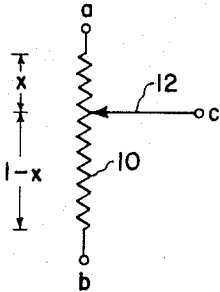


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Fig. 1A



PRIOR ART

Fig. 1B

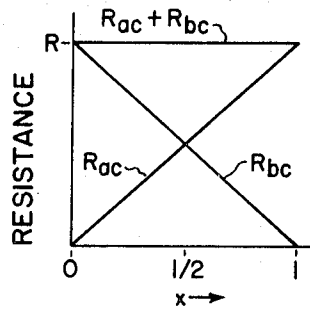


Fig. 1C

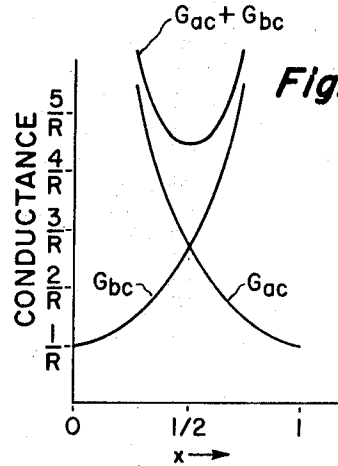


Fig. 2A

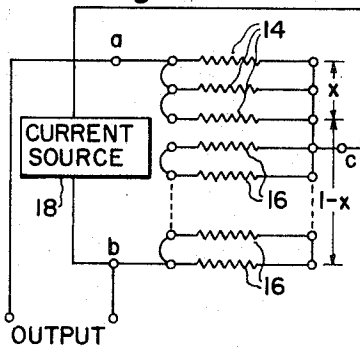


Fig. 2B

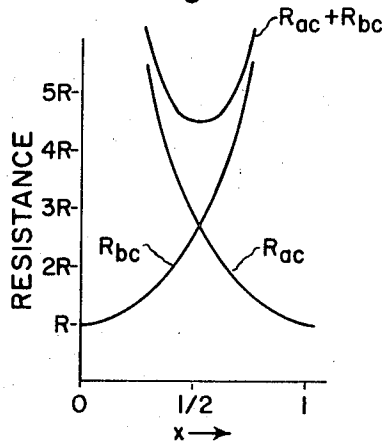


Fig. 2C

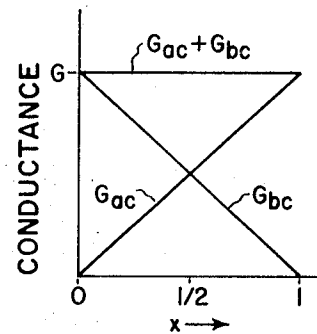
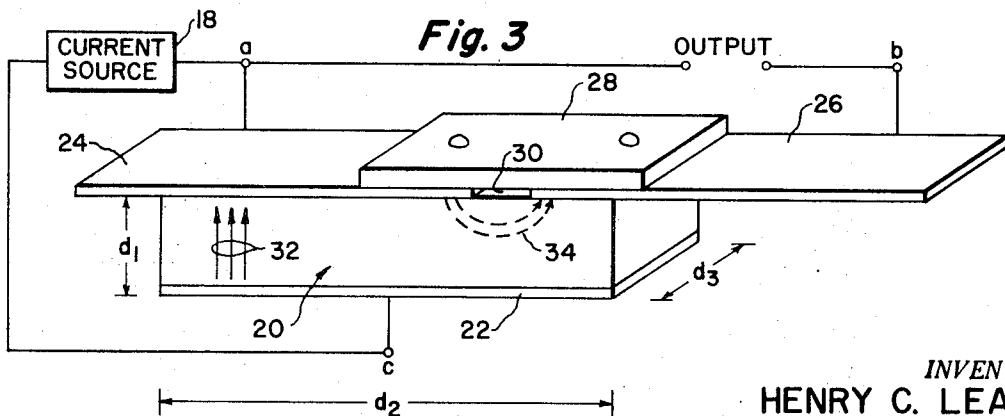


Fig. 3



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6 Claims

ABSTRACT OF THE DISCLOSURE

Described is a three-terminal electrical device, somewhat similar to the variable resistance network known as a potentiometer, but which is the mathematical inverse of a potentiometer. Variation in conductance between a pair of output terminals is achieved by relative movement of a pair of spaced conductors to which the output terminals are connected with respect to a body of anisotropic resistance characteristics, a source of input current being connected to one of said terminals and the body of anisotropic resistance characteristics.

BACKGROUND OF THE INVENTION

A potentiometer is a well known and widely employed device. It consists essentially of a length of resistive material and a movable tap. In such a device, the sum of the resistances on either side of the tap is a constant; while the resistance values on either side of the tap are simple linear functions of the position of the tap between the opposite ends of the resistance element. The conductances, however, are very different in nature. That is, a curve defining the sum of the conductances on both sides of the tap is parabolical; while curves defining the individual conductances on either side of the tap are hyperbolical.

If it is desired to use a potentiometer as a voltage divider, with very small currents drawn from the movable tap, the input terminals at opposite ends of the resistance element of the potentiometer represent a constant load to some source, and the voltage is divided in proportion to the lengths of the resistance element on either side of the tap. If, however, a current divider is desired with no significant voltage difference between an input terminal and a movable tap, a conventional potentiometer cannot be used since the conductance will vary considerably with changes in tap position.

SUMMARY OF THE INVENTION

As an overall object, the present invention seeks to provide a new and improved conductance divider wherein current between an input terminal and an output terminal can be varied in direct proportion to the position of a movable member.

More specifically, an object of the invention is to provide a three-terminal current divider wherein the current between an output terminal and one of two input terminals can be varied by movement of a body of anisotropic resistance characteristics.

In accordance with the invention, a conductance divider is provided comprising a body of anisotropic electrical resistive material which presents a higher resistance to current flow along a first dimension than along a second dimension at right angles to the first dimension. A first electrical contact is engaged with said member at one end of said second dimension, while second and third spaced electrical contacts are in sliding contact with

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the body at the other end of the second dimension. A source of current is connected between the first contact and one of the second and third contacts such that current flow between the second and third contacts will be a function of the relative areas of said second and third contacts in engagement with said member.

Preferably, the member of resistive material comprises a block of graphite having anisotropic resistance characteristics. That is, its resistance along a first transverse dimension will be less than that along a dimension at right angles thereto. The contacts preferably comprise flat plates, two of which are spaced and engaged with one side of the block, while the remaining contact is secured to the opposite side of the block whereby current can flow between the plates along a dimension of the block which presents a low value of electrical resistance. At right angles to this direction, however, the electrical resistance of the block is extremely high, thereby severely restricting current flow between the two spaced contacts to which a source of current is applied. Thus, the current will flow between one of the two spaced contacts and the third contact on the opposite side of the block; and the magnitude of this current will be a function of the relative areas of the spaced plates in engagement with the block.

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings which form a part of this specification, and in which:

FIG. 1A is a schematic diagram of a conventional prior art potentiometer included herein for purposes of explanation;

FIG. 1B is a plot of resistance versus tap position for the potentiometer of FIG. 1A;

FIG. 1C is a plot of conductance versus tap position for the potentiometer of FIG. 1A;

FIG. 2A is a schematic diagram of a conductance divider in accordance with the principles of the present invention;

FIG. 2B is a plot of resistance versus tap position for the conductance divider of FIG. 2A;

FIG. 2C is a plot of conductance versus tap position for the conductance divider of FIG. 2A; and

FIG. 3 is an isometric view of a preferred embodiment of the conductance divider of the invention.

With reference now to the drawings, and particularly to FIG. 1A, a conventional potentiometer is shown which comprises a resistor 10 having a movable tap 12 slideable thereon. A source of voltage, not shown, is applied to the input terminals *a* and *b*; and an output voltage is derived between terminal *c* and one of the other two terminals. The position of the tap 12 with respect to resistor 10, expressed as a fraction of the total length, is indicated by the reference letter *x*.

If the total resistance between terminals *a* and *b* is *R*, the tap position *x* is proportional to part of the total resistance between terminals *a* and *c*. That is:

$$x = R_{ac}/R$$

$$1 - x = R_{bc}/R$$

and

$$R_{ac} + R_{bc} = R$$

where R_{ac} and R_{bc} are the resistance values between terminals *a* and *c* and *b* and *c*, respectively. This is illustrated, for example, in FIG. 1B. Note that the sum of the two resistances R_{ac} and R_{bc} is constant and that the variable

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resistances R_{ac} and R_{bc} are simple linear functions of tap position x . The conductances, however, are very different in nature. That is, conductance G is equal to $1/R$ and:

$$G_{ao} = \frac{1}{R_{ao}} = \frac{1}{xR} = \frac{G}{x}$$

$$G_{bo} = \frac{1}{R_{bo}} = \frac{1}{(1-x)R} = \frac{G}{1-x}$$

and

$$G_{ao} + G_{bo} = \frac{G}{x} + \frac{G}{1-x} = \frac{G}{x-x^2}$$

The conductances are plotted in FIG. 1C as a function of tap position; and it will be noted that the sum of the conductances, $G_{ao} + G_{bo}$, is parabolical and that the individual conductances G_{bo} and G_{ao} are hyperbolical.

The current divider of FIG. 2A has exactly inverse properties. It comprises a first plurality of resistors 14 connected in parallel between terminal a and terminal c , and a second plurality of resistors 16 connected in parallel between terminal b and terminal c . The terminals a and c are connected to a constant current source 18; while the output appears across terminals a and b . Note that this is the inverse of the arrangement of FIG. 1A. In FIGS. 2B and 2C, it can be seen that the resistance and conductance characteristics of the conductance divider of FIG. 2A are exactly the inverse of those for the potentiometer of FIG. 1A, assuming that the values of all of the resistors 14 and 16 are the same. That is, the resistance R_{ac} between terminals a and c is:

$$1/R_{ac} = 1/R_{14} + 1/R_{14} \dots 1/R_{14}$$

where R_{14} is the value of each individual resistor 14. Assuming that the values of all resistors are the same, and that x is the fraction of the number of resistors 14 to all resistors 14 and 16, the foregoing equation can be written as:

$$1/R_{ac} = x/R$$

or

$$R_{ac} = R/x$$

where R is the total resistance, $R_{ac} + R_{bc}$. It can be seen, therefore, that the resistance R_{ac} for the conductance divider of FIG. 2A varies in the same manner as the conductance G_{ao} for the potentiometer of FIG. 1A. Similarly, the resistance R_{bc} for the device of FIG. 2A will be equal to

$$\frac{R}{1-x}$$

its conductance G_{ac} will be equal to Gx ; and its conductance G_{bc} will be equal to $G(1-x)$.

The circuit of FIG. 2A, however, presents a practical difficulty in that while the value of x can be changed with the potentiometer of FIG. 1A by simply moving the tap 12, the same value x in the circuit of FIG. 2A must be changed by changing the break in the circuit between the upper ends of the resistors 14 and 16. The device of FIG. 2A could be realized with a finite number of taps using a switch and an appropriate number of fixed resistors. However, such a device has very limited resolution.

The conductance divider of the present invention is shown in FIG. 3 and, in contrast to that of FIG. 2A, has infinite resolution. It is continuously rather than stepwise adjustable. It includes a block of graphite 20 having anisotropic resistance characteristics. Such a block of graphite, for example, may be formed from the vapor state in well known pyrolytic techniques such that its resistance to current flow along the dimension d_1 , which may be on the order of about 20-30 mils, is much less than along the dimension d_2 . In contact with the lower surface of the block 20 and at one end of the dimension d_1 is a first plate or contact 22 formed from electrical

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conducting material and to which the terminal c is connected. At the other end of the dimension d_1 , and in engagement with the upper surface of the graphite block 20, is a pair of spaced plates or contacts 24 and 26 interconnected by means of an insulating member 28 such that the two may slide across the upper face of the graphite block 20 in unison while maintaining a fixed gap 30 between the two.

With the arrangement shown, very little resistance is offered to currents flowing along the dimension d_1 and in the direction of arrows 32. However, a very high resistance is offered at right angles to the dimension d_1 or along dimension d_2 . Consequently, short-circuiting current paths 34 between the plates or electrodes 24 and 26 are essentially eliminated; and all of the current must flow between plate 24 and plate 22, or between plate 26 and between plate 22. Furthermore, the proportion of the current flowing between plate 26 and plate 22, for example, will be directly proportional to the area of the plate 26 covering the upper surface of the graphite block 20; and this area may be varied by simply varying the position of the plates 24 and 26 on the graphite block 20.

As will be appreciated, the greater the thickness of the dimension d_1 , the greater the resistance between the upper and lower contacts. Conversely, as the width of the graphite block 20, represented by the dimension d_3 decreases, the resistance between the plate 24 and plate 22, or between plate 26 and plate 22 increases.

With the arrangement of FIG. 3, therefore, the resistance and conductance characteristics of FIGS. 2B and 2C result wherein the conductance and consequent current flow between electrode 26, for example, and electrode 22, is a linear function of the ratio of the areas of plates 24 and 26 covering the top of the graphite block 20.

Although the invention has been shown in connection with a certain specific embodiment, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and scope of the invention. In this respect, it will be appreciated that a desired non-linear relationship may be obtained between G_{ac} and x , for example, while simultaneously preserving the crucial $(G_{ac} + G_{bc})$ constant by shaping block 20 in the d_3 dimension.

I claim as my invention:

1. A conductance divider comprising a body of electrical resistive material which presents a higher resistance to current flow along a first dimension than along a second dimension at right angles to the first dimension, a first electrical contact engaged with said member at one end of said second dimension, and second and third spaced electrical contacts in sliding engagement with said member at the other end of said second dimension whereby the current passing between said first contact and one of said second and third contacts will be a function of the relative areas of said second and third contacts engaged with said member.

2. The conductance divider of claim 1 wherein said member comprises a block of graphite having anisotropic resistance characteristics.

3. The conductance divider of claim 1 wherein said contacts comprise flat plates of electrical conducting material in contact with opposite sides of a block of graphite having anisotropic resistance characteristics.

4. The conductance divider of claim 3 wherein the resistance of said graphite block is greater in a direction perpendicular to said plates than in a direction parallel thereto.

5. The conductance divider of claim 1 wherein said second and third spaced electrical contacts were interconnected by means of an insulating member to maintain the spacing therebetween.

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6. The conductance divider of claim 1 wherein said first and second contacts are adapted for connection to a source of constant current, while an output is derived between said second and third contacts.

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