction will move the cathode-ray beam of the cathode-ray tube 1 vertically in one direction, and moving such contacts in the opposite direction will move the beam in the opposite direction on the screen. The horizontal beam control is similar except that, with it, the beam may be shifted back and forth horizontally on the screen of the scope tube 1. This method of positioning provides a continuously variable control and instantaneous response for reference positioning of the beam. It compensates for differences in tube characteristics and the value of plate load resistors, thus making the pair of tubes of each amplifier operate as nearly identical tubes. This method of positioning is not greatly affected by changes in line voltage so there is no need for an elaborate regulated power supply. The plate currents flow through load resistors such as indicated at 35. In the vertical amplifier, inductance, such as shown at 36, is also preferably included in the plate circuits to improve the frequency response. A filter network composed of resistance and capacity is connected across the plate load impedance of tube 23. A connection 37 is made on this network to provide a voltage for the purpose of synchronizing the sweep voltage generator with the input signal to the vertical amplifier.

Image distortion control

In the conventional oscilloscope there is a tendency for the image formed on the screen of the cathode-ray tube to be distorted into an oblong shape either in the vertical or horizontal direction. This distortion effect is caused by the electron optic lenses formed by the parallel deflecting plates when there is a difference in potential between these plates and the second anode. Since the vertical and horizontal deflecting plates are displaced at different distances along the axis of the cathode-ray tube, the lens effect of each pair of plates operates at different settings of the focus control. I have discovered that if the voltage of the second anode 38 of the cathode-ray tube 1, which is usually connected to chassis ground, has a value corresponding to the average voltage of the horizontal and vertical deflecting plates, this astigmatic distortion, as it might be called, disappears and the beam has a round shape giving a sharp even width trace on the screen in all directions of movement.

One method of accomplishing this end is shown in Fig. 1 where anode 38 is connected to the adjustable contact between the plate supply voltage for the vertical and horizontal amplifiers and ground. By adjusting the anti-distortion control 4, the second anode voltage 38 can be made equal to the average voltage of the four deflecting plates and the desired result of a round image on the cathode-ray tube screen is obtained. The

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anode 38 is also connected to all four deflecting plates through resistances 39 and 40, the resistances 39 being connected across the vertical plates 25 with the connection to anode 38 at a midpoint between the resistances. A similar connection is made from anode 38 to the midpoint of resistances 40 connected between the horizontal deflecting plates 27. Such a resistance between the deflecting plates and the anode 38 prevents the plates from accumulating electrostatic charges.

A second method of accomplishing correction for image distortion is shown in Fig. 5 where the second anode 38 is connected to an intermediate voltage on voltage divider 8. The high voltage supply mains for the vertical and horizontal amplifiers are, in this figure, connected to the adjustable contact arms of slide wire resistors 77 and 78 respectively. The resistors 77 and 78 are connected between the most positive point of voltage divider 8 and that point to which anode 38 is connected. In this system the plate supply voltage of each amplifier is adjusted until the voltage at the respective deflecting plates equals the voltage of the second anode 38. When this condition has been attained, the image on the screen of the cathode-ray tube is round and sharp.

This latter system offers the advantage over the previous system of providing an adjustment of the second order thereby taking into account any differences between the vertical and horizontal amplifiers; whereas, the first system provides only an adjustment of the first order. The practical results of the first system are, however, sufficiently good and for most applications this system will be found to be adequate. There are of course other methods which can be used to make the voltage of the second anode 38 equal to the average voltages of the deflecting plates 25 and 27.

Sweep generator connection

The sweep generator 13 is of conventional design but the connection to the horizontal amplifier from the sweep voltage generator is believed to represent an improvement in that it is designed so as to minimize distortion of the sweep voltage. The selected condenser of the sweep generator is charge through an adjustable control resistor 41 and resistors 42 and 43 from across the voltage divider resistance 9, and discharged through the gaseous tube 44. As a result the voltage across tube 44 gradually builds up and suddenly decreases to zero, producing the well-known triangular shape sweep voltage wave. A corresponding voltage is fed to the input of the horizontal amplifier for amplification as desired. One difficulty heretofore has been in feeding this widely and suddenly-varying voltage to the control grid of the horizontal amplifier without distortion. I employ a cathode follower tube 45 which performs a direct current transformer function between the sweep generator and input to the horizontal amplifier tube 23. Tube 45 with its cathode follower resistance 46 is supplied from the high voltage end of potential divider 9 to the negative voltage end of potential divider 8 and is grid controlled in response to the voltage across the sweep generator. The input voltage to the control grid of horizontal amplifier tube 23 is taken off of an adjustable point of the cathode follower resistance 46 through a slide wire contact and connection 47. This connection includes a further slide wire resistance 48 con-

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nected to ground with an adjustable contact from resistance 48 to the control grid of horizontal amplifier tube 23. It is evident that the current which flows through resistances 46 and 48 is not taken from the sweep generator but is merely controlled in proportion to the value of sweep generator voltage, and hence, there is minimum distortion of the sweep voltage applied to the horizontal amplifier.

There is a synchronizing selector switch associated with the horizontal amplifier and sweep generator control, and the connection just described is made through the upper blade 49 of this switch in any one of four positions. In the extreme left-hand position of switch blade 49 the horizontal amplifier may be connected to an external source of voltage through a terminal 50. The terminal 51 which is connected to be controlled by the sweep generator through a condenser 52 is used when it is desired to synchronize the operation of some external device, such as an electronic switch, with the oscilloscope operation. The lower blade 53 of the selector switch is connected to the control grid circuit of sweep generator gaseous tube 44. When the horizontal amplifier input is controlled by an external source of sweep frequency with switch blade 49 connected to terminal 50, the blade 53 which is connected to and moves with blade 49 is connected to a ground terminal 54. In the next position of the selector switch moving clockwise, the sweep generator input control is connected to a terminal 55 to enable the sweep generator to be synchronized with the frequency of an external signal which will be connected at terminal 55. In the next or third position of the selector switch, switch blade 53 connects the sweep generator control to a lead marked A which connects to a point marked A just above rectifier tube 6, and which is connected to the cathode of this double wave rectifier. With a 60-cycle power supply to transformer 5 the point A will have a frequency of 120 cycles per second and the sweep generator 13, when properly adjusted to near this frequency, will be synchronized accordingly. In the next or fourth position of switch 53 it is connected to a lead marked X which connects with the filament supply found in the lower right-hand corner of Fig. 1 and which has a synchronizing frequency of 60 cycles. In the final or fifth position of the synchronizing blade 53 of the selector switch, the sweep generator synchronizing control is connected through wire 37 with the vertical amplifier circuit, so that the sweep generator 13 will be synchronized with the signal frequency applied at 15—22 or 16—22 to the vertical amplifier. The sweep generator is made to synchronize with the selected frequency by turning it to a condition where its natural frequency will be near the selected control frequency by the capacitance control switch 80, variable resistance 41 in the charging circuit of the sweep generator, and the input grid voltage control potentiometer at 56.

The oscilloscope with its control system power supply etc. is adapted to be housed in an ordinary luggage case 57, Fig. 2, the cover 58 of which is removable by opening in the usual way and then sliding it off of its hinges 59. The luggage case with oscilloscope inserted and with cover removed is shown in Fig. 2, in which condition the apparatus is ready for use. The scope tube 1 with its chassis is removable as a unit from the carrying case by removing six nuts 60 from bolts 61 which extend through the front panel 62. A rear view

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of the chassis as removed from the carrying case is shown in Fig. 3. The bolts 61 are secured in wooden cleats 63 fastened in the luggage case at the necessary points. In one corner of the carrying case is a built-in compartment 64 for the storing of the necessary connector cables, accessories, and a pair of plug-in attenuators 65 and 66, the attenuator 66 being shown in its compartment and the attenuator 65 removed in Fig. 2. The attenuators 65 and 66 have different resistance ranges and are used interchangeably when the signal voltage to be investigated is sufficiently high as to make the use of the vertical amplifier unnecessary. These attenuators have three plugs extending from their back sides, identified as 67a, 68a, and 61a (see Fig. 4), positioned to fit into plug sockets between the vertical amplifier and vertical deflection plates and identified in Fig. 1 as 67, 68 and 61, respectively. The jumpers 26 in the vertical amplifier scope deflection plate circuits are exposed on the front panel as shown in Fig. 2 and are removable and use plug sockets 68 and 67, and when removed, either of the attenuators 65 or 66 may be plugged in.

When one of these attenuators is used, the signal which is usually applied at terminals 22 and 15 or 16, Fig. 1, is applied to a pair of terminals 70 and 71 on the attenuator. The connection of these terminals to plug sockets 61a, 68a and 67a and to the adjustable rheostat 72 of the attenuator is shown in Fig. 4, together with the plug socket connections 61, 67 and 68 on the panel.

In Fig. 2 the various terminals and controls are identified by reference characters used in Fig. 1 for the corresponding part. It is to be noted that these are readily accessible on the front of the panel when the carrying case cover 58 is removed. The 110-volt, 60-cycle power supply is plugged into a socket at 73 and just to the right of this socket is a fuse 74 in such power supply circuit. The power supply may be turned off and on by a switch 75, and when on, a pilot light 76 lights. Ground connection may be made at 77 or 22.

In order to house the cathode-ray tube 1 in the carrying case and to be able to view its screen from the front of the exposed panel shown in Fig. 2, the tube is disposed longitudinally near the top of the carrying case behind the panel, with its screen end to the left, and a 45 degree angle mirror 78 is used to reflect the screen end of the tube at right angles through a window 79. Another function served by this method of mounting the cathode-ray tube in its carrying case is improved shading from incident light. It is, therefore, much easier to observe the pattern on the screen of the tube as well as being able to see transient phenomena which might otherwise be obliterated by the strong room lights.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A combined amplifier and positioner for cathode-ray oscilloscopes for amplifying deflection plate voltages and positioning the cathode-ray beam, comprising a pair of vacuum tubes having plate, cathode, control grid, and screen grid electrodes, means for impressing the signal to be amplified on the control grid of one of said tubes, means connecting said tubes as a cathode coupled phase inverter, and means for simultaneously and inversely varying the voltage between the screen grids of said tubes and their

corresponding cathodes for cathode-ray tube beam positioning purposes.

2. In combination with a cathode-ray oscilloscope, means for amplifying deflection plate voltages for a given axis and establishing the reference position of the cathode-ray beam in such axis, comprising a pair of vacuum tubes having plate, cathode, control grid, and screen grid electrodes; means for impressing the voltage to be amplified on the control grid of one of said tubes; connections for connecting said tubes as a cathode connected phase inverter; connections for impressing the tube plate voltages between a pair of deflection plates of the oscilloscope; a voltage divider serving as a source of supply for said tubes, a pair of resistances connected across an intermediate portion of said voltage divider, connections to the screen grids of said tubes ad-

justable along said resistances, and means for simultaneously moving both of said connections to inversely vary the screen grid voltages of said tubes.

HARRY W. A. CHALBERG.

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