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POTENTIOMETER APPARATUS

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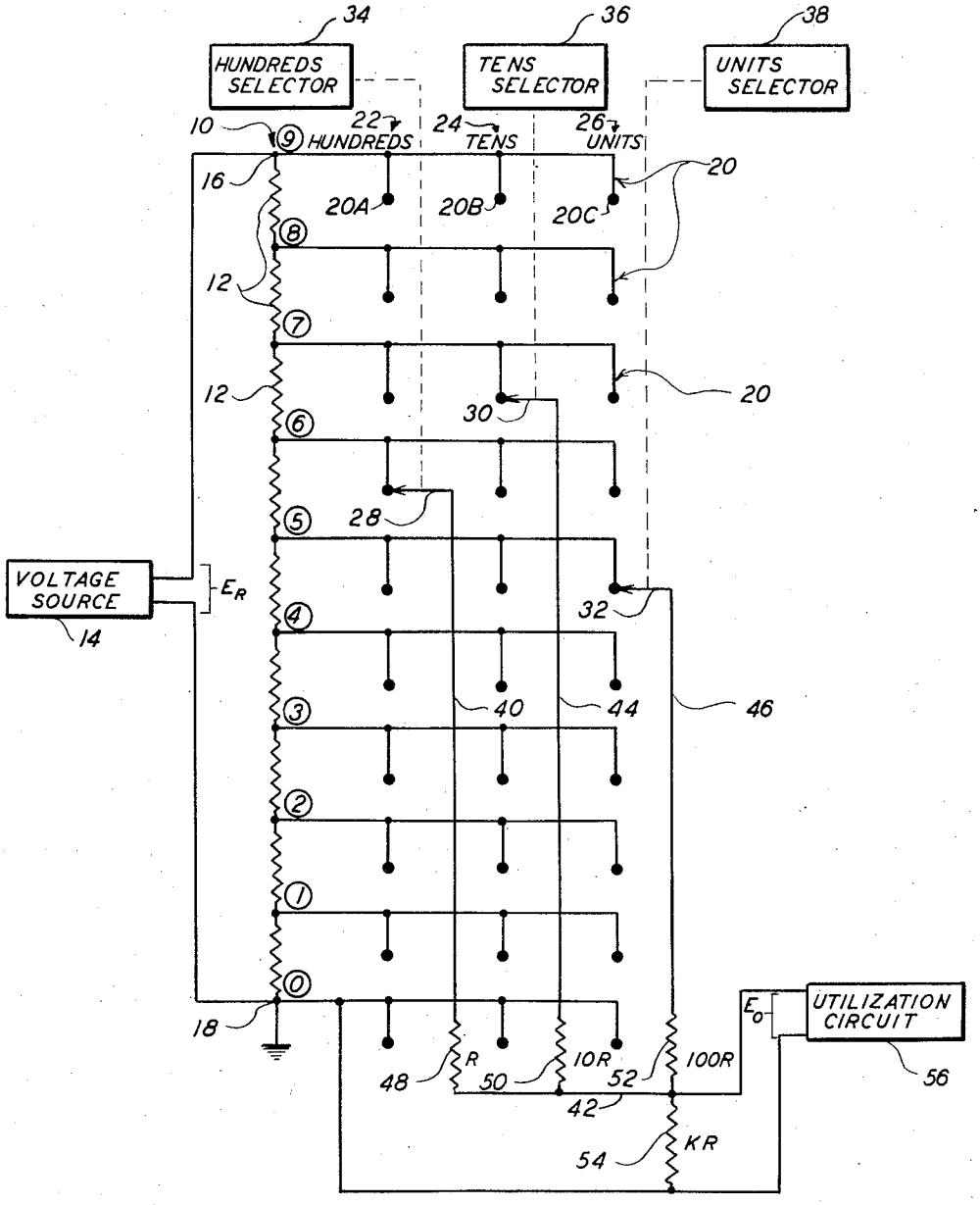

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2,894,197

POTENTIOMETER APPARATUS

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4 Claims. (Cl. 323—79)

This invention relates to potentiometers and it has particular reference to potentiometer apparatus for providing an output voltage proportional to selected numerical values.

Conventionally, a large number of expensive precision resistors are required in such potentiometers, making the apparatus complex and expensive. For example, the well known Thompson-Varley precision decade potentiometer requires eleven precision resistors for each decade order of digits represented except the least significant where ten such resistors are needed.

The present invention provides potentiometer apparatus requiring less than half the number of precision resistors required in conventional potentiometers of this type, and it accomplishes the same function without sacrificing any significant operational qualities. To this end, the potentiometer apparatus of the invention includes electrical resistance means for receiving a reference voltage, with a plurality of electrical taps spaced along the length of the electrical resistance means and dividing the resistance means into a plurality of resistances having predetermined relative values and arranged in electrical series, a plurality of output circuits commonly coupled to an output terminal, a separate summing resistance of different value included in each output circuit, said summing resistances having predetermined relative values, and means for concurrently making electrical contact between any of the plurality of electrical taps and output circuits.

In a preferred embodiment, the reference voltage is applied across the respective ends of an electrical resistance. The electrical resistance has ten electrical taps representing a decade of digital values spaced along its length, thereby dividing the resistance into nine substantially equal resistances arranged in electrical series with the reference voltage. An output circuit is provided for each decade order of decimal digits to be represented, and there is a summing resistance for each output circuit with the values of the summing resistances being in ratio to one another approximately as 1:10:100 etc. going from the most significant to the least significant decade of values represented by the output circuits. The respective summing resistors are coupled between a common output terminal and the respective output circuits. A load resistance is coupled to the output terminal, and means are provided for selectively making electrical contact between any of the ten electrical taps and the output circuits to provide a voltage at the output terminal representative of corresponding numerical value.

Thus, a simplified decade potentiometer is provided by using a single voltage divider circuit, as represented by the nine resistances in series with the reference voltage, and commonly contacting the taps of this same voltage divider with all output circuits, the differentiation between output circuits being made by way of summing resistors.

The invention is explained in detail with reference to the accompanying drawing which is a schematic representation of the preferred embodiment of the invention.

Referring to the drawing, a three-decade potentiometer

employs a voltage dividing circuit **10** made up of nine substantially equal resistors **12** connected in series. A voltage source **14**, providing a reference voltage E_r, is connected in series with the resistor series by a pair of input terminals **16**, **18** located at the respective ends of the resistor series.

In the voltage divider circuit, equal resistance increments are designated by the encircled numerals 0–9 respectively.

Ten electrical taps **20**, each having three tap contact points, as typically shown at **20A**, **20B**, **20C** respectively are severally connected at equal resistance increments along the resistance series, i.e. severally connected between the adjacent resistors of the series and to the respective ends of the resistor series. The tap contact points **20A**, **20B**, **20C** are given "hundreds," "tens" and "units" designations respectively in accordance with the relative values of number orders they are to represent. Thus, three sets of tap contacts are provided by the plurality of taps: a "hundreds" set of ten tap contacts **22**; a "tens" set of ten tap contacts **24**; and a "units" set of ten tap contacts **26**.

A "hundreds" selector arm **28** is provided for making electrical connection with the tap contacts in the "hundreds" set. A "tens" selector arm **30** is provided for making electrical connection to the tap contacts of the "tens" set, and a "units" selector arm **32** is provided for making electrical connection to the tap contacts of the "units" set.

The "hundreds" selector arm **28** is positioned along the "hundreds" set of tap contacts by a "hundreds" selector **34**. The selector and associated tap contacts and selector arm may be any suitable electrical or mechanical device, such as a stepping switch or the like. Likewise, a "tens" selector **36** and a "units" selector **38** control the position of the "tens" and "units" selector arms **30**, **32** respectively.

A "hundreds" output circuit **40** is connected between the "hundreds" selector arm **28** and an output terminal **42**. A "tens" output circuit **44** is connected between the "tens" selector arm **30** and the output terminal **42**, and a "units" output circuit **46** is connected between the "units" selector arm **32** and the output terminal **42**.

A "hundreds" summing resistor **48**, having a resistance value designated as R, is coupled in the "hundreds" output circuit **40**. Likewise, a "tens" summing resistor **50** having a resistance value designated as **10**R and a "units" summing resistor **52** having a resistance value designated as **100**R are coupled in the "tens" and "units" output circuits respectively.

A load resistor **54** of arbitrary value designated as KR may be connected between the output terminal **42** and ground as shown.

The output of the device is represented by E_0 and it is received by a utilization circuit **56** which may be any circuit wherein it is desired to utilize the output of the potentiometer.

The potentiometer operates as follows. The reference voltage E_r provided by the voltage source divides across the series of resistors **12** in equal voltage drops, with the plurality of taps **20** being spaced at substantially equal voltage increments along the resistor series. The "hundreds," "tens" and "units" selectors are actuated to position the respective selector arms in accordance with any desired numerical value as represented by the encircled numerals, and because of the relative proportions of the respective summing resistors **48**, **50**, **52** the output of the potentiometer at the common output terminal **42** is representative of the numerical value selected.

Conventionally, three complex voltage divider circuits are required for a three-decade potentiometer. The present invention uses one simple voltage divider circuit

which is common to all output circuits and thereby effects a substantial saving in the number of precision resistors required. This is accomplished through the use of a summing resistance for each output circuit with the values of the summing resistances being in ratio to one another in accordance with the inverse ratio of the values of the respective decimal orders represented by the output circuits.

It will be obvious to those skilled in the art that this device is an approximate one; however, the approximation in principle can be made as close as desired by decreasing the value of the resistors **12** in the voltage dividing circuit or increasing the values of the summing resistances **48**, **50**, **52**. The reason for the approximate nature is that the summing resistances draw current from the dividing circuit and upset slightly the potential distibution therein.

Assuming for the moment that this effect is negligible, a straightforward mathematical analysis can be made. Suppose that the "units," "tens" and "hundreds" selectors are set respectively at N_u, N_t and N_h, where the N's represent the encircled numerals associated with the taps on the divider. Considering the summing point or output terminal shown at **42** in the circuit, the sum of the currents flowing into this point must equal 0. Thus,

$$-\frac{E_0}{KR}=\frac{\frac{N_uE_r}{9}-E_0}{100R}\times\frac{\frac{N_tE_r}{9}-E_0}{10R}\times\frac{\frac{N_hE_r}{9}-E_0}{R}=0$$

where K is the ratio of the load resistance **54** to the lowest value summing resistance R. Solving this equation for E_0 we find

$$E_0=\frac{(N_u+10N_t+100N_h)E_r}{999+\frac{900}{K}}$$

Since the denominator is constant, it is seen that the output voltage E_0 is proportional to the numerical value corresponding to the tap position of the three selector arms.

If the total divider resistance is of the order of 1000 ohms and the source impedance of the input voltage is low, the maximum impedance looking back into the divider circuit (encircled points 4 and 5) is about 246 ohms. If the lowest summing resistance R is greater than 246,000 ohms, the error introduced by the loading of the divider circuit is less than one-tenth of one percent. It follows that the precision of the "tens" and the "units" summing resistors need be within only one percent of 10R and ten percent of 100R respectively.

Thus, a three-decade precision potentiometer is provided by use of only ten precision resistors, nine resistors **12** in the voltage divider circuit and the lowest value summing resistor R. An equivalent Thompson-Varley type potentiometer uses about 32 precision resistors together with relatively complex circuits. Since precision resistors represent a major portion of the cost of the instrument, both complexity and cost are considerably reduced in the present invention.

It will be obvious to those skilled in the art that the invention is not limited to the use of the decimal system of numbers. Also, any desired number of decades may be employed, and the invention is not limited to three decades as illustrated in the drawing.

I claim:

1. Apparatus for providing a selection of voltage levels proportional to decimal numbers comprising electrical resistance means for receiving a reference voltage, a decade of electrical taps dividing the resistance means into a plurality of nine equal resistances arranged in electrical series, an output terminal, a plurality of output circuits corresponding to the number of higher and lower order decades of decimal digits to be represented, the output circuits being coupled selectively to the decade of taps and coupled commonly to the output terminal for producing a combined voltage output at said terminal, each output circuit having a different amount of resistance in it, with the resistances of the several output circuits being in ratio to one another approximately as 1:10:100: etc., going from the higher to the lower order decades of values represented by the output circuits, and a load resistance coupled between the output terminal and one end of the equal resistance series.

2. Apparatus for providing a selection of voltage levels comprising electrical resistance means for receiving a reference voltage, a set of electrical taps dividing the resistance means into a plurality of resistances having predetermined relative values and arranged in electrical series, an output terminal, a plurality of output circuits commonly coupled to the output terminal, means including a plurality of selector arms independently movable relative to one another for concurrently coupling each of the output circuits to any of the taps in the set, and a separate summing resistance of different value included in each output circuit, said summing resistances having predetermined relative values so that each output circuit has a different order of magnitude effect on the voltage level at the output terminal in accordance with the relative value of its summing resistance.

3. Apparatus for providing a selection of voltage levels proportional to numerical values comprising electrical resistance means for receiving a reference voltage, a set of electrical taps dividing the resistance means into a plurality of susbtantially equal resistances arranged in electrical series, an output terminal, a plurality of output circuits which severally correspond to higher and lower order values of numbers to be represented, the output circuits being commonly coupled to the output terminal, means including a plurality of selector arms movable relative to one another for concurrently coupling each of the output circuits to any of the taps in the set, and a separate summing resistance included in each output circuit, with the values of said summing resistances being in predetermined relation to one another in accordance with the inverse ratio of the respective higher and lower orders of value represented by the output circuits.

4. Apparatus for providing a selection of voltage levels in accordance with decimal numbers comprising electrical resistance means for receiving a reference voltage, a decade of electrical taps dividing the resistance means into a plurality of sustantially equal resistances arranged in electrical series, an output terminal, a plurality of output circuits corresponding to the number of higher and lower order decades of decimal digits to be represented, the output circuits being commonly coupled to the output terminal, means for concurrently coupling each of the summing resistance included in each output circuit, with the values of said summing resistances differing form one another by factors of ten.

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UNITED STATES PATENT OFFICE

Certificate of Correction

Patent No. 2,894,197 July 7, 1959

Clifford E. Berry

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, lines 27 to 30 inclusive, the equation should read as shown below instead of as in the patent:

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Signed and sealed this 22nd day of December 1959.

[SEAL]

Attest:
KARL H. AXLINE,
Attesting Officer.

ROBERT C. WATSON,
Commissioner of Patents.

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