

June 28, 1966

A. C. SULESKI

3,258,601

PHOTOSENSITIVE VARIABLE RESISTANCE DEVICE

Filed March 15, 1960

2 Sheets-Sheet 1

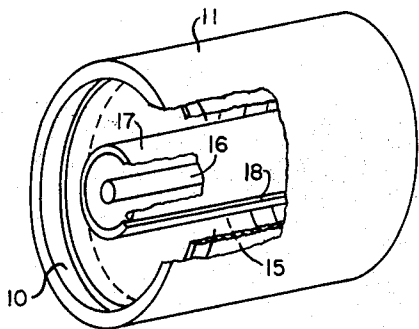


FIG. 1a

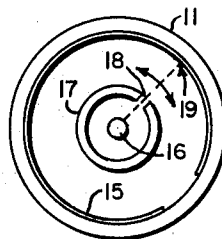


FIG. 1b

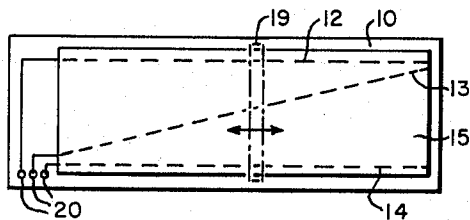


FIG. 2

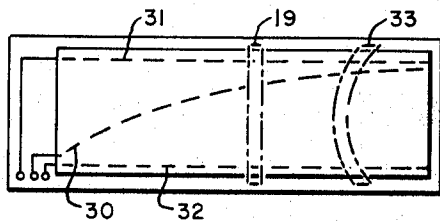


FIG. 3

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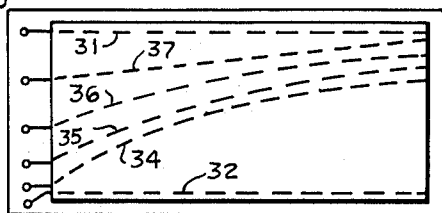


FIG. 4

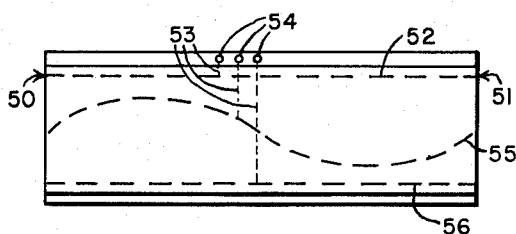


FIG. 5

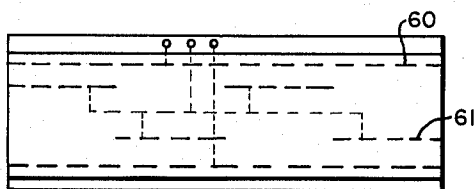


FIG. 6

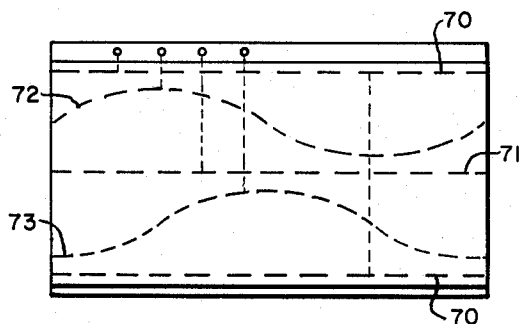


FIG. 7

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PHOTOSENSITIVE VARIABLE RESISTANCE DEVICE

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11 Claims. (Cl. 250-211)

This invention relates to variable resistance devices and, more particularly, to such devices utilizing photosensitive materials. For the purposes of this specification, "photosensitive" will be defined as meaning "sensitive electrically to the action of radiant energy," the sensitivity more particularly referred to being that of conductivity.

In previous variable resistance devices, such as potentiometers, sliding contacts have generally been required. Inherent in such arrangements is undesirable electrical noise created by the movement of the contacts. In the past, it has also been difficult to construct potentiometers with precision resistance characteristics. For example, complicated exponential tapers have been especially hard to achieve.

It is an object of this invention to provide a new type of variable resistance device.

It is an additional object of this invention to provide a resistance device which avoids one or more disadvantages of prior art arrangements.

It is a further object of this invention to provide a variable resistance device which can be constructed to a high degree of electrical accuracy.

It is a further object of this invention to provide a variable resistance device in which the range over which the resistance can be varied can be adjusted.

It is a further object of this invention to provide a new type of signal generator.

In accordance with the present invention, a variable resistance device comprises a first pair of conductors spaced along their length, at least one additional conductor positioned between the first pair of conductors so that the spacing between the third conductor and the first pair of conductors varies over the length of the third conductor. The apparatus further comprises a photosensitive layer, whose electrical resistance is dependent upon the illumination of the layer, in contact with each of the conductors and extending between them, and means for illuminating a variable portion of the layer, which portion always includes points at which the layer contacts each of the conductors, the variable resistance device being so constructed and arranged that if a potential is applied between the first pair of conductors, the portion of the potential existing between the additional conductor and either one of the first pair of conductors is determined by the particular portion of the layer which is illuminated.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawings:

FIGS. 1a and 1b represent one form of variable resistance device in accordance with the invention;

FIG. 2 is a development of the surface of the cylinder of FIG. 1;

FIGS. 3 and 4 represent configurations in accordance with the invention capable of producing exponential resistance relationships; and

FIGS. 5, 6, and 7 illustrate arrangements suitable for use in signal generators for producing sinusoidal wave forms, square wave forms and sine-cosine wave forms, respectively.

Referring now to FIGS. 1 and 2 of the drawings, FIG. 1a shows a variable resistance device in the form of a

potentiometer utilizing the invention, FIG. 1b is an end view of the FIG. 1a arrangement and FIG. 2 is a development of the surface of the cylinder of FIGS. 1a and 1b.

The variable resistance device includes a surface, illustrated as the concave surface 10 of a hollow ceramic cylinder 11, having thereon conductors shown as the three conductors 12, 13, and 14. These conductors may be in the form of gold or silver painted on the cylinder and then fired, or of any other suitable material placed on the surface. The dotted line in FIG. 1a can be considered to represent either conductor 12 or conductor 14 of FIG. 2; however, the conductor configuration cannot be clearly shown in the FIG. 1a view, and FIG. 2 should be referred to for details of conductor layout.

The variable resistance device also includes a photosensitive layer, shown as layer 15, disposed upon said surface and in contact with the conductors. This layer may be composed of any appropriate photosensitive or photoconductive material, the use and composition of such materials being well known.

The variable resistance device further includes means for illuminating a variable portion of the layer. This means is illustrated as a long filament source 16 which is surrounded by a hollow opaque cylinder 17 having a longitudinal slit 18.

Referring now to FIG. 1b, which is an end view of the device of FIG. 1a, it will be seen that the arrangement is such that the illumination coming from filament 16 is so constrained by cylinder 17 as to allow only an area similar to area 19 of FIG. 2 to be illuminated. (Shield 17 is shown as a simple split cylinder but it will be appreciated that a more complicated shielding system may be required to accurately constrain the illumination.) By rotating cylinder 17, any desired portion of the surface 15 can be illuminated.

As shown in FIG. 2, the conductors 12, 13, and 14 may be connected to terminals 20 to allow coupling to external circuitry.

In the operation of the FIG. 1 arrangement, the device may be used as a potentiometer with a resistance between the outer two conductors 12 and 14 determined by the characteristics of the photosensitive surface, the physical dimensions of the device, the quantity and quality of illumination and the area illuminated. With all these variables held constant, the photosensitive layer assumed to be a uniform layer and the illuminated area 19 in the form of a narrow band 19 as shown in FIG. 2, a particular resistance will result between the two outer conductors 12 and 14. The middle conductor 13 will have a resistance to each of the two outer conductors, the sum of these two resistances equaling the resistance between the conductors 12 and 14 and the ratio of these two resistances depending upon the particular axial portion (such as the portion illuminated by area 19 in FIG. 2) of the photosensitive layer illuminated. The device can thus be utilized in the manner of an ordinary resistive potentiometer, the resistance adjustment being accomplished by movement of the illuminated area along the photosensitive layer.

It will be seen that the resistance range of a device such as described will depend on the over-all resistance between conductors 12 and 14. This over-all resistance, in turn, depends upon the quantity and quality of the illumination striking area 19. Thus, the range of such a device can be varied by controlling the characteristics of the illumination. In this way a variable resistance device can be constructed using only two conductors, such as 12 and 14, and arranging for the intensity of illumination to be varied or by varying the area illuminated (as by changing the width of area 19) for example.

Referring now to FIGS. 3 and 4, there are shown two surface arrangements which may, for example, be utilized

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in devices similar to that shown in FIG. 1. The conductors of FIG. 3 are arranged so as to give an exponential taper. This taper is achieved by giving conductor 30 the configuration of an exponential curve while conductors 31 and 32 have a straight line configuration. "Taper" as used here is intended to refer to the relationship between changes in resistance proportions and changes in the area illuminated. Thus, in FIG. 3, if the illumination band 19 is moved one unit to the left the resistance between conductors 30 and 31 will increase by a particular amount. However, if illumination band 19 is moved two units to the left the resistance increase between conductors will not be twice the particular amount of the one unit movement, and an exponential equation will be required to describe the actual relationship of resistance change with illumination movement. This device will be said to have an exponential taper.

While the FIG. 3 arrangement may use a straight illumination band similar to 19, it should also be appreciated that a curved or exponential illumination band such as 33 can be used to obtain a more mathematically sophisticated taper. FIG. 4 shows an arrangement similar to that of FIG. 3 except that a plurality of middle conductors 34, 35, 36 and 37, each having a different taper, is included in place of the single conductor 30 in FIG. 3. In the operation of a device such as this, connections can be made to one or more of the middle conductors during operation.

Referring now to FIGS. 5, 6, and 7, there are shown surface arrangements of conductors and a photosensitive layer suitable for placement on a hollow cylinder such as that shown in FIG. 1. These surfaces are constructed so that when placed on a cylinder each conductor forms a continuous closed curve, and the photosensitive layer forms a closed cylindrical surface. (That is to say, for example, that the ends 50 and 51 of conductors 52 connected to each other.) In these arrangements, connections to the conductors can be made by bringing leads through the cylinder and out on the other side, as shown by the leads 53 of FIG. 5 which connect to terminals 54.

In the operation of devices using surfaces such as those shown in FIGS. 5, 6, and 7, a potential is applied between the outside conductors (52 and 56 in FIG. 5) and an area similar to 19 of FIG. 2 is illuminated, for example, by a long filament and hollow opaque cylinder such as 16 and 17 of FIG. 1. The cylinder 17 is then arranged to be continuously rotated. In operation, it will be seen that as the cylinder 17 rotates the illumination band will travel continuously along the surface and the result in FIG. 5, which has a sinusoidal middle conductor 55, will be (assuming the potential between conductors 52 and 56 to be a D-C. potential) a sinusoidal wave form potential appearing between terminals connecting to conductors 52 and 55. Thus, this device is a sinusoidal wave form signal generator.

FIG. 6 illustrates a surface arrangement which may be utilized in the manner outlined above to produce a square wave output. The operation is similar to that of the FIG. 5 arrangement except that the changes in potential appearing between the outside conductor 60 and the middle conductor 61 will be of an abrupt nature and a square wave potential variation will result.

The FIG. 7 arrangement may be utilized as a sine-cosine generator. Thus, if a potential is caused to appear between conductors 70 and 71 and the surface is then illuminated as explained in conjunction with FIG. 5, the result will be a sine wave form potential variation appearing between conductors 71 and 72, and a wave form which has a cosine potential variation with respect to the first-mentioned wave form appearing between conductors 71 and 73.

While only certain arrangements in accordance with this invention have been discussed, it should be appreciated that a large variety of devices are possible, and the invention is not intended to be limited to the particular

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configurations described. For example, while the devices discussed have been primarily concerned with uniform photosensitive layers, it is obvious that a layer whose thickness, for example, varies in a desired manner, can be utilized with any desired conductor arrangement. Similarly, the quality and quantity of illumination can be varied or controlled in a desired manner, as can the movement of the illumination beam along the surface and the characteristics of an applied potential, thereby resulting in a wide variety of possible resistance variations. It is, therefore, intended in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A variable resistance device comprising:

a first pair of conductors spaced along their length; at least one additional conductor positioned between said first pair of conductors so that the spacing between said third conductor and said first pair of conductors varies over the length of said third conductor;

a photosensitive layer, whose electrical resistance is dependent upon the illumination of said layer, in contact with each of said conductors and extending between them;

and means for illuminating a variable portion of said layer, which portion always includes points at which said layer contacts each of said conductors;

the variable resistance device being so constructed and arranged that if a potential is applied between the first pair of conductors, the portion of said potential existing between said additional conductor and either one of said first pair of conductors is determined by the particular portion of the layer which is illuminated.

2. A variable resistance device as described in claim 1, wherein said first pair of conductors are parallel to each other over their length.

3. A variable resistance device as described in claim 1, wherein each of said conductors is metallic and has negligible electrical resistance over its entire length and effectively all electrical resistance in the complete device is provided entirely by the photosensitive layer.

4. A variable resistance device comprising:

a plurality of spaced conductors whose spacing varies as a function of length, each said conductor having negligible electrical resistance over its entire length;

a photosensitive layer, whose electrical resistance is dependent upon the illumination of said layer, in contact with each of said conductors and extending between them;

and means for illuminating a variable portion of said layer, which portion always includes points at which said layer contacts each of said conductors;

the variable resistance device being so constructed and arranged that the quantity and quality of the illumination are fixed, the size and shape of the illuminated portion of the layer are fixed, effectively all electrical resistance in the complete device is provided entirely by the photosensitive layer and variation in the resistance between the conductors is controlled solely by varying the points along the conductors at which the illuminated portion is positioned.

5. A variable resistance device as described in claim 4, wherein the photosensitive layer has the form of a hollow cylinder with the conductors in contact with the external surface of the layer and internal portions of the layer are illuminated.

6. A variable resistance device comprising:

a continuous cylindrical layer of photosensitive material whose electrical resistance is dependent upon the illumination of said layer;

a first pair of spaced conductors, each conductor in the form of a closed continuous loop in contact with said layer over the length of the conductor;

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at least one additional conductor spaced between said first pair of conductors and in contact with said layer over the length of the conductor;

means for illuminating a variable longitudinal portion of said layer, which portion always includes points at which said layer contacts each of said conductors; the variable resistance device being so constructed and arranged that if a potential is applied between the first pair of conductors, the portion of said potential existing between said additional conductor and either one of said first pair of conductors is determined by the particular portion of the layer which is illuminated.

7. A variable resistance device as described in claim 6, wherein the conductors are in contact with the external surface of the cylindrical photosensitive layer and internal portions of the layer are illuminated.

8. A variable resistance device as described in claim 6, wherein said first pair of conductors are parallel to each other over their length and the spacing of said additional conductor varies as a function of its length.

9. A variable resistance device, useable for generating a periodic time-varying electrical signal, comprising: a continuous cylindrical layer of photosensitive material whose electrical resistance is dependent upon the illumination of said layer;

a first pair of spaced conductors, each conductor in the form of a closed continuous loop in contact with said layer over the length of the conductor;

at least one additional conductor spaced between said first pair of conductors and in contact with said layer over the length of the conductor;

means for illuminating a variable longitudinal portion of said layer, which portion always includes points at which said layer contacts each of said conductors, and for permitting continuous movement of said illuminated portion along the length of said conductors;

the variable resistance device being so constructed and arranged that if a potential is applied between the first pair of conductors, the portion of said potential existing between said additional conductor and either one of said first pair of conductors is determined by the particular portion of the layer which

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is illuminated and a periodic time-varying electrical signal is generated by causing the illuminated portion to periodically move along the entire length of said conductor.

10. A variable resistance device as described in claim 9, wherein:

the first pair of conductors are parallel to each other over their length, the additional conductor is a closed continuous loop and the spacing between said additional conductor and said first pair of conductors varies as a sine function;

the construction being such that a time-varying sine-wave electrical signal can be generated.

11. A variable resistance device as described in claim 9, wherein:

the first pair of conductors are parallel to each other over their length, the additional conductors are a series of short segments with different spacings from the parallel conductors and all of said segments are electrically interconnected by external wiring not in contact with the photosensitive layer;

the construction being such that a time-varying square-wave electrical signal can be generated.

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