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SNAP-ACTION MAGNETIC SWITCH EMPLOYING
A FLEXIBLE BIMETAL SWITCH ARM
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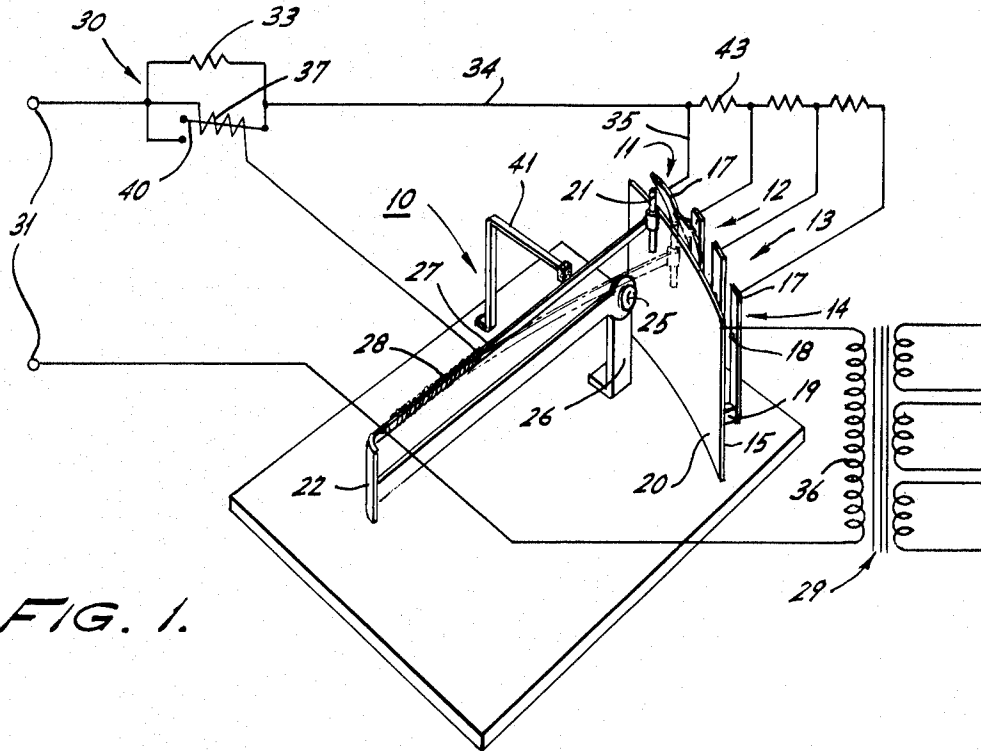


FIG. 1.

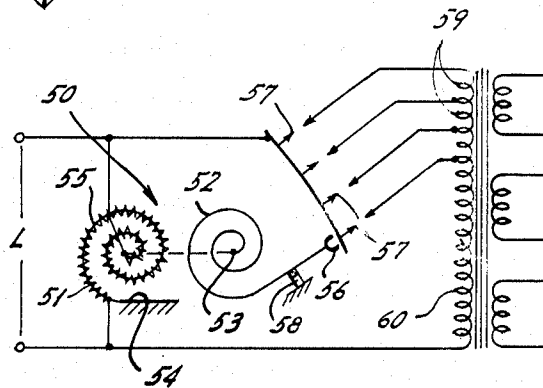


FIG. 2.

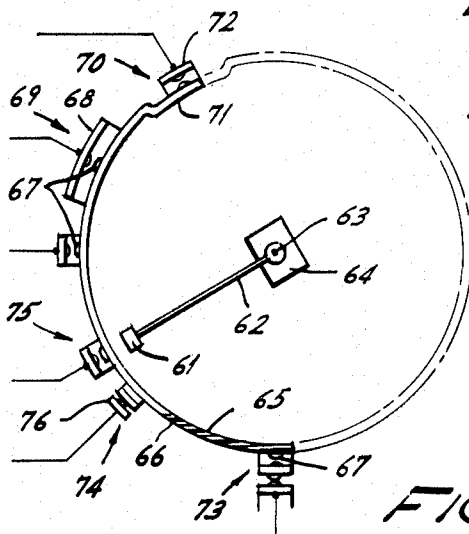


FIG. 3.

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1

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SNAP-ACTION MAGNETIC SWITCH EMPLOYING A FLEXIBLE BIMETAL SWITCH ARM

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4 Claims. (Cl. 200—88)

This invention relates generally to switching mechanism and more particularly to an improved snap-action electrical switch.

This invention while of broader applicability will be illustrated and described in conjunction with its use in the field of voltage regulation and as a timer sequencing control mechanism, to which applications the invention has particular utility.

One particularly troublesome factor in the design of TV receivers is the variable line voltage to which sets are subjected during normal operation. The voltage in any one locality may vary in the course of a single day from 105 to 130 volts. Present day sets must accordingly be designed to operate over this broad voltage range. This necessitates the use of components capable of operation at the extremes of voltage and results in a considerable increase in set cost. Furthermore operation over a range of voltages does not allow for optimized system performance. Specifically, in the case of tube filament circuits, excessive voltage produces physical deterioration of the heater coil and premature boiling-off of the cathode's electron emissive surface, shortening tube life.

One obvious solution to this problem is the use of a voltage regulator. From a practical standpoint, however, this approach has been too expensive when resort is had to prior art voltage regulating techniques.

It is accordingly a particularized object of this invention to provide a novel switching mechanism making possible the achievement of simple and inexpensive voltage regulation.

It is a further object of this invention to provide a simplified, magnetically, operated, multiposition switch capable of snap-action electrical switching.

In accomplishment of the aforementioned general objectives and features there is provided a multiple position, electrical switch in which magnetic attraction is utilized so provide snap action operation. The switch basically comprises means defining a series of individual switching stations each including a resilient, magnetically actuatable switching element mounted for flexible closure with a cooperating contact, through the agency of a magnetic actuator.

In particular accordance with the invention snap-action advance between successive switching stations is obtained by mounting a magnetic actuator on one end of elastic support means and then traversing the actuator into actuating proximity with each of the switching elements successively through application of a driving force to the elastic support means. As the magnetic force of attraction closes a switching element this same attraction resists further motion of the actuator end of the support member. This causes the actuator to pause, or "dwell," at each station, while the support is elastically flexed through the continued application of the driving force. When the elastic force build-up due to continued flexure of the support is sufficient to overcome the magnetic force of attraction the support undergoes substantially instantaneous release providing snap-action advance of the actuator between successive switching stations.

The specific manner in which the foregoing as well as other objectives and advantages of the invention can best be achieved will be understood upon consideration of the

2

following detailed description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a perspective view of a preferred form of the inventive switch, diagrammatically illustrating its novel use as a voltage regulating device;

FIGURE 2 illustrates an alternative embodiment designed to produce a more compact switching mechanism; and

FIGURE 3 illustrates a sequencing control device employing a magnetic switch of modified construction.

Referring to FIGURE 1 of the drawing, there is shown a preferred form of the invention embodied in a unique voltage regulating device. The illustrated stepper switch 10 consists of a number of individual switching stations 11 through 14 comprise of an arcuate, non-magnetic sheet-like member 15 which may for example be made of a plastic insulative material provided with contacts and associated printed wiring circuitry or which as shown may comprise a plate made of a non-magnetic, electrically conductive material such as copper or stainless steel to form a common contact for each of the switching stations. The other contact element of each station is a magnetically actuatable member 17 made for example of spring steel. The member 17 may itself form the electrical contact or may, as shown, have mounted thereon, for movement therewith, a contact button 18 made of Phosphor bronze or other suitable wear-resistant, conductive material. The resilient contact may if desired be of non-magnetic material in which case there is imbedded therein a strip of magnetically permeable material. In the event a stainless steel plate is used, each strip is spaced from the plate by an insulative pad or block 19, the strips being mounted so that on magnetic actuation thereof they are drawn into flexible closure with the plate 15 or with contacts carried or printed on its surface as the case may be. Disposed adjacent the forward surface 20 of plate 15 in spaced relation thereto is a permanent magnet 21 mounted on one end of an elastic support member 22. One suitable form of support is to use a bi-metallic element, a construction which is particularly well adapted to use of the switch as a voltage regulating device. This element is desirably temperature compensated as for example by resort to the U-shaped configuration shown. To provide motive force for traversing the magnet 21 past the various switch contacts, one end of the support is anchored at 25 to a rigidly mounted L-shaped bracket 26, and the leg 27 is wrapped by a heater coil 28. When the switch is used as a voltage regulator the heater coil is connected across the line being regulated. In the illustrated example the coil is connected across the primary of the power transformer 29. The apparatus illustrated is designed to provide a constant average voltage and is not designed to respond to transient, short-time-duration voltage changes. A typical application of such a regulator would be to a television or high fidelity radio receiver. In the normal application, the regulator would desirably be designed to maintain a certain low operating voltage, to permit, among other important advantages, the use of electrical components having minimal high temperature tolerance limits. A voltage regulator incorporating this switch is diagrammatically illustrated in FIGURE 1, the stepper switch being disposed in novel cooperation with resistive elements, to provide simple, inexpensive voltage regulation. In addition to a temperature compensation the circuit includes a fail-safe device 30, it being understood, however, that the circuit is fully operative without the inclusion of either of these refinements. When a television set, high fidelity receiver, or other device incorporating such a regulator on by means not shown, line voltage is applied to terminals 31. To insure an initial, low operating voltage regardless of input conditions a

series connected, voltage dropping line resistor 33 is employed. The operating circuit, before warm up of the set, is thus through resistor 33, lines 34 and 35, through the closed contacts of switching station 11 to the transformer primary 36 and back to the other side of the line. In parallel with this circuit are the series connected heater coils 37 and 28. This arrangement of circuitry prevents initial high voltage loading of the transformer secondary and insures regulated operation on initiation of the operating cycle. Current will only flow through coil 37 when the bi-metal heater coil 28 is operative. Under these conditions switch 40 is designed to close when the bi-metal support element 27 comes up to operating temperature, insuring set operation only under proper voltage regulation.

In the event the heater coil 28 opens during operation, current ceases to flow through coil 37 opening switch 40 and placing the voltage dropping resistor 33 back in the circuit.

In the start position the bi-metal arm 27 and magnet 21 are maintained in registration with the spring steel contact strip 17 of switching station 11. To insure movement of the bi-metal arm 27 from this position only when a predetermined voltage is exceeded, the arm is biased against the fixed stop 41. When the voltage rises above a predetermined value the coil 28, which is directly across the input line, heat arm 27 sufficiently to result in its movement to a successive switching station thereby connecting sufficient resistance in the circuit to bring the voltage across the transformer primary back to the required value. In the illustrated example the voltage is regulated by a four step progression, and while only four positions are shown, of equal air gap pitch, it should be understood that the embodiment is merely illustrative of the invention. Assuming a constant voltage of 110 volts is desired and a six volt increment control is imposed, a rise in the voltage to 116 volts would actuate the bi-metal arm 27, moving it to the position indicated in phantom in FIGURE 1. This would magnetically close the contacts of switching station 12 placing resistor 43 in series circuit with the transformer primary 36 dropping the volts per turn ratio to the required value.

The operation of this switch converts the uniformly increasing force differential impressed on the bi-metal arm by the heater drive means into a series of discrete steps to produce snap-action advance of the magnet between successive switching stations. This is important in preventing disruptive transient voltage conditions occurring during the making and breaking of electrical contact. As the magnet is carried into actuating proximity with a switching blade or element 17 the magnetic interaction between the element and magnet prevents movement of the bi-metal support for a predetermined dwell period during which time an elastic force build-up can occur in the support as a result of its continued flexure, induced by heating or other appropriate drive or motive means. When the magnetic force of attraction is exceeded by the elastic force the spring loaded arm 27 produces snap-action advance of the magnet from one switching station to the next.

An alternative switch construction and method of voltage regulation is diagrammatically illustrated in FIGURE 2. In this embodiment the stepper switch 50 is comprised of wound spiral loops 51 and 52 connected at their common eye 53 to provide temperature compensation in the conventional fashion. Loop 51 is anchored at one of its ends 54 and has wound thereon a heating coil 55 connected across the input line voltage L. The other spiral loop has a horseshoe magnet 56 attached to its free end for translation by the bi-metal support on heating of the spiral loop 51 by coil 55. The magnet moves in an arcuate path along which switch contacts 57 are arrayed. As mentioned previously, the magnet need not be brought into physical contact with the switching elements, and where desirable the switch portions of

the circuit may be totally encased in a suitable dust-free enclosure. For simplicity of illustration the contacts are shown only diagrammatically, their construction being that generally shown in FIGURE 1 and described above. In this embodiment, voltage regulation is effected by stepper switch selection of the proper primary voltage tap in order to maintain the desired volts per turn transfer ratio between the primary and secondary of the transformer. The arrangement shown is designed for normal operation at the low end of the voltage scale. The horseshoe magnet is maintained in the start position shown by means of the bias stop 58 and does not move from this position until the line voltage exceeds some fixed operating value by a predetermined voltage increment. When the voltage exceeds the desired operating value a heavier current flows in coil 55 heating the spiral loop 51 resulting in snap-action movement of the horseshoe magnet 56 to another switching station. By the simplified arrangement shown, movement of the magnet is directly correlated with the value of the impressed line voltage. Thermal inertia of the unit prevents the switch from being affected by a short duration voltage transients. As will be appreciated the bimetal element can be made to move in either clockwise or counterclockwise direction by modifying its construction. In the circuit shown the bi-metal support is constructed to produce counterclockwise rotation of the magnet on heating of the bimetal by the coil 55. Hence increase of line voltage results in the introduction of additional turns 59 into the transformer primary 60 maintaining, for all practical purposes, a constant volts per turn ratio between primary and secondary. Snap-action operation is obtained in the manner as previously described.

FIGURE 3 illustrates a sequencing control mechanism of the type used in regulating the operating cycle of a washing machine. This timer embodies still another variation of the basic switch mechanism described in detail above. In this embodiment the magnet 61 is mounted on the end of a resilient steel shaft or rod 62 keyed to the output shaft 63 of a gear reduction drive 64, powered by a motor not shown. Peripherally bounding the circular path of motion traversed by the magnet, and disposed in spaced relation thereto, is a non-magnetic partition 65 on the face 66 of which are arrayed a series of printed wiring contacts 67 and associated circuitry not shown. To provide varying periods of dwell, the deflectable, magnetically actuatable switch blades 68 may be made of different arcuate widths as seen for example by comparison of the blades comprising switching stations 69 and 70.

An alternative method of producing different periods of dwell time is to vary the reluctance of the air gap separating the magnet from the magnetizable switching element as by providing a recessed wall portion 71 to permit the flexible blade 72 to be drawn closer to the magnet 61 during actuation of switch 70. This latter technique changes the intensity of magnetic coupling between the switching element and magnet by decreasing the reluctance of the magnet flux path, thereby permitting time variation of the dwell period through prolonged holding of the elastic magnet-support means. As shown circuits may be arranged for sequential actuation individually or for concurrent action in pairs, as for example provided for by the single pole double throw switch at station 73. By utilizing an extremely slow speed continuous drive in connection with the aforementioned features a sequencing cycle of long time duration having variable periods of dwell is provided. Manual advance of arm 62 from position 74 to position 75 initiates operation by permitting closure of switch blade 76, the timer automatically turning off when it completes its clockwise rotation back to station 74 through opening of the normally closed switching element 76.

In summary, snap-action electrical switching of a plurality of magnetically permeable switching elements is

5

achieved by elastically coupling a magnetic switch actuator to its drive or motive means. This construction allows the actuator to be stalled at each switching station through the agency of the magnetic flux interlinking the actuator and switching elements. During this dwell period energy is transferred from the drive or motive means to the elastic coupling. By proper selection of the coupling a sufficient elastic force is developed in the coupling through this energy transfer to overcome the magnetic force of attraction and to provide snap-action advance of the actuator from one switching station to the next.

Although the invention has been described with particular reference to specific embodiments and practice it will be understood by those skilled in the art that the apparatus of the invention may be changed and modified without departing from the essential scope of the invention as defined in the appended claims.

I claim:

1. A snap-action electrical switch, comprising: means defining a plurality of individual switching stations each including a magnetically actuatable switching element mounted for switching movement with respect to a co-operating contact; magnetic means for actuating said element; temperature-sensitive means constructed and arranged for flexural movement on heating thereof, and adapted to carry said magnetic means into actuating proximity with said switching elements successively as a result of such movement; and motive means for heating said temperature-sensitive means to provide such flexural movement, the spacing between said magnetic means and said magnetically actuatable switching element at individual switching stations being such that movement of said magnetic means past a switching station is temporarily retarded by the force of magnetic attraction between said magnetic means and its associated switching element to permit flexure of said temperature-sensitive means by said motive means and an elastic force build-up sufficient to overcome said force of magnetic attraction, whereby to provide snap-action advance of said magnetic means between successive switching stations.

2. A switch in accordance with claim 1, and further characterized in that said temperature-sensitive means comprises a bi-metal element, and in which said motive means comprises an electrical resistance heater disposed in heat exchange relation with said bi-metal element.

3. A snap-action electrical switch, comprising: means defining a plurality of individual switching stations each including a magnetically actuatable switching element; magnetic means for actuating said elements; a temperature compensated bi-metal element constructed for flexural movement on heating thereof and arranged on such flexure to carry said actuator into actuating proximity with said switching elements successively; and thermal actuating mean in heat exchange relation with said bi-metal ele-

6

ment to provide flexural movement thereof, the properties, construction and arrangement of said magnetic means and said magnetically actuatable switching element being such that movement of said magnetic means past a switching station is temporarily retarded by the magnetic force of attraction between said magnetic means and an actuated switching element thereby to develop, during such retardation, by continued heating of said bi-metal element, an elastic force sufficient to overcome said magnetic force of attraction and provide snap-action advance of said magnetic means between successive switching stations.

4. A snap-action electrical switch, comprising: means defining a plurality of individual switching stations each including a magnetically actuatable switching element mounted for switching movement with respect to a co-operating contact; magnetic means for actuating said elements; a bi-metal element of spiral configuration constructed for flexural movement on heating thereof and arranged, upon such flexural movement to transport said magnetic means into actuating proximity with said switching elements successively; and means for heating said bi-metal element to provide flexural movement thereof, the spacing between said magnetic means and switch elements being such that traverse of said magnetic means past a switching station is temporarily resisted by the magnetic force of attraction between said magnetic means and an actuated switching element to develop, through elastic deformation of said bi-metal element by continued heating thereof during retardation, an elastic force sufficient to overcome said magnetic force of attraction and to provide snap-action advance of said magnetic means between successive switching stations.

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