Oct. 25, 1949. R. F. CLEAVER 2,485,568

ARRANGEMENT FOR REPEATING OSCILLOGRAPH INDICATIONS AT A DISTANCE

Filed May 4, 1946 2 Sheets-Sheet 1

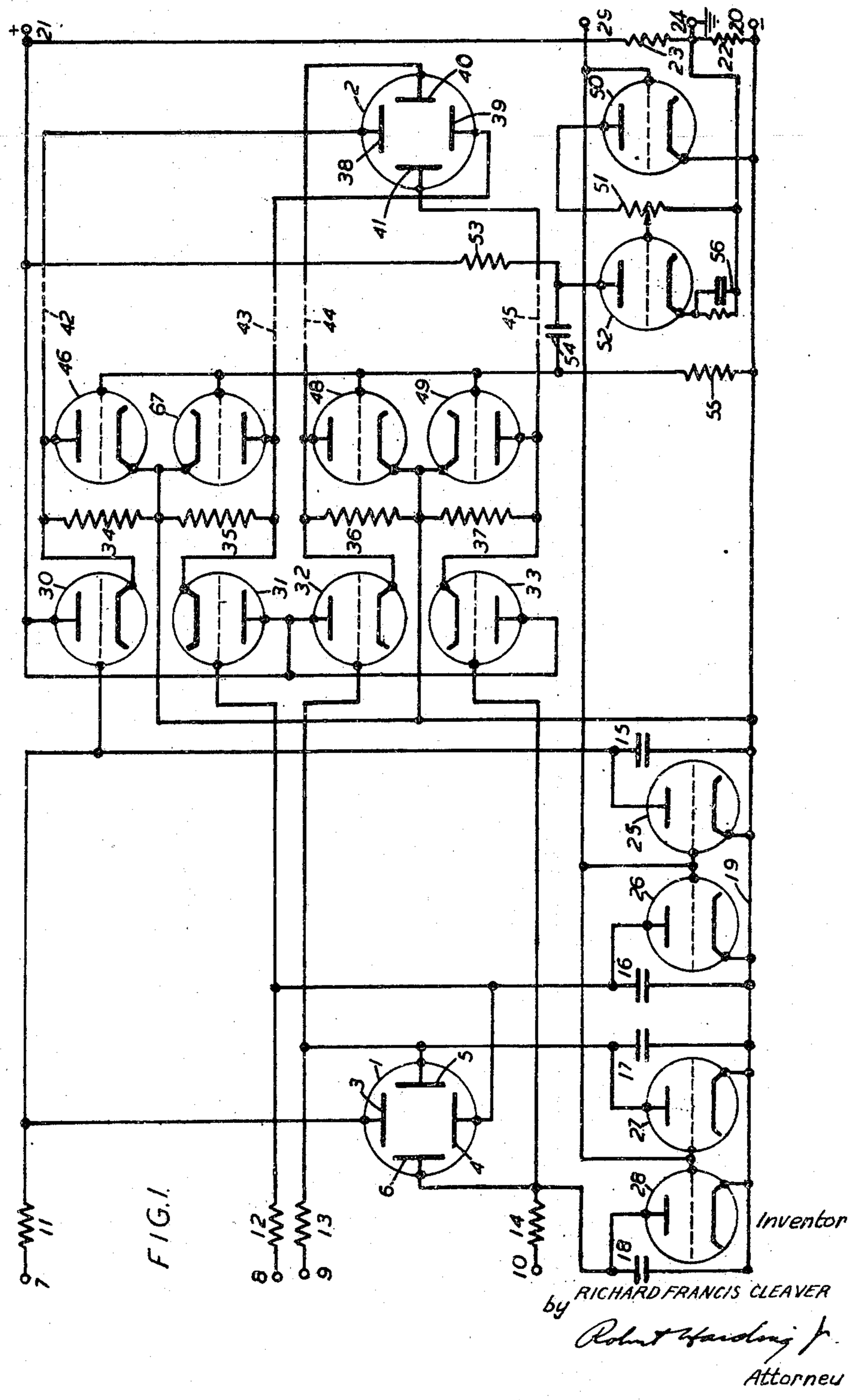

FIG. 1.

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FIG.2.

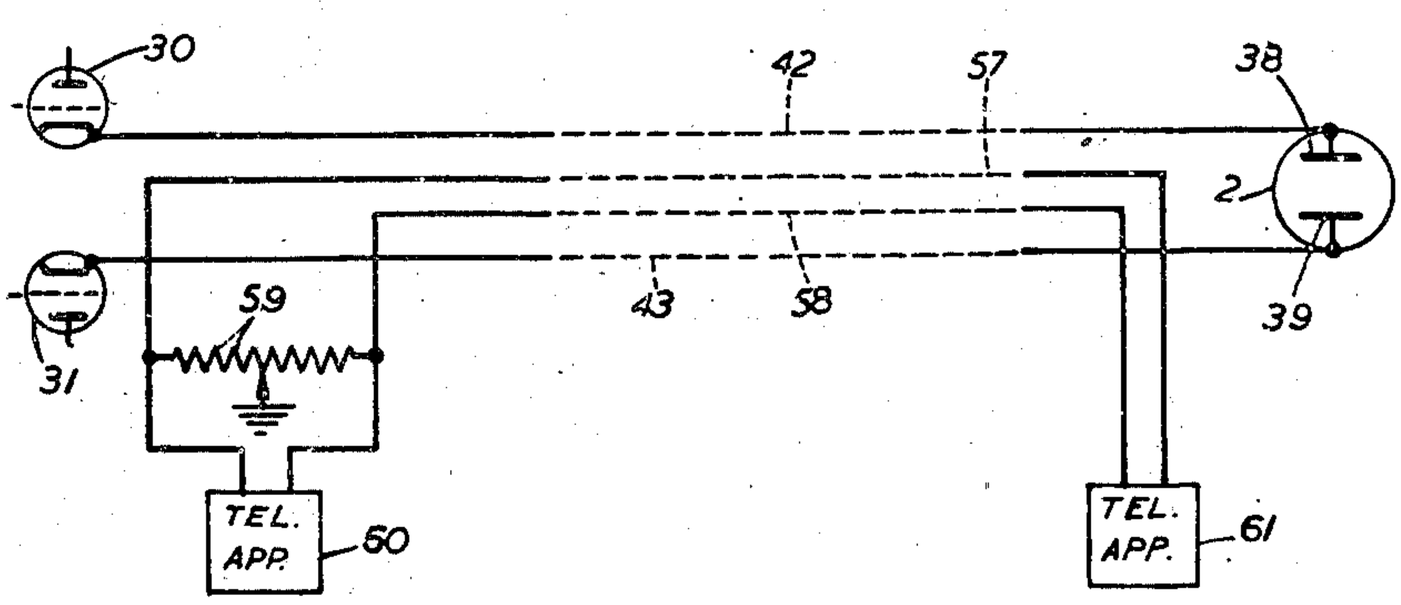
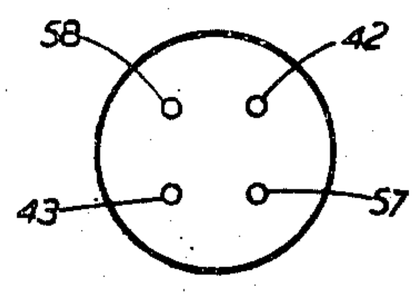


FIG.3.



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ARRANGEMENT FOR REPEATING OSCILLOGRAPH INDICATIONS AT A DISTANCE

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13 Claims. (Cl. 315—9)

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This invention relates to arrangements for repeating the indications of an electric oscillograph at a distance.

In the specification of British Patent No. 590,260 there are described arrangements for obtaining a line trace on the oscillograph screen by the application thereto of steady deflecting voltages or currents which in the ordinary way would simply deflect the tracing element to a fixed position. In a preferred embodiment employing a cathode ray oscillograph with electrostatic deflection of the cathode beam, the result is achieved by means of a periodically operated switch which alternately charges and discharges condensers connected to the deflecting plates from the steady voltages which are applied for obtaining the indication. The spot on the oscillograph screen travels backwards and forwards along a straight line radiating from the centre as the condensers are periodically charged and discharged.

In arrangements of this kind it is sometimes required to give a repetition of the indication of the oscillograph on a second oscillograph located at a distant point. In such a case it is, of course, necessary to reproduce the voltages applied to the deflecting plates of the local oscillograph at the distant oscillograph without appreciably affecting these voltages. It is found that direct parallel connection of the deflecting plates of the two oscillographs is not possible excepting over a very short distance, on account of the effect of the capacity to ground of the connecting leads which affects the time constants of the charging and discharging circuits of the local oscillograph, and in particular prevents the condensers from being completely discharged before the charging period commences. The maximum distance at which remote indication can be obtained by direct connection depends, of course, upon the frequency of the switching and upon the time constants of the charge and discharge circuits. In a typical case the maximum distance for direct connection is likely to be less than about 100 feet, and in any case some undesirable effect upon the deflecting voltages will usually occur.

According to the present invention these undesirable effects are removed or at least minimised by interposing in each connection between corresponding plates of the two oscillographs a thermionic valve arranged in a cathode follower circuit, which enables a connecting cable having moderately high capacity to be used without introducing circuits with undesirably high time

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constants which would intefere with the accuracy of the repetition.

The invention will be described with reference to the accompanying drawings, in which—

Fig. 1 shows a schematic circuit diagram of a preferred arrangement according to the invention;

Fig. 2 shows a circuit to illustrate the manner in which a cable connecting the two oscillographs may be arranged also to carry a telephone circuit; and

Fig. 3 shows the cross-section of the cable shown in Fig. 2.

Fig. 1 shows a circuit similar to Fig. 3 of the above-quoted specification which has been extended to show the preferred means according to the present invention for repeating the indications of the local oscillograph on a second or remote oscillograph connected thereto by cable or other transmission line conductors. In this arrangement, the local cathode ray oscillograph of conventional pattern is designated 1, and the distant oscillograph on which the indications are to be repeated is designated 2. The deflecting plates 3, 4, 5, 6 of the oscillograph 1 are supplied with steady deflecting potentials from the terminals 7, 8, 9 and 10 respectively through resistances 11, 12, 13 and 14. The other parts of the oscillograph are not shown. The four plates are respectively connected to a conductor of fixed negative potential by four condensers 15, 16, 17 and 18. The fixed potential conductor 19 is connected to the negative terminal 20 of the high tension supply source whose positive terminal is 21. The potential of the conductor 19 is determined by two resistances 22 and 23 connected in series between the terminals 20 and 21, the junction point of the two resistances being connected to a grounded terminal 24. The negative potential of the conductor 19 should be of such magnitude that the potential of each of the four terminals 7, 8, 9 and 10 is always positive with respect to the conductor 19 under all conditions of operation.

Four similar triode valves 25, 26, 27 and 28 have their cathodes connected to the conductor 19 and their anodes respectively to the terminals of the four condensers 15, 16, 17 and 18, which are connected to the corresponding oscillograph plates. These valves act as electronic short-circuiting switches for the respective condensers, and are controlled by rectangular pulses applied simultaneously to the four control grids from a source (not shown) which will be connected between terminals 20 and 29. These pulses should

be of such amplitude and polarity that the four valves are simultaneously and periodically blocked and unblocked at an appropriate frequency such as 50 cycles per second.

It is explained in the above-mentioned specification that in the periods when the valves are blocked, the condensers charge up through the corresponding resistances, at rates depending on the corresponding time constants, causing the spot on the screen of the oscillograph to trace a corresponding line. When the four time-constants are equal, the trace is a radial straight line whose length and orientation is determined by the values of the four deflecting potentials applied to the terminals 7, 8, 9 and 10. When the four valves are unblocked, the condensers are practically short-circuited and discharge very quickly, the spot being swept rapidly back to the starting point. This cycle of operation is repeated at 50 cycles per second (say) and the appearance on the screen is a continuous radial straight line, whose length and position shift in accordance with the variations of the applied potentials. Full details of the properties of this arrangement are given in the specification previously referred to.

When it is desired to repeat the indications of the local oscillograph 1 on a remote oscillograph 2, it is not possible to connect the deflecting plates of the two oscillographs directly together unless the distance is short, because the capacities to ground of the connecting conductors would shunt the condensers 15, 16, 17 and 18 and seriously affect the indications of the local oscillograph. According to the present invention, four buffer valves 30, 31, 32 and 33 are interposed in the connections between the corresponding plates of the two oscillographs. These valves are arranged as cathode followers with their anodes connected directly to the positive high tension terminal 21 and their cathodes through four respective preferably equal cathode resistances 34, 35, 36 and 37 to the common conductor 19. The control grids of these four valves are connected respectively to the plates 3, 4, 5 and 6 of the local oscillograph 1, and the cathodes are also connected to the corresponding deflecting plates 38, 39, 40 and 41 of the oscillograph 2 through relatively long conductors shown dotted at 42, 43, 44 and 45. These conductors may be cable conductors or any other suitable lines.

The action of the four cathode follower circuits is the same, so only one of them will be decsribed. Considering therefore the valve 30, it will be seen that the ground capacity of the conductor 42 is now removed from the condenser 15, which is shunted only by the grid-cathode capacity of the valve 30, and this can be negligible if the valve is suitably selected. As is well known, the cathode follower circuit can be designed so that the voltage amplification ratio is nearly equal to 1, so that in this case the voltage variation of the plate 3 of the oscillograph 1 will be transferred with only slight reduction to the conductor 42, and thence to the corresponding plate 38 of the oscillograph 2. As is well known, the voltage amplification ratio m of the valve 30 is given by

$$m=\frac{\mu R}{r+R(1+\mu)}$$

in which R is the value of the resistance 34, r is the internal anode circuit impedance of the valve and μ is the amplification factor. By choosing a valve with a high value of μ, and by selecting

R so that R is large compared with r, the value of m may be made very close to 1.

It will be noted that the capacity to ground of the conductor 42 now shunts the resistance 34. Since the resistance 34 will generally be much smaller than the resistance 11, the time constant of the resistance 34 and the corresponding shunting capacity will be lower than that of the resistance 11 and condenser 15, and the charging stroke will therefore be repeated on the oscillograph 2 without appreciable modification. However, it is essential for the proper operation of the circuit that the conductor 42 be substantially completely discharged during the discharge period of the condenser 15, and this requires a time constant which is very small compared with the time constant of the elements 11 and 15. If the length of the conductor 42 therefore exceeds several hundred feet, the actual limiting distance depending on the switching frequency employed, it is desirable to adopt additional means for dealing with the discharging period.

In Fig. 1 such additional means comprises four similar discharger valves 46, 47, 48 and 49 shunted respectively across the cathode resistances 34, 35, 36 and 37. The anodes of the discharger valves are all connected respectively to the cathodes of the buffer valves 30, 31, 32 and 33. These discharger valves are indirectly controlled by the rectangular pulses which are used to control the switching valves 25, 26, 27 and 28, and are arranged to be cut off during the charging period and to conduct during the discharging period. Thus in the case of the valve 46, for example, during the discharging period it conducts and substantially short-circuits or at least heavily shunts the cathode resistance 34 so that the corresponding time constant is very greatly reduced, thus discharging very rapidly the conductor 42. As soon as the charging period commences, the valve 46 is cut off, and the charging stroke is repeated on the oscillograph 2 as previously explained.

The four discharger valves are controlled by a switching valve 50 similar to the other switching valves 25, 26, 27 and 28, with its cathode connected to the conductor 19 and its control grid to the terminal 29 to which the rectangular switching pulses are applied. The anode is connected to the ground terminal 24 through a potentiometer 51 the movable contact of which is connected to the control grid of an inverter valve 52, the anode of which is connected to the positive high tension terminal 21 through an anode resistance 53, and to the control grids of the four discharger valves 46, 47, 48 and 49 through a large blocking condenser 54, which control grids are connected to the conductor 19 through a high resistance 55. The cathode of the inverter valve 52 is connected to the ground terminal 24 through a conventional condenser-resistance bias network 56.

The necessity for the inverter valve 52 will be understood when it is remembered that the discharger valves should conduct when the switching valves conduct, and this occurs when the control grids of the switching valves have positive potential applied to them. In the case of valve 50, this will produce a negative output pulse which has to be inverted by the valve 52 in order that a positive pulse may be applied to unblock the discharger valves. The potentiometer 51 enables the amplitude of the unblocking pulses to be appropriately adjusted.

It will be evident that the time constant of the elements 54 and 55 should be large compared with the switching period, in order that they shall not

cause any appreciable delay in the operation of the discharger valves.

It is to be noted that the valves **50** and **52** could, if desired, be omitted together with all the associated elements, and the control grids of the four discharger valves could be connected directly to the terminal **29**. By this arrangement, the rectangular pulses could be applied directly to control these valves, but since the discharger valves will frequently not be of the same type as the switching valves, the operating conditions may not be the same in the two cases, and this might result in the discharger valves beginning to conduct before the commencement of the discharge period, and/or they might continue to conduct after the charging had commenced. This would produce undesired discontinuities in the trace on the second oscillograph. However, these difficulties could be overcome and the arrangement could be made to operate satisfactorily. The use of the valves **50** and **51** in the manner described is, however, preferred. This preferred arrangement has the advantage that the control voltage applied to the control grids of the discharger valves cannot become positive until the switching valves **25**, **26**, **27** and **28** begin to discharge the corresponding condensers, while at the end of the discharge period the control voltage must become negative at the same instant as the condensers begin to charge. This voltage changes negatively more rapidly than the condensers charge up on account of the small time constant of the anode circuit of the valve **50**, which does not include any condenser. This ensures that the discharge valves are fully cut off at the earliest possible moment.

By the use of the four discharger valves, it has been found possible to repeat the indications of the local oscillograph over distances of several miles. In a system of this kind forming part of a direction indicating system it was found possible to repeat the indication over a distance of 1½ miles without producing bearing errors greater than 1 degree.

It should be pointed out that while it is preferred to use vacuum triodes for the discharger valves **46**, **47**, **48** and **49**, grid controlled gas-filled tubes, or the like, could be used instead, as will be clear to those skilled in the art. Further, it is obvious that mechanical commutators or electromagnetic relays could in some circumstances be used satisfactorily for short-circuiting the cathode resistances **34**, **35**, **36** and **37**.

The co-pending specification previously referred to describes a number of other types of charge and discharge circuits which may be used for producing the line trace on the local oscillograph **1**. The arrangements described with reference to Fig. 1 of the accompanying drawings may be used with most of these, but those in which the reactive element is an inductance are less suitable for repeating in this manner because the indicating trace follows the fly-back stroke immediately without any interval during which the potentials of the conductors **42** to **45** can be reset. It is also to be noted that while in the arrangement shown in the accompanying Fig. 1 the tracing stroke occurs while the condenser potentials are increasing positively, there are other arrangements in which the tracing potentials increase negatively. In such cases as these the discharger valves are not necessary because the discharge stroke occurs in a positive direction, and the cathode follower valves **30** to **33** will then conduct and will themselves rapidly

discharge the capacity of the conductors **42** to **45**.

It is again emphasised, however, that when the distance to the remote oscillograph is not too great, for example a few hundred feet, the discharger valves **46**, **47**, **48** and **49**, and the corresponding switching valves **50** and **51**, may be omitted, as already explained.

The conductors **42**, **43**, **44** and **45** connecting the two oscillographs may be of any desired type, but should preferably be conductors of some form of screened cable or cables. In repeating distances of several miles, the cable ground capacities will behave substantially as capacities lumped at the cathodes of the valves **30**, **31**, **32** and **33** at the low switching frequency employed. It should be noted, however, that the direct capacities between the four conductors should be small compared with these ground capacities, otherwise there will be interference between the deflecting voltages of the two pairs of plates of the remote oscillograph **2**. In order to remove this interference completely, four separate coaxial cables with the outer conductors grounded may be used for connecting the two oscillographs, but such cables should be of low capacity otherwise the repeating distance may be limited. Other theoretically less perfect arrangements, however, give satisfactory results in practice. For example, for a repeating distance of 1½ miles, two screened rubber insulated quadded cables may be used, one of which is used for each pair of deflection plates. In each cable two diagonally opposite conductors are used for the conductors **42**, **43** (or **44**, **45**), and the other two serve as partial screens, and are grounded. It has further been found that the screen conductors need not be directly grounded so that they can be used at the same time for a telephone circuit, in the manner indicated in Figs. 2 and 3, which illustrates the arrangements for connecting the cathodes of the valves **30** and **31** of Fig. 1 to the plates **38** and **39** of the oscillograph **2**.

The two conductors **42** and **43** will be a pair of diagonally opposite conductors of the guadded cable whose cross-section is shown in Fig. 3. The screen conductors **57** and **58** are the other diagonally opposite pair. At the near end, a potentiometer **59** having its movable contact grounded is connected between the conductors **57** and **58**, and telephone or other communication apparatus **60** and **61** is connected at the two ends of these conductors.

The potentiometer **59** will be adjusted in order to balance out the voltages induced in the conductors **57** and **58** by the deflecting voltages in the conductors **42** and **43**.

It will be evident that the cable between the valves **32** and **33** and the plates **40** and **41** of the oscillograph **2** may be arranged to provide a second communication circuit in a similar way, if desired.

A single quad cable (or two separate paired cables) could evidently be used if desired for the connection to the remote oscillograph but there will be a risk of interference, as already explained, unless the direct capacity between the conductors in the same cable is small compared with the ground capacity of any of them, for example not more than one third. If the repeating distance is not very great, this condition could be secured by connecting appropriate capacities between the several conductors and ground at one end of the cable or cables.

What is claimed is:

1. An arrangement for repeating the indication of a cathode ray oscillograph at a local station on a cathode ray oscillograph at a remote station comprising reactive elements connecting a deflecting plate of said local oscillograph to the control grid of a cathode follower thermionic valve stage, switching valves shunting said reactive elements, and means connecting a deflecting plate of the remote oscillograph to the corresponding deflecting plate of the local oscillograph, said connecting means comprising a long lead directly connecting the cathode of one of the valves in said valve stage to said remote plate, and a short lead directly connecting said local plate to the control grid of said valve, the length of said lead being sufficient to span the distance between said stations.

2. An arrangement according to claim 1 including means for supplying high tension energy to said long lead, by way of said valve, in such manner as to avoid interference with said local switching means.

3. An arrangement according to claim 2 in which the said last named means includes a short-circuiting device shunted across a resistance connected in series with the cathode of the said valve.

4. An arrangement according to claim 3 in which the said device is a thermionic valve, means being provided for periodically blocking and unblocking the said valve.

5. An arrangement according to claim 3 comprising discharging means for periodically short-circuiting the cathode resistances of the cathode follower stages.

6. An arrangement according to claim 5 in which the discharging means comprises a discharger valve individually shunting each of the cathode resistances, and means for periodically blocking and unblocking the said discharger valves.

7. An arrangement according to claim 6 comprising a source of rectangular pulses and means for applying the said pulses to block and unblock the said discharger valves.

8. An arrangement according to claim 7 in which the said pulses are also applied to block and unblock the said switching valves.

9. An arrangement according to claim 8 in which the said pulses are applied to the discharger valves through a switching valve adapted to be alternately blocked and unblocked by the said pulses, an inverter valve being interposed between the said switching valve and the said discharger valves.

10. An arrangement according to claim 1 including a cable constituting the vehicle for extension of the long leads running from the cathodes of the cathode follower valves to the deflecting plates of the remote oscillograph.

11. An arrangement according to claim 10 in which the cable contains additional conductors, means being provided for connecting the additional conductors to ground.

12. An arrangement according to claim 11 in which the said additional conductors are adapted also to carry a communication channel.

13. An arrangement according to claim 12 comprising two quadded cables each of which has one pair of conductors connecting one pair of plates of the remote oscillograph to the cathodes of the corresponding cathode follower valves, the other pair of conductors being connected to ground.

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