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CHARACTERISTIC CHANGER AND LINEAR POTENTIOMETER

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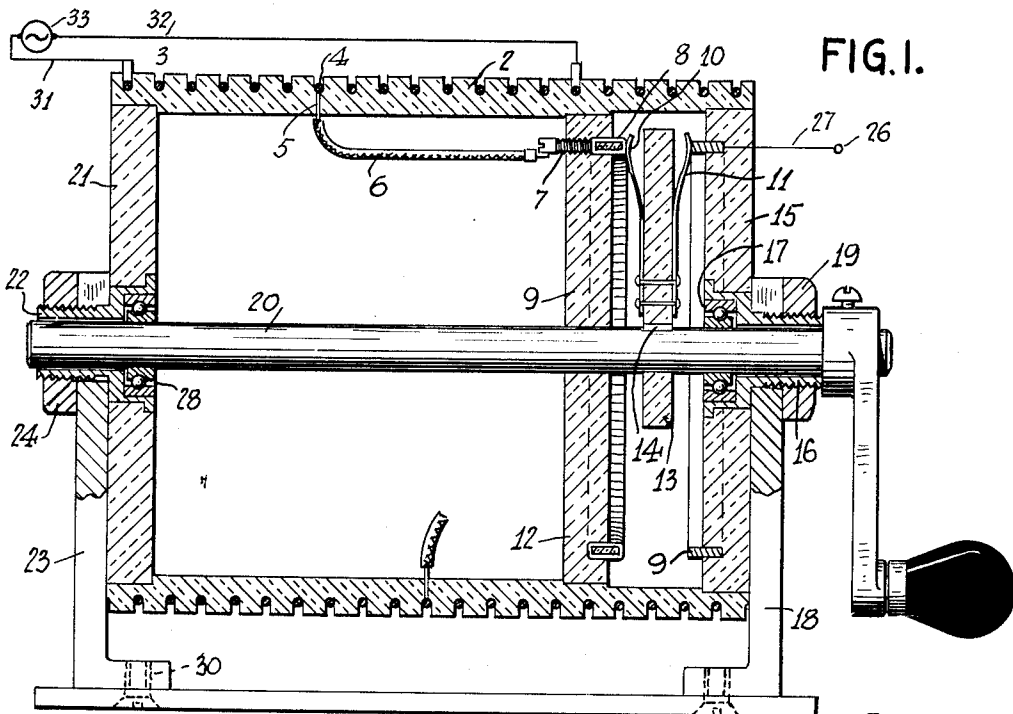


FIG. 1.

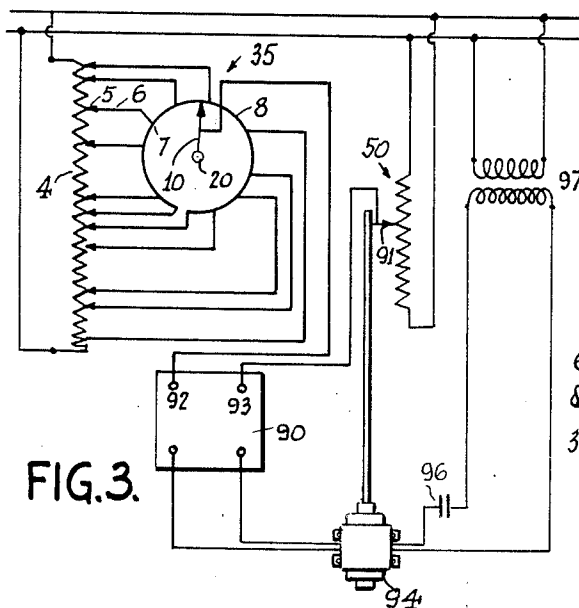


FIG. 3.

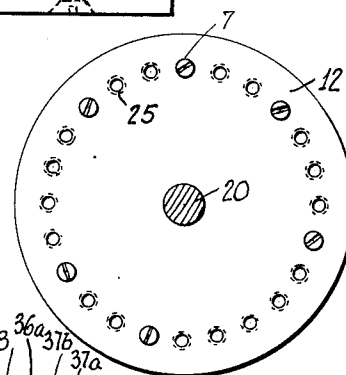


FIG. 2.

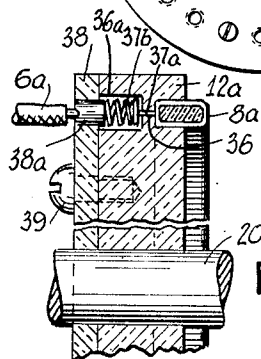


FIG. 4.

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CHARACTERISTIC CHANGER AND LINEAR
POTENTIOMETER

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7 Claims. (Cl. 201—56)

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This invention relates to improvements in voltage and in position control systems comprising primary control means, wherein the output "y" can be varied as a function of the displacement "x" of the primary control means according to any desired function $y=f(x)$, and is a continuation in part of my co-pending application, Serial No. 155,864 filed on April 14, 1950.

An object of the invention is to provide a system of the aforementioned character in which the output "y" expressed as a voltage function is composed of a large number of straight line sectors located in a plane "x-y," the location and the slope of said sectors being determined individually and set into the instrument in such a manner as to approximate the curvature of a desired function.

Several features of novelty characterize this invention over my above mentioned co-pending application.

One of them deals with a design modification of the "interpolating resistor" and enables a continuous rotation of the control shaft to generate pulses of desired form and frequency. Means are provided to connect a relatively large number of taps to a circular potentiometer resistance winding and to compensate for current take-off by the interpolating resistor.

Another feature of novelty is concerned with new design of taps for potentiometer winding.

For a better understanding of the invention, its advantages over the existing art and the specific objectives attained with its use, reference should be had to the following description and accompanying drawings in which preferred embodiments of the invention have been illustrated and described.

In the drawings:

Fig. 1 is a sectional view of the instrument according to the invention.

Fig. 2 is a rear view of a disc supporting the interpolating resistor.

Fig. 3 is a diagrammatic representation of a unit control system according to the invention.

Fig. 4 is a partly broken sectional view of a modification of the interpolating resistor provided with spring loaded taps.

Referring first to Fig. 1, there is shown a helical, multi-turn groove 3, arranged along the external periphery of a cylindrical, non-conducting mandrel 2, a resistance wire 4 being arranged within and along the length of the former. The wire 4, referred to as the selective resistor, makes a pressure electrical contact with respective contact pins 5 (only one of the latter being shown in Fig. 1). The contact pins 5 are inserted in holes drilled at selected locations of the groove 3. Each contact pin is connected to a respective

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contact screw 7 by means of a conductor 6. The electrical connections between respective screws 7, conductors 6 and pins 5 can be made by soldering or by other suitable methods. The contact screws 7 are adapted to be screwed into respective tapped holes 25 in a non-conducting disc 12, the holes 25 being arranged at a uniform distance from each other, or at predetermined locations along the periphery of the disc 12; this being shown more clearly with reference to Fig. 2. The screws 7 make an electrical contact with a resistance wire 8, referred to as the interpolating resistor, and wound helically on a circular, heavily insulated copper core cemented within a circular groove in the disc 12.

In a modification of the arrangement shown in Fig. 2, spring loaded taps shown in Fig. 4 have been used. In this arrangement a disc 12a is provided with a plurality of holes 36 arranged in a circle at selected locations of its external periphery. The diameter of a hole 36 is sufficiently large to allow insertion within of a respective contact tip 37a made of suitable conducting material and adapted to cooperate conductively with a resistance wire 8a, the latter being wound helically on a heavily insulated copper core cemented within a circular groove in the disc 12a. To produce an adequate spring loading effect between the tips 37a and the wire 8a, a circular non-conducting disc 38 is coupled to the disc 12a by means of screws 39 and adapted to exert pressure on respective springs 37b by virtue of having a larger radius than the radius of the circle at which the centers of respective holes 36 are located. The spring 37b, the tip 37a and an external conductor 6a can be connected together by soldering, by pressure, or can be made out of one solid piece of spring wire.

In a preferred embodiment illustrated in Fig. 4, the disc 38 has been provided with a plurality of conducting pins 38a arranged at selective location relative to location of respective holes 36 in the disc 12a. The pins 38 cooperate conductively with respective springs 37b and are connected to selected points along the resistor 4 (not shown in Fig. 4, but seen in Fig. 1), via respective conductors 6a.

Referring back to Fig. 1 a contact disc 13 is adapted to be displaced by means of a control shaft 20. The disc 13 carries a pair of interconnected spring contacts 10 and 11, the contact 10 being adapted to cooperate with the resistance 8 and the contact 11 with a collector ring 9, the latter being inserted in a non-conducting end plate 15. The plate 15 supports a bushing 16 and a bearing 17 and can be fastened by means of a nut 19 to a stand 18. The collector ring 9 is connected by means of a conductor 27 to an output

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terminal 26. At the other end of the mandrel 2, there is provided an end plate 21, a bushing 22 and a bearing 23 to support the shaft 20. The plate 21 is fastened to a stand 23 by means of a nut 24. Both the stands 23 and 18 are coupled to a base plate 29 by means of screws 30. The ends of the resistance wire 4 are connected by means of conductors 31 and 32 to a suitable source of voltage 33. For applications requiring a continuous rotation of the shaft 20, the resistance 6 can be of continuous mechanical rotation type having a small gap between the winding terminals.

The contact device 10 being displaced by the control shaft along the periphery of the interpolating resistor 8 interpolates linearly between respective potentials of a pair of taps between which it is situated and reproduces the desired function.

By rotating the shaft 20 continuously in one or in the other direction, at a desired speed of rotation, shaped voltage pulses of desired form and frequency can be produced.

In a specific instant of a sine function potentiometer, by substitution in place of a single contact 10 a pair of contacts (not shown), adapted for simultaneous displacement in conductive engagement with the interpolating resistor 8 and being 90 degrees apart from each other, the functional potentiometer can perform the function of a resolver and produce a simultaneous sine-cosine voltage wave output. A pair of collector rings connected to respective output terminals are of course provided in this arrangement.

For laboratory and other applications, instead of fixed contact pins 5, attachable contacts could be used, adapted to be attached to the resistance wire 4 at any desirable point thereof. In such applications the form of the groove 3 would be that of a T. The attachable contact consists generally of a flanged holder adapted to be inserted manually within the T groove and a spring loaded contact cooperating conductively with the resistance wire 4. Modifications of this arrangement have been described in my co-pending application Serial No. 155,864 filed on April 14, 1950 and are therefore not discussed at length herein.

It will be understood, that instead of a helical resistance 4 arranged in a grooved mandrel 2, a conventional, circular resistance winding, arranged in a manner substantially similar to arrangement of resistor 8 could be used and provided with a plurality of selectively located taps.

In the following section of the specification there is described a method of compensation for current take-off by the interpolating resistor.

Let me consider two cases in which the resistance between a pair of successive taps has been referred to as resistor-sector.

In case 1, the resistance of respective sectors of the interpolating resistor is assumed to be infinite, subsequently no current flows in the interpolating resistor and the potential distribution along the length of the selective resistor is linear.

Assuming that the voltage drop between two successive taps on the selective resistor is desired to be u_a , u being the voltage input to the instrument, the taps would have to be spaced at a distance of $(u_a/u)R$ from each other, R being the total resistance in the selective resistor, said distance being expressed in ohms.

In case 2, the resistance of the interpolating resistor is of a finite value. Subsequently, current flows in the interpolating resistor and the linearity of potential distribution along the selec-

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tive resistor is destroyed. To realize a voltage drop of u_a (same voltage drop as in case 1), between two successive taps on the selective resistor, the taps will have to be placed at a distance R_a (in ohms). Calling r_a the resistance of a sector of the interpolating resistor in parallel with R_a , the linearity condition can be expressed in the following form:

$$r_a R_a / (r_a + R_a) = (u_a / u) R$$

$$R_a = \frac{(u_a / u) r_a}{r_a / R - u_a / u}$$

$$\left(R_a - \frac{u_a R}{u} \right) = \frac{R^2 (u_a / u)^2}{r_a - (u_a / u) R}$$

The values of R_a can be found by simple calculation shown above for various rates of change of the function. Since the resistance of individual sectors of the circuit in case 2 is equal to the resistance of corresponding sectors of the circuit in case 1, the total resistance of the circuit will be identical, the current flow will remain constant and the potential of respective tapping points will remain the same in either case. It will be noted, that the resistance of a sector of the selective resistor in case 2 will increase by

$$\frac{R^2 (u_a / u)^2}{r_a - (u_a / u) R}$$

when compared to the resistance of a corresponding sector in case 1, therefore the total resistance of the selective resistor in case 2 will be higher than in case 1. This increase of resistance in the selective resistor can be realized easily by providing additional turns of wire on the helically grooved mandrel 2 in Fig. 1.

It will be noted that the potential distribution along the selective resistor is dependent on the rate of change of the simulated function, and that the location of a tapping point from which a potential of a predetermined magnitude has to be obtained will vary as a function of location of preceding taps on the selective resistor.

Assuming that the tapping points along the interpolating resistor are spaced at an even distance from each other, a table can be prepared for predetermined, constant values of r_a and of R from which the values of R_a can be obtained directly as a function of u_a / u . u_a / u is the slope of respective sectors of the simulated voltage function.

This may find application in laboratory type of instruments mentioned above, wherein the operator will avail himself of such a table when setting in a desirable function form. It is of course understood that at least one terminal of the source of input voltage is designed as an attachable contact and adapted to be shifted along the length of the selective resistor winding so as to accommodate for different function curvatures.

The only design modification required in this arrangement relative to arrangement shown in Fig. 1, is that respective conductors 6 will be brought outside through suitable apertures in the mandrel 2 or in the disc 21 for external connection with the selective resistor 4 instead of being connected to it internally.

The purpose of the system shown in Fig. 3 is to control the displacement "y" of a motor driven load as a desirable function $y=f(x)$ of displacement "x" of the control shaft 20. The system incorporates a vari-function potentiometer 35 at the control point, which has been described fully in the preceding section of this specification and

a linear potentiometer 50 at the controlled point.

The output contact devices 10 and 91 of vari-function potentiometer 35 and the linear potentiometer 50 are connected to respective input terminals 92 and 93 of a combination voltage and polarity sensing power amplifier 90, the latter being of any conventional or commercially available type.

In a balance condition of the system, the potential magnitude of the contact 10 will equal that of the contact 91, but for a condition of unbalance the voltage applied to the voltage amplifier 90 can be in phase or 180 degrees out of phase with the line voltage considered as a reference.

In general the polarity of the error voltage depends on whether the ratio of the mechanical input "x" to the changer 35 and of the electrical output "y" from the linear potentiometer 50 is higher or lower than that determined by the function $y=f(x)$. This relationship provides the means following amplification for driving the balancing motor 94 in the proper direction of rotation to rebalance the control circuit.

The balancing motor can be a two phase, reversible induction motor having two separate windings, one winding being connected to the output terminals of the amplifier 90 and the other winding through condenser 96 and a transformer 97 to the a. c. voltage supply legs. The motor 94 will rotate in one sense or the other or remain stationary, depending on whether the error voltage is positive, negative or zero, respectively.

If the error voltage is zero, the current output of the amplifier 90 is composed of two actual pulses for each cycle of the supply voltage tending to drive the motor unit 94 in one direction on one half and in the opposite direction on the other half cycle and resulting in no motion of the motor. If the error voltage is positive (in phase with the voltage source) the current output from the power amplifier will be composed of pulses in phase with the positive pulses of the voltage source.

If the error voltage changes signs, the supply current to the motor will be shifted 180 degrees in phase, and the motor will reverse its sense of rotation.

The speed of the motor 94 in either direction depends on the magnitude of the error voltage and decreases as the error voltage decreases.

It will be understood from the foregoing explanation that the motor 94 displaces the contact 91 in conductive engagement with the potentiometer resistance in such direction that tends to decrease the error voltage until it becomes zero, upon which the motor is stopped. The motor 94 drives a load (not shown) which can be any position controlled object.

For monotonic functions $y=f(x)$, (the slope remains positive or negative throughout the entire range), the respective location of the changer 35 and of the linear potentiometer 50 could be reversed without affecting the performance. In such an arrangement, the linear potentiometer would be controlled manually and the changer by means of a motor unit.

While the invention has been described with reference to certain embodiments, it should be borne in mind that it is applicable not merely to resistance elements, but to all types of variable voltage sources comprising voltage division means provided with tapping points from which voltages of different magnitude, phase, frequen-

cy, etc. may be obtained and applied selectively to voltage interpolating means.

What I claim as novel and desire to secure by Letters Patent is:

1. In a functionally adjustable, variable resistor, in combination, a mandrel, a wire of appropriate resistivity disposed along the length of said mandrel, a plurality of contact elements, interlocking means common to said mandrel and to said contact elements to maintain said elements in electrical engagement with said wire at any point along the length of said wire, means to manually adjust and readjust said contact elements along the length of said wire, resistance means, conductor means connecting said contact elements to points located selectively on said resistance means, and wiping means adapted to be disposed along the length and in conductive engagement with said resistance means.

2. In combination, a mandrel, a plurality of selectively located holes in said mandrel, a corresponding plurality of contacts disposed in said holes, a resistance winding and spring means to maintain said contacts in conductive engagement with said winding.

3. The combination according to claim 2, including a wiping means adapted to be disposed along the length of said winding and control means to move said wiping means.

4. In combination, a resistance winding, a support for said resistance winding, a plurality of selectively located holes in said support in the plane of said winding, a plurality of contacts disposed in respective ones of said holes in conductive engagement with said winding, a plurality of helical springs in respective ones of said holes to maintain said contacts in conductive engagement with said winding and wiping means displaceable along the length of said winding.

5. In combination, a resistance winding, a support for said resistance winding, a plurality of selectively located holes in said support in the plane of said winding, a plurality of contacts disposed in respective ones of said holes, a plurality of spring elements disposed in respective ones of said holes to maintain said contacts in conductive engagement with said winding, plug means to lock said contacts and said spring elements in respective ones of said holes and wiping means displaceable along the length of said winding.

6. The combination according to claim 5, wherein said plug means comprises a plurality of metallic lugs in conductive engagement with respective ones of said spring elements.

7. The combination according to claim 6, including resistance elements connected between respective ones of said lugs.

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