May 14, 1940. T. W. VARLEY 2,200,462

MICROPHONE SYSTEM

Filed April 8, 1938

FIG. 1.

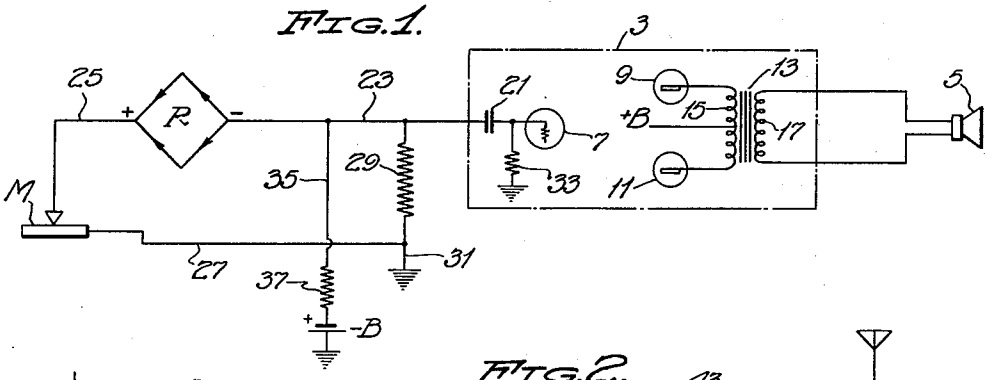


FIG. 2.

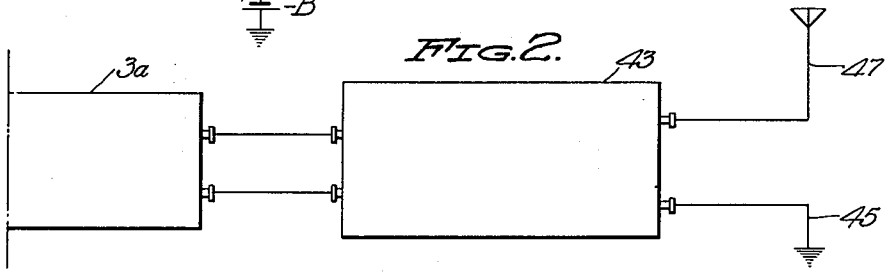


FIG. 3.

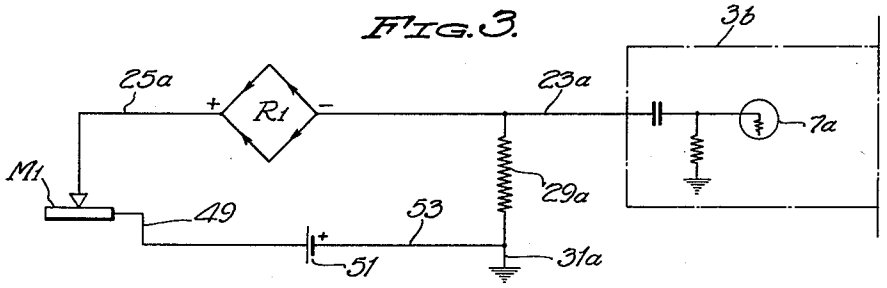
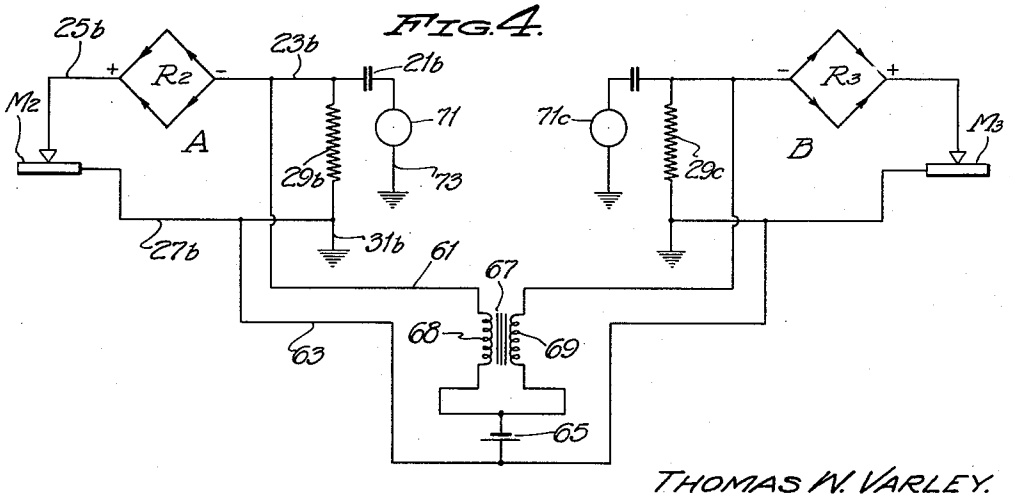


FIG. 4.



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MICROPHONE SYSTEM

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13 Claims. (Cl. 179—1)

This invention relates to microphone systems, and it has special reference to such systems in which carbon type microphones are employed.

The sensitivity and efficiency of the ordinary carbon type microphone, when utilized in any system of sound transmission, depends upon the amount of change in the resistance thereof necessary to effect a certain amount of change in current therethrough, in comparison with the degree of change in energy made effective upon a load device at some other point in the system which may be applicable to useful work.

As a practical matter, microphones of the carbon type are more or less standardized in design and construction, so far as electrical characteristics are concerned. For instance, the usual single button carbon microphone is commonly designed for 2 volts, 200 ohms resistance and a normal current of 10 milliamperes when idly operating and unaffected by speech or other sounds. However, in actual use and affected by speech, the normal current changes in the neighborhood of 10%. If the service conditions exceed these general limits, objectionable disturbances and possible arcing results. Accordingly, these factors of design, when considered in connection with the many conventional circuit arrangements to which microphones are commonly applicable, impose rather definite restrictions as to the operating conditions to which they properly may be subjected.

In view of these limitations in operating conditions, improved sensitivity and efficiency can only be secured through suitable changes in the circuit arrangements of the systems in which such microphones are employed.

One of the objects of my invention is to provide a microphone system which shall be arranged and operated in such manner as to improve the sensitivity and the efficiency of the system in general over and above that which is obtained in accordance with present practice.

Another object is to accomplish this end, in whatever class of system or service to which my invention is applied, through the employment of a control resistance, preferably but not necessarily, of the well-known Rectox type, having a negative resistance-current characteristic, and connected in such circuit relationship with the usual carbon microphone of standard design, as to increase the sensitivity of the microphone system.

Through the use of such a control resistance in such circuit relation to the microphone, I find that the normal 10% change in current occasioned by speech in the conventional microphone use, requires considerably less change in pressure of the microphone diaphragm on the carbon particles, inasmuch as the necessary change in resistance of the microphone circuit is not restricted to the change in the microphone resistance alone, but is effected to a marked extent by the change in resistance of the auxiliary control resistance, by reason of its peculiar negative resistance-current characteristic.

Thus, for the same results, my invention enables the usual carbon microphone to be used with a materially decreased amount of change in the microphone resistance per se, or from a somewhat different aspect, if the microphone is so used as to effect the conventional degree of resistance change, the effective results upon the system are greatly improved. Hence, the sensitivity and the efficiency of the system are materially enhanced.

Obviously, the principles of my invention may be applied to various types of systems employing carbon microphones and to many classes of service, a few examples of which I shall set forth herein as typical.

The foregoing and other objects and features of my invention may best be understood from the following description of the illustrative embodiments thereof, as shown in the accompanying drawing, in which

Fig. 1 is a simplified diagrammatic view of the circuit connections of a microphone system embodying my invention, as applied to the transmission of sound by electronic amplification, as in a so-called announcing or public address system;

Fig. 2 is a fragmentary diagrammatic view of certain circuit connections which, taken in connection with those of Fig. 1, illustrate the application of my invention to broadcasting service;

Fig. 3 is a diagrammatic view of another embodiment of my invention which may be applied to announcing, broadcasting or other classes of service; and

Fig. 4 is a simplified diagrammatic view of a still further modification of my invention, as applied to a telephone system.

Referring to the drawing, my invention, as illustrated in Fig. 1 thereof, comprises an announcing system including a microphone M, an electronic amplifying unit 3, a loud speaker 5, an auxiliary control device R having a negative resistance characteristic, preferably in the form of a so-called Rectox resistance, and other ancil-

lary appurtenances as will be hereinafter described.

The microphone M, as shown for purposes of simplification, is of the single button carbon type of conventional construction, but it should be understood that the principles of my invention are not so restricted but may be utilized by means of suitable circuit connections with a double button microphone of ordinary construction.

The electronic amplifying unit 3, which constitutes the load, may be of any well-known conventional type, having one or more stages of amplification, together with one or more power tubes, which, if desired, may be arranged in push-pull relation. In the drawing, for purposes of simplification, only the first amplifying tube 7 and the push-pull power tubes 9 and 11 are shown, together with the usual output transformer 13, the primary coil 15 of which is connected between the power tubes, while the secondary coil 17 is connected to loud speaker 5. The mid-point of the transformer primary coil has a positive battery connection +B, in accordance with usual practice.

The input side of the amplifying unit 3 has its first amplifying tube 7 connected to the button of the microphone M through condenser 21, conductor 23, control device R, preferably of the Rectox type, and conductor 25. The other terminal of the microphone M is connected by means of conductor 27 to the lower end of a shunt resistance 29 which is also connected to ground by conductor 31, while the upper end of the shunt resistance is connected to the conductor 23 at a point intermediate the condenser 21 and the control device R.

The grid circuit of the first amplifying tube 7 is connected to ground through resistance 33, and from a point in conductor 23 between the control device R and the point of connection of shunt resistance 29 therewith, a conductor 35 leads to ground through a series resistance or impedance 37 and a +B extraneous source of energy of relatively high voltage.

The control device R is preferably of the dry copper oxide type, known in the art as Rectox, such as that described in Patent No. 1,640,335, granted August 23, 1927, to Grondahl, although my invention is not limited to devices of this specific class. This type of device is indicated in the drawing and is marked with arrows in its several legs, as is conventional in the art, to indicate the direction of flow of current permissible therethrough, while the positive and negative terminals thereof are conventionally marked by plus and minus signs, respectively.

This Rectox control device has a negative resistance-current characteristic or curve, i. e., its internal resistance decreases with an increase of current passing therethrough. Moreover, its resistance change is instantaneous with changes in current therethrough. It is this peculiar negative resistance characteristic of the Rectox control device which I utilize so effectively in my invention to secure the highly beneficial results of extraordinary efficiency and sensitivity, as will become more apparent from the following explanation of the operation.

For purposes of explanation, I will set forth as an example, the capacities of several parts of an equipment which I have operated with remarkable success. The microphone M is of standard construction and designed for 2 volts, 200 ohms and a normal operating current of 10 milliamperes, while unaffected by talking. The +B source is about 100 volts. The series resistance 37 is of 4800 ohms, and the Rectox has a resistance of 200 ohms at a current of 10 milliamperes, when not affected by talking, while the shunt resistance 29 is of 400 ohms.

With the above indicated equipment, and a normal current of 10 milliamperes through the microphone M, there are also 10 milliamperes flowing through the shunt resistance 29, while the +B source delivers 20 milliamperes through the series resistance 37. Thus, the voltage drop through the series resistance is 96 volts, leaving a voltage of 4 volts impressed across the shunt resistance 29 and also across the series connected Rectox R and microphone M, or 2 volts across each.

Now, assuming an increase in current through the microphone M of 10% by reason of conventional talking conditions, then there would flow through the microphone and Rectox a current of 11 milliamperes. Since the shunt resistance 29 is in parallel circuit to the microphone and Rectox device, and assuming a constant current source of energy, there is necessarily a 10% decrease in current passing through the shunt resistance 29. Thus, 9 milliamperes flows through the shunt resistance and a voltage of 3.6 volts is impressed across both of the parallel circuits.

With this voltage across the series-connected microphone M and Rectox resistance R, and 11 milliamperes flowing therethrough, the total resistance of the circuit is

$$\frac{3.6}{.011}$$

or 327 ohms. Now, with 11 milliamperes passing through the Rectox, its internal resistance is decreased by 12 ohms by reason of its negative resistance-current characteristic. The Rectox resistance therefore is 188 ohms with 11 milliamperes flowing. Under these conditions, the resistance of the microphone is 327—188, or 139 ohms. The decrease in microphone resistance is 61 ohms or about 30½%.

Thus, a 30½% change in microphone resistance produces a 10% change in microphone current and effects a voltage change of .4 volt across the shunt resistance 29, which voltage change is applied to the amplifying unit or load device.

For purposes of comparison, it may be stated that with the present announcing systems of this general class, an increase of 10% current in the microphone requires a 20% decrease in microphone resistance and effects a .2 volt change of voltage as applied to the amplifying unit. These figures are well known in the art and will be found on page 38 of the August 1936 issue of "QST," which is a recognized authority, published monthly by The American Radio Relay League, Inc., as its official organ.

Thus, in accordance with my invention, the change of energy applied to the amplifying unit resulting from a 10% increase in microphone current, is vastly greater than that occasioned by the same percentage of current increase in the microphone of the present-day standard announcing system. Manifestly, if the usual voltage change of .2 volt is applied to the amplifier unit, the necessary microphone resistance change would be only about 15%, as compared to a 20% change in microphone resistance, as is required in present practice. This means better efficiency and greater sensitivity in operation.

Of course, instead of employing my invention for use with an amplifying unit and loud speaker, as in an announcing or public address system, it may be employed for broadcasting service, as depicted in Fig. 2.

In this event the general circuit connections of the microphone may be similar to those already described, except that the amplifying unit 3 of Fig. 1 is utilized as a modulator 3_a in the usual manner and the loud speaker 5 of Fig. 1 is replaced by any conventional type of radio frequency transmitter 43, which is provided with the usual ground and antenna connections 45 and 47, respectively.

In Fig. 3, I have shown my invention as embodied in a somewhat different circuit arrangement, which, however, is adapted for announcing systems as in Fig. 1 or broadcasting service as in Fig. 2.

Referring to Fig. 3, a carbon button microphone M_1 of common construction has one of its terminals connected by conductor 49 to one side of a battery 51, while the other side of the battery is connected by conductor 53 to the lower terminal of resistance 29_a which is also grounded through conductor 31_a. The upper end of the resistance 29_a is connected to conductor 23_a at a point between the negative terminal of the control resistance R_1, preferably of the Rectox type and the first amplifying tube 7_a of the amplifier unit or modulator 3_b, which constitutes the load. The Rectox device R_1 is similar to that already described and its positive terminal is connected by conductor 25_a to the button of the microphone M_1.

With this arrangement of circuits, the capacities of the usual accessory devices are as follows: microphone M_1 having a resistance of 200 ohms, Rectox R_1 of 200 ohms resistance, resistance 29_a of 400 ohms, and the battery 51 of 8 volts. A current of 10 milliamperes flows through the circuit under normal conditions.

With a normal current of 10 milliamperes flowing through series resistance 29_a, the voltage across it is 4 volts.

Now, assuming a 10% increase in current through the microphone circuit, or 11 milliamperes, due to talking conditions, the total resistance of the entire microphone circuit is 727 ohms, of which the 400 ohms of the shunt resistance 29_a is fixed. The balance of 727—400, or 327 ohms must be supplied by the Rectox device R_1 and the microphone M_1. Now, the Rectox, by reason of its negative resistance-current characteristic, has a resistance of 200—12, or 188 ohms. Thus, the resistance of the microphone M_1 is 327—188 or 139 ohms. This is a decrease of 200—139, or 61 ohms in the original microphone resistance, or a change of about 30% to effect a 10% increase in current, which also effects an increase in voltage of .4 volt across the resistance coupling 29_a, which is applied to the amplifier unit 3_b.

In ordinary practice, where no Rectox device is employed, it requires a 20% change in microphone resistance to increase the current 10% and which gives a .2 volt increase of voltage applied to the amplifier.

With this in mind, it is apparent that if the usual .2 volt change in voltage of the prior art were to be secured with my invention, it would require a 15% change in the resistance of the microphone.

Thus, the use of my invention results in a definite improvement over present practice.

In Fig. 4 I have shown a further modification of my invention, as applied to telephone service. Referring to this figure, the system illustrated, embodies the use of control resistances of the Rectox type, and comprises stations A and B which are interconnected by telephone lines 61 and 63 to which electrical energy is supplied from a battery 65 through a coupling transformer 67 having coils 68 and 69, in the usual manner.

The equipments of the two stations A and B are alike, and the circuit arrangements of each includes a Rectox device having a negative resistance-current characteristic. Hence, a description of only one station will suffice. Of course, the diagram of Fig. 5 is greatly simplified, but will amply serve for purposes of explanation.

With this understanding, station A comprises a carbon button microphone M_2, having one of its terminals connected by conductor 27_b to the lower end of a shunt resistance coupling 29_b which is also connected to ground by means of conductor 31_b. The upper end of the shunt resistance 29_b is connected by conductor 23_b to the negative terminal of the control Rectox resistance R_2, while its positive terminal is connected by conductor 25_b to the button of the microphone M_2.

A telephone receiver 71 is connected in shunt relation to the shunt resistance coupling 29_b from the upper end thereof through condenser 21_b and the opposite terminal of the receiver is connected to ground by conductor 73.

Energy from battery 65 is supplied to station A by means of telephone lines 61 and 63, the former being connected to conductor 23_b at a point between the upper end of the shunt resistance 29_b and the negative terminal of the Rectox R_2, while the latter is connected to conductor 27_b between the lower end of the shunt resistance 29_b and the microphone M_2. The energy from the battery, therefore, is supplied to parallel circuits, one of which includes shunt resistance 29_b, while the other branch includes the Rectox R_2 and the series-connected microphone M_2.

The circuit connections of station B are similar to those just described and include microphone M_3, Rectox resistance R_3, shunt resistance 29_c and telephone receiver 71_c.

The capacities of the equipment are about as follows: The microphones M_2 and M_3 have resistances of 200 ohms and are designed for 10 milliamperes of current under normal conditions, when not affected by speech. The Rectox devices R_2 and R_3 have normal resistances of 200 ohms at 10 milliamperes of current, and the shunt resistances 29_b and 29_c are of 400 ohms.

It will be understood that in telephone service, when microphone M_2 at station A is in use, the receiver 71_c at station B is in service, while if microphone M_3 at station B is being employed, the receiver 71 at station A is in use.

With the circuit arrangements and capacities of the component parts of the system as above described, it will be found that in order to secure the required conventional voltage change of .2 volt, as applied to the receiver 71_c at station B, when the microphone M_2 of station A is in service, it requires a resistance change in microphone M_2 of about 28½%.

This compares with the usual required 36½% conventional change in microphone resistance to effect a .2 volt change on the receiver, in accordance with the present-day telephone circuit connections, when resistance couplings are employed and no Rectox devices are utilized.

These comparative results indicate the superiority in efficiency and sensitivity of the telephone

system when utilized in accordance with my invention. This improvement is occasioned through the employment of the Rectox devices, whose negative resistance-current characteristics cause a material decrease in resistance with an increase of current flowing therethrough, and vice versa.

Moreover, for telephone service, where such a Rectox device is used at both stations, both of such devices function in such manner as to decrease the necessary resistance change in the microphone in service, whereby the sensitivity efficiency of the system is enhanced.

Obviously, other specific circuit connections and service applications, involving the use of control resistance devices having negative resistance-current characteristics, for the purpose of increasing the sensitivity and operation of systems embodying carbon type microphones, will suggest themselves.

Therefore, although my invention has been shown and described, for illustrative purposes, as embodying a few more or less specific circuit connections and arrangements and locations of parts, it should be understood that my invention, in its broader aspects is not so limited, but that many modifications may be made therein without departing from the spirit and scope of my invention. Hence, only such limitations should be imposed as are indicated in the appended claims.

I claim as my invention:

1. A microphone system comprising a carbon type microphone, an electronic amplifier to be operated in accordance with the operation of said microphone, and circuit connections between the microphone and said amplifier, including a control resistance having a negative resistance-current characteristic so arranged and connected directly in the microphone circuit ahead of the amplifier that its resistance change, resulting from changes in current through the microphone and the control resistance due to talking, operates to increase the sensitivity of the microphone by decreasing the necessary change in microphone resistance required in microphone systems of the conventional type.

2. A microphone system comprising a carbon type microphone, an electronic amplifier to be operated in accordance with the operation of said microphone, and circuit connections between said microphone and said amplifier, including a control resistance connected directly in the microphone circuit ahead of said amplifier in series circuit with said microphone, to materially increase the sensitivity and the efficiency of the system in delivering energy to said amplifier.

3. A microphone system comprising a carbon type microphone, an electronic amplifier to be operated in accordance with the operation of said microphone, and circuit connections between said microphone and said amplifier, including a control resistance having a negative resistance-current characteristic connected directly in the microphone circuit ahead of said amplifier and in series circuit relation with said microphone, for controlling the energy applied to said amplifier.

4. A microphone system comprising a carbon type microphone, an electronic amplifier to be operated in accordance with the operation of said microphone, and circuit connections between said microphone and said amplifier, including means connected directly in the microphone circuit ahead of said amplifier and in series circuit relation with said microphone for automatically changing the resistance of the microphone circuit as the microphone resistance is changed, for controlling the energy applied to said amplifier.

5. A microphone system comprising a carbon type microphone, an electronic amplifier to be operated in accordance with the operation of said microphone, and circuit connections between said microphone and said load device, including a control device having a negative resistance-current characteristic connected directly in the microphone circuit ahead of said amplifier and in series circuit relation with said microphone and operating to change the resistance of the microphone circuit as the resistance of the microphone changes and in the same direction, for controlling the energy applied to said amplifier.

6. A microphone system comprising a carbon type microphone, a load device to be operated in accordance with the operation of said microphone, and circuit connections between said microphone and said load device, including a shunt resistance coupling between the microphone and the load device and a control resistance having a negative resistance-current characteristic connected directly in the microphone circuit and in series circuit relation with said microphone between said microphone and said resistance coupling and in shunt to said shunt resistance, and a +B extraneous source of energy and a series impedance connected across said shunt resistance, whereby the energy applied to said load device is controlled.

7. A microphone system comprising a carbon type microphone, an electronic amplifier to be operated in accordance with the operation of said microphone, and circuit connections between said microphone and said amplifier, including a shunt resistance coupling between the microphone and the amplifier and a control resistance having a negative resistance-current characteristic and an extraneous battery both connected directly in the microphone circuit ahead of said amplifier and in series circuit with said microphone across said shunt resistance, for increasing the sensitivity and the efficiency of the system in delivering energy to said amplifier.

8. A microphone system comprising a carbon type of microphone, and an electronic amplifying unit, in combination with means including a control device, having a negative resistance-current characteristic, connected directly in the microphone circuit ahead of said amplifier and in series circuit relation with said microphone for controlling the energy applied to said amplifying unit.

9. A microphone system comprising a carbon type of microphone, and an electronic amplifying unit, in combination with means including a shunt resistance coupling between said microphone and said amplifying unit, a control device of the Rectox type connected directly in the microphone circuit and in series circuit relation with said microphone between said microphone and said resistance coupling and in shunt to said shunt resistance, and a +B extraneous source of energy and a series impedance connected across said shunt resistance, whereby the energy applied to said amplifying unit is controlled.

10. A microphone system comprising a carbon type of microphone, and an electronic amplifying unit, in combination with means including a control device of the dry copper oxide type connected directly in the microphone circuit ahead of the amplifying unit and in series circuit relation with said microphone for controlling the energy ap-

plied to the amplifying unit and materially increasing the sensitivity and efficiency of the system.

11. A telephone system comprising a plurality of stations interconnected by telephone lines, each station including a carbon type of microphone, a telephone receiver and a control resistance having a negative resistance-current characteristic arranged and connected directly in the microphone circuit ahead of the telephone lines and to decrease the necessary change in the resistance of the microphone in use at one station to effect the desired change in energy applied to the receiver in use at the other station.

12. A telephone system comprising a carbon type microphone, a telephone receiver, and circuit connections between said microphone and said receiver, including a shunt resistance coupling connected between said microphone and said receiver and a control resistance having a negative resistance-current characteristic connected directly in the microphone circuit and in series circuit relation with said microphone between said microphone and said resistance coupling and telephone lines including a source of energy connected across said shunt resistance and also across the series-connected microphone and control resistance.

13. A telephone system comprising a plurality of stations interconnected by telephone lines, each of said stations including a carbon type microphone, a telephone receiver, a shunt resistance coupling between said microphone and said receiver and a control resistance device having a negative resistance-current characteristic connected directly in the microphone circuit ahead of said telephone lines and in series circuit relation to said microphone, said telephone lines being connected across said shunt resistance and also across said series-connected microphone and control resistance.

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