Dec. 17, 1935. J. H. CLARK 2,024,275

POTENTIOMETER DEVICE

Filed June 13, 1935

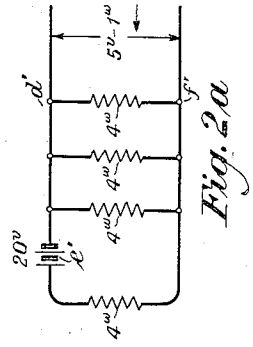


Fig. 2a

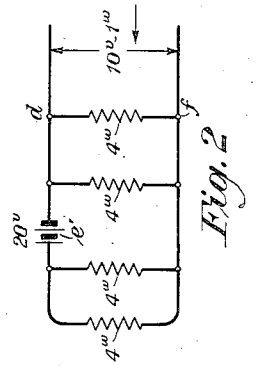


Fig. 2

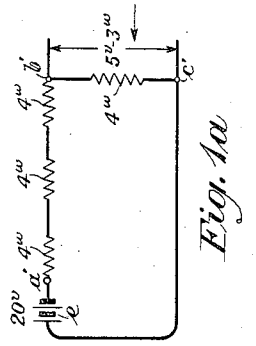


Fig. 1a

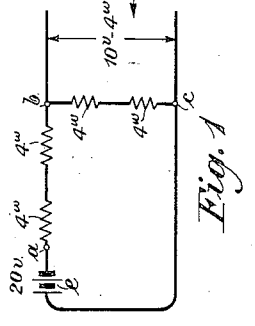


Fig. 1

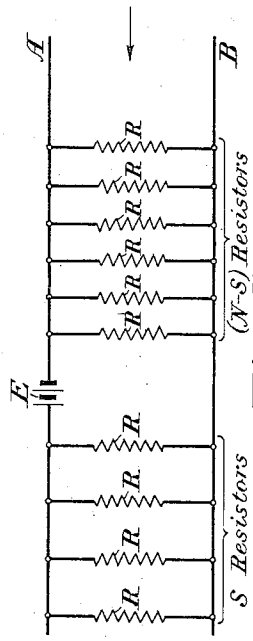


Fig. 3

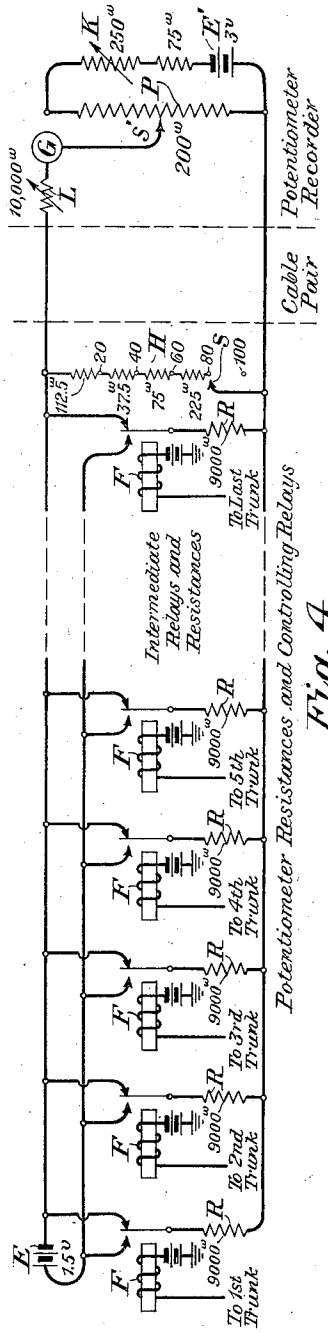


Fig. 4

INVENTOR
J. H. Clark
BY
ATTORNEY

Patented Dec. 17, 1935

2,024,275

UNITED STATES PATENT OFFICE

2,024,275

POTENTIOMETER DEVICE

Jean Harold Clark, El Monte, Calif., assignor to American Telephone and Telegraph Company, New York, N. Y., a corporation of New York

Application June 13, 1935, Serial No. 26,510

6 Claims. (Cl. 179—8)

This invention relates to improvements in potentiometer devices, and more particularly to a potentiometer device which will have a constant impedance regardless of variations in the settings or adjustments thereof during its operation.

In potentiometer devices of the prior art variations in voltages produced by the potentiometer have also involved changes in the impedance of the potentiometer. Accordingly, one of the primary objects of the invention is to provide a potentiometer which will present a constant impedance regardless of variations in voltages produced by the device itself. In the arrangements of the invention this is accomplished by connecting across the potentiometer circuit on one side of the voltage source a plurality of resistances or impedances. To change the voltage produced by the potentiometer any desired number of these resistances would be shifted to a position across the potentiometer circuit, but on the other side of the voltage source. As the number of resistances or impedance elements connected across the circuit will always be the same after the shifting as before, the device will present a constant impedance while different voltages are produced thereby. Other objects and features of the invention will appear more fully from the detailed description thereof hereinafter given.

The advantages of the potentiometer device of this invention in presenting a constant impedance are many. For example, it permits an unlimited number of adjustments with one voltage source. A particular adaptation of the invention to telephony is shown in more detail hereinafter, wherein the potentiometer device is utilized to indicate the number of lines of a group which are simultaneously in use. The potentiometer device of this invention has further advantages in that variations in the resistance elements, for example, by contact resistance, changes in temperature, or inaccuracy in construction, introduce less error than in the usual type of device heretofore used. The device of the invention has the further advantage that all contacts are "wet" even when it is supplying no output current.

The invention may be more fully understood from the following description together with the accompanying drawing in the Figures 1, 1*a*, 2, 2*a*, 3 and 4 of which the invention is illustrated. Figs. 1 and 1*a* are schematic diagrams of potentiometer devices of the prior art. Figs. 2, 2*a* and 3 are schematic diagrams of the potentiometer device of this invention. Fig. 4 is a circuit diagram illustrating one manner in which the device of the invention may be utilized. Similar reference characters have been utilized to denote like parts in all of the figures.

In Fig. 1 is shown schematically a conventional type potentiometer device of the prior art which supplies an external voltage across the points *b*, *c* of 10 volts and has an internal impedance of 4 ohms, looking in the direction of the arrow. In Fig. 1*a* the same potentiometer is shown adjusted to supply 5 volts across the points *b'*, *c'*. It will be seen that in this case the internal impedance looking in the direction of the arrow will be 3 ohms. In other words, with the conventional type potentiometer of the prior art the variation in the voltage supplied thereby will result in a change in the internal impedance of the device. Fig. 2 is a schematic showing of a potentiometer embodying the principles of this invention and supplying an external voltage across the points *d*, *f* of 10 volts, with an internal impedance of 1 ohm looking in the direction of the arrow. The resistance of the voltage source *e'* in Fig. 2 is considered negligible. Fig. 2*a* shows schematically the same potentiometer device of the invention as shown in Fig. 2 but adjusted to supply 5 volts across the points *d'*, *f'*. It will appear from the diagram that the internal impedance looking in the direction of the arrow will be the same as before, namely, 1 ohm. In other words, with the potentiometer device of this invention an adjustment thereof to produce a different voltage will not result in a change in the internal impedance of the device.

In Fig. 3 there is shown schematically the general conditions for the constant impedance potentiometer of this invention. Assume a source of potential E, having a negligible internal resistance, in a circuit having a total number N of equal resistors R arranged as shown. Then the internal impedance of the circuit looking in the direction of the arrow as represented at points A, B is independent of the distribution of the R resistors on the two sides of E, and the voltage supplied at the points A, B is in direct proportion to the number of R resistors connected on the left side of E.

Internal resistance $R' =$

$$\frac{\left(\frac{R}{S}\right)\left(\frac{R}{N-S}\right)}{\frac{R}{S}+\frac{R}{N-S}} = \frac{\frac{R^2}{S(N-S)}}{\frac{RN-RS+RS}{S(N-S)}} = \frac{R^2}{RN} = \frac{R}{N}$$

External voltage $E' =$

$$\frac{\frac{R}{N-S}}{\frac{R}{S}+\frac{R}{N-S}} \cdot E = \frac{\frac{R}{N-S}}{\frac{RN-RS+RS}{S(N-S)}} = \frac{S}{N} \times E$$

In Fig. 4 is shown a circuit diagram illustrating how the potentiometer device could be utilized in a system for recording the number of telephone lines in a group in use simultaneously. For example, each of the telephone lines might have associated with it a relay, such as the relays F. When any line was in use its associated relay would be caused to operate and change the voltage pro-

duced by the potentiometer. These changes in voltage could be utilized to determine the number of lines in use. The potentiometer device would comprise a pair of conductors, one of which would include the source of voltage E. Normally there would be bridged across these conductors on the right hand side of source E a plurality of resistors R, one for each of the number of telephone lines in the group under supervision. When none of the lines was in use and none of the F relays operated, all of the resistors R would be bridged across the conductors on the right hand side of source E and the device would be idle. Whenever one or more of the telephone lines were in use and its associated F relay operated, one or more of the resistors R would have its connection shifted so that it would be connected across the potentiometer conductors on the left hand side of source E. As pointed out heretofore with respect to Figs. 2, 2a and 3, this would result in a change in the voltage applied from source E to the terminals of the conductors without any change in the internal impedance of the device.

As heretofore pointed out, these changes in voltage applied to the terminals of the potentiometer conductors may be utilized to determine the number of busy telephone lines under supervision. For this purpose a measuring device would be provided at the terminals of the conductors. For purposes of illustration this device is shown as a potentiometer recorder of a type well known in the art. This would include a 200 ohm slide-wire potentiometer P, the slider S' of which might be automatically adjusted by the recorder mechanism (not shown) to such a value as will balance the galvanometer G. The record might be made by a moving pen on a paper chart or tape, the position of the pen on the tape being determined by the position of the potentiometer slider S'. In the circuit shown the operation of the meter depends upon unbalanced voltages between the two potentiometers rather than upon the principle of the Wheatstone bridge. The galvanometer G is connected between the two potentiometers and the current in it reduced to zero by the operation of slider S'. However, other types of measuring devices than the specific one shown may be utilized to measure the changes in voltage produced by the constant impedance potientometer device of the invention, if desired.

In the arrangements shown in Fig. 4 there are also provided means for compensating for changes in the impedance of the potentiometer device of the invention by adding to or taking away therefrom certain of the resistors R. These means are the resistance unit H which is adjustable by the switch S and which is connected across the conductors of the potentiometer device. Obviously, any increase in a given number of the R resistors, shown for purposes of illustration as 9000 ohms each, will decrease the internal impedance of the device. Also, any decrease in the number of these R resistors will increase the internal impedance. Compensation for this may be made by adjusting switch S to the proper step on resistance H. For example, in the arrangement shown, resistors R can be provided in multiples of 20 up to 100, and proper compensation for any number of resistors less than 100 is obtained by setting switch S on the proper step of resistance H. This will be clear from the following:

For convenience the impedance of the potentiometer with a varying number of resistors is to be held at, say, 90 ohms. This is its impedance with 100 resistors of 9000 ohms each. It may be noted that the adjustment of switch S for this condition opens the circuit for the shunt resistance H. When only 80 resistors are to be used, since the impedance of these is 112.5 ohms, 450 ohms is placed in parallel to obtain the desired 90 ohm impedance by adjusting the switch S to step 80. The total resistance of H which is 450 ohms is connected in shunt on this step. The parallel combination of 112.5 ohms and 450 ohms is 90 ohms. When 60 resistors are to be employed having an impedance of 150 ohms resistance H is to be adjusted to 225 ohms by setting switch S to step 60. The parallel combination of 150 ohms and 225 ohms is 90 ohms. For 40 resistors of 225 ohms impedance a shunt of 150 ohms is used. For 20 resistors of 450 ohms impedance a shunt of 112.5 ohms is used.

In the above described arrangements the impedance elements referred to as the resistors R may consist either of resistance, of capacity, or, of inductance. Furthermore, the voltage utilized and designated as E might, if desired, be alternating current derived from a low impedance source. Also, the impedance elements might obviously be designed to change the output by fractional amounts so that variation in decibels or in steps of .1, .01, .001, might be obtained.

The arrangements of the invention might, if desired, be used as a voltmeter multiplier by connecting a low resistance meter movement in place of the voltage source, thus securing different voltage scales while the impedance of the voltmeter remains substantially constant.

It is pointed out that one of the reasons for desiring the constant impedance device, such as that of the invention, is that when it is connected to a circuit of substantially constant impedance, the current in the circuit is varied in accordance with the setting of the potentiometer. The device is thus useful for calibrating meters. For pyrometric work with a thermocouple, or for electrometric titration, the sensitivity of the meter or the impedance of the potentiometer may be adjusted by means of a rheostat so that a variation of one step on the potentiometer will change the meter reading an integral number of divisions such as 10, 20, 50 or 100, when the meter reading may be used directly for interpolation. This is a considerable improvement over the present methods, both in speed and in the cost of the equipment required for the same accuracy in results. A plug box type of potentiometer using steps of .1, .2, .2, .5, .01, .02, .02, .05, etc., could be constructed providing variations from .0001 to 1.0000 by ten thousandths and requiring only 16 impedance elements.

Accordingly, while the invention has been disclosed as embodied in certain specific arrangements which are deemed desirable, it is understood that it is capable of embodiment in many and other widely varied forms without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. A potentiometer device comprising a circuit including a source of potential and a measuring device included in said circuit, a plurality of impedances bridged across said circuit, and means to shift the connections of said impedances from one terminal of said source to the other terminal of said source without changing the impedance looking into said circuit from said measuring device.

2. A potentiometer device comprising a pair of conductors, a source of voltage connected in

one of said conductors, a plurality of impedances bridged across said conductors, and means to shift the connections of any number of said impedances from one side of said source to the other side of said source without changing the impedance measured across said conductors.

3. A potentiometer device comprising a pair of conductors, a source of voltage included in one of said conductors, a plurality of impedances bridged across said conductors, and means to shift the connections of any number of said impedances from one side of said source to the other, whereby the voltage applied from said source across the terminals of said conductors may be changed without changing the impedance measured across the terminals of said conductors.

4. A potentiometer device comprising a pair of conductors, a source of voltage included in one of said conductors, a plurality of impedances bridged across said conductors, means to shift the connections of any number of said impedances from one side of said source to the other side of said source, whereby the voltage applied from said source across the terminals of said conductors may be varied without changing the impedance measured across said conductors, and a variable resistance device bridged across said conductors to compensate for any increase or decrease in the number of said impedance devices connected across said conductors.

5. A potentiometer device comprising a pair of conductors, a source of voltage included in one of said conductors, a plurality of impedances bridged across said conductors, means to shift the connections of any number of said impedances from one side of said source to the other side of said source, whereby the voltage applied from said source across the terminals of said conductors may be varied without changing the impedance measured across said conductors, a variable resistance device bridged across said conductors to compensate for any increase or decrease in the number of said impedance devices connected across said conductors, and a measuring device connected across said conductors for measuring changes in the voltage applied across the terminals of said conductors.

6. A potentiometer device comprising a pair of conductors, a source of voltage included in one of said conductors, a plurality of impedances normally bridged across said conductors on one side of said source of voltage, and a plurality of relays individual to each of said impedances whereby the connections of any number of said impedances may be shifted from the side of said source of voltage to which they are normally connected to the other side of said source for changing the voltage applied from said source across the terminals of said conductors without changing the impedance measured across said conductors.

JEAN H. CLARK.