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2,310,138

ELECTRICAL SWITCHING APPARATUS

Filed Oct. 23, 1941

2 Sheets-Sheet 1

Fig. 1.

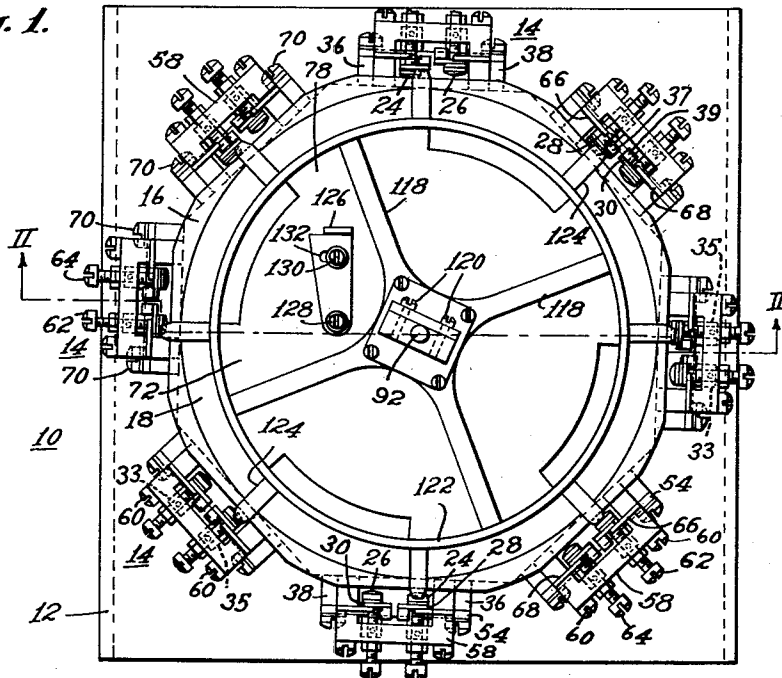
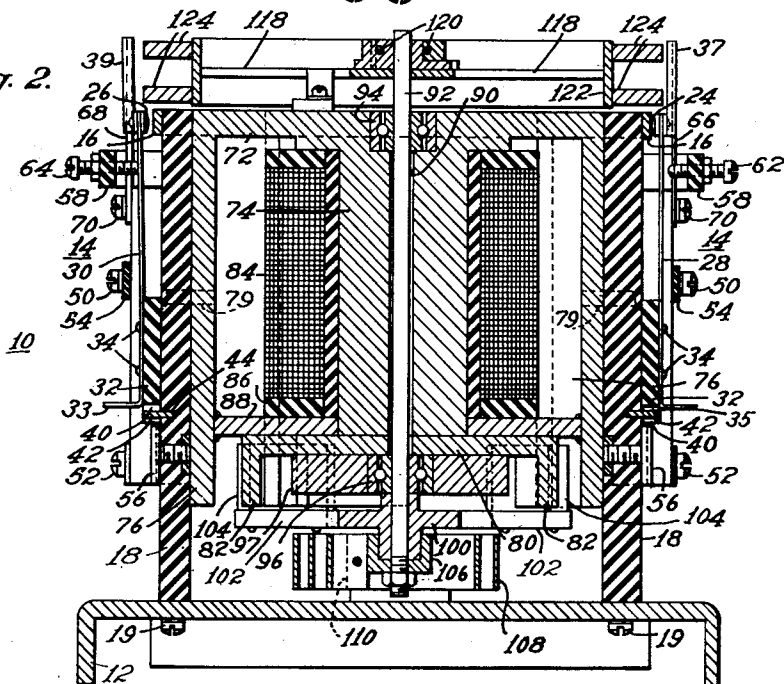


Fig. 2.



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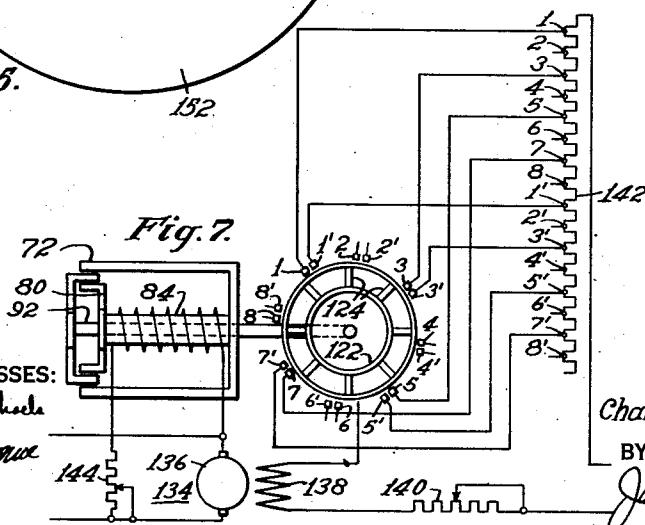
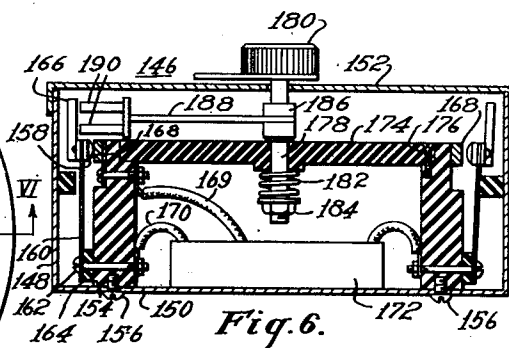
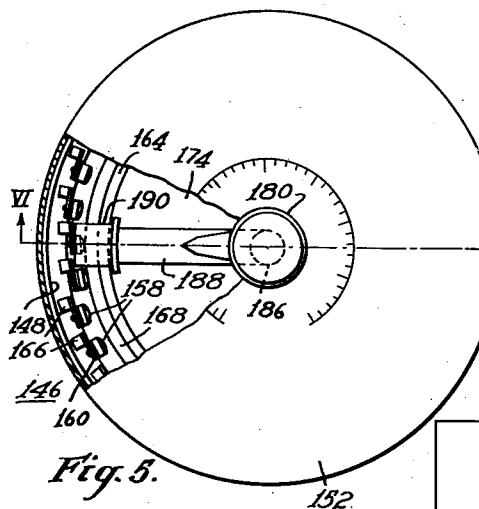
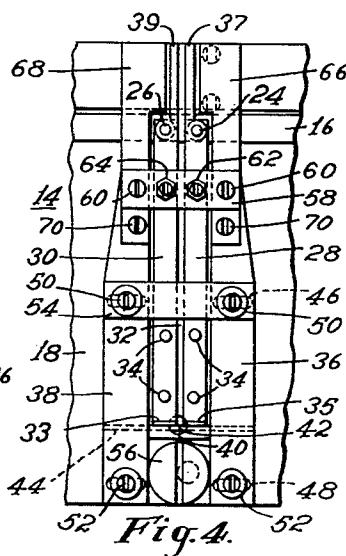
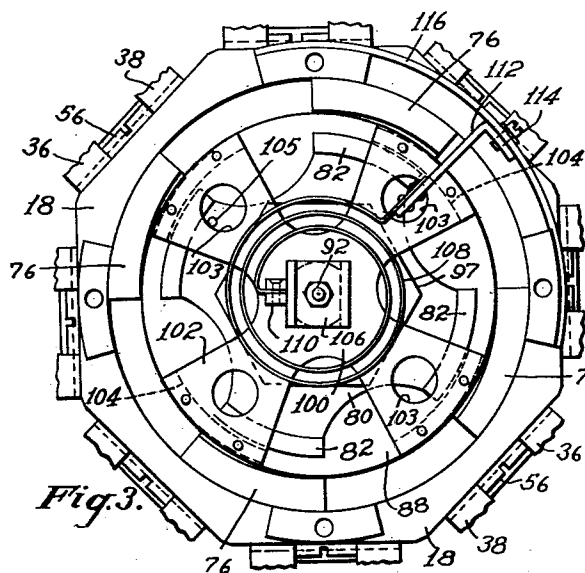
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2 Sheets-Sheet 2



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2,310,138

ELECTRICAL SWITCHING APPARATUS

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Application October 23, 1941, Serial No. 416,174

9 Claims. (Cl. 200—104)

This invention relates to electrical apparatus and, in particular, to an electrical switching apparatus.

An object of this invention is to provide for the adjustment of the contact members of a switching apparatus to obtain a predetermined sequence of movement thereof when they are actuated.

A further object of this invention is to utilize a permanent magnet for controlling the operation of movable contact members of a switching apparatus to effect a predetermined switching operation.

Other objects of this invention will become apparent from the following description when taken in conjunction with the accompanying drawings, in which

Figure 1 is a top plan view of the switching apparatus of this invention;

Fig. 2 is a view in section of a switching apparatus taken along the line II—II of Fig. 1;

Fig. 3 is a bottom plan view of the switching apparatus with the supporting base removed;

Fig. 4 is an elevational view of one of the movable contact member assemblies of the switching apparatus of Fig. 2;

Fig. 5 is a top plan view of a rheostat embodying the teachings of this invention;

Fig. 6 is a view in section of the rheostat taken along the line VI—VI of Fig. 5; and

Fig. 7 is a schematic diagram illustrating the switching apparatus of this invention utilized as a regulator for controlling the voltage of a dynamo-electric machine.

Referring to the drawings and particularly to Figs. 1 and 2 thereof, this invention is illustrated by reference to the switching apparatus 10. The switching apparatus 10 includes a plurality of cooperating elements mounted on a base 12 of metal or any other suitable supporting material.

The switching apparatus 10 comprises a plurality of movable contact member assemblies 14 and a fixed contact member 16 secured in operative assembled relation on a substantially cylindrical supporting member 18 of insulating material such as fibrous material impregnated with a synthetic resin. The supporting member 18 is secured to the base 12 by means of the screws 19. The movable contact assemblies 14 are similar and are disposed in spaced relation to each other about the outer surface of the supporting member 18, the surface of which has been machined to present suitably spaced and substantially flat portions for receiving the assemblies 14.

As illustrated in Figs. 1 through 4, each of the assemblies 14 include two movable contact mem-

bers formed of the contact buttons 24 and 26 secured to elongated leaf-spring members 28 and 30, respectively of suitable conducting material. As more clearly illustrated in Figs. 2 and 4, the spring members 28 and 30 are spaced apart and are secured adjacent one of their ends to an insulating block 32 as by means of rivets 34, the block 32 forming a connecting bridge for the elongated portions 36 and 38 of the insulating support for the spring members of the assemblies 14. The connecting bridge 32 is recessed with respect to the elongated portions 36 and 38 so that the leaf springs are positioned within the recess formed by the portions 36 and 38 and the bridge 32. The fixed end of each of the conducting spring members 28 and 30 are flared or bent outwardly from the bridge 32 to form the terminals 35 and 33, respectively, for connecting leads (not shown) thereto. The free end of each of the spring members 28 and 30 carry elongated soft iron members 37 and 39, respectively, the purpose of which will be explained more fully hereinafter.

The bridge 32 is also provided with an opening 40 of a size to receive a key 42 which is seated in a slot 44 provided around the cylindrical supporting member 18. The key 42 functions to prevent lateral motion of the assembly 14 with respect to the axis of the supporting member 18 and aids in positioning the assembly 14 when assembling the switch apparatus. In order to secure the respective assemblies 14 to the cylindrical supporting member 18, the elongated portions 36 and 38 are each provided with slots as at 46 and 48 for receiving set screws 50 and 52, respectively which are screwed into the supporting member 18. The strip 54 of insulating material is also provided for bridging the recess between the elongated portions 36 and 38, this strip aiding in protecting the spring members 28 and 30 when secured in position over the spring members by the set screws 50.

As more clearly illustrated in Fig. 4, an eccentric screw 56 is so disposed between the ends of the elongated portions 36 and 38 below the bridge 32 and secured to the supporting member 18 that when the set screws 50 and 52 are turned to permit relative movement between the assembly 14 and the supporting member 18, the assembly can be moved to the right or left by turning the eccentric screw 56. As each of the contact assemblies 14 is mounted in this manner, the operation of their associated eccentric screws 56 permits the adjustment of the spacing between the different assemblies 14.

The assemblies 14 also have a bridge 58 of insulating material disposed across the upper ends of the elongated portions 36 and 38 and secured thereto as by means of the screws 60 for carrying the adjustable set screws 62 and 64. The set screws 62 and 64 are operatively associated with the spring members 28 and 30 respectively, and are employed for limiting the movement of the spring members 28 and 32 as normally biased in the one direction. Guard or shield members 66 and 68 are also provided and so secured to the upper ends of the elongated portions 36 and 38, respectively, by the screws 70 as to form extensions thereon. These guard members are of magnetizable material and extend outwardly to the ends of the soft iron members 37 and 39 the purpose of which will be explained more fully hereinafter.

The fixed contact member 16 is formed of any suitable conducting material and is in the form of a ring secured about the upper end of the supporting member 18 by means of screws (not shown). The contact member 16 is positioned in operative relation with respect to the contact buttons 24 and 26 of each of the contact assemblies 14 and is disposed to be engaged thereby when the movable contact members are actuated to perform a switching operation.

Referring again to Figs. 1 and 2, an electromagnetic device is provided for initiating the actuation of the movable contact members into engagement with the fixed contact member 16. In this embodiment, the electromagnetic device comprises a core member 72 having a central portion 74 and four depending leg portions 76 connected thereto by the connecting yoke 78. The core member 72 is secured in operative position to the supporting member 18 by means of screws 79 disposed in spaced relation about the supporting member 18 to engage the depending legs 76 of the core member. A plate member 80 is provided as a base portion of the core member, the outer edge of the plate member 80 terminating in four depending leg members 82 so spaced about the periphery of the plate member as to cooperate with the lower end portions of the legs 76 to provide a tapered gap between the legs 80 and 76. This tapered gap is more clearly illustrated in Fig. 3 of the drawings.

A coil 84 wound on a bobbin 86 of insulating material is positioned on the central portion 74 of the core member and is disposed to be energized to establish a flux in the core member. In practice, a plate 88 of non-magnetizable material such as brass, is disposed between the central portion 74 and the legs 76 for strengthening the core and coil assembly.

The central core portion 74 and the base portion 80 of the core member 72 is provided with a central aligned opening 90 for receiving a shaft 92. The shaft 92 is retained in operative position in the core member by the ball bearing connection 94 disposed in the upper end of the central core portion 74, the race of the bearing being secured as by a press fit between the core portions 74 and the shaft 92. Another ball bearing connection 96 is secured to the shaft below the base portion 80 of the core member, the bearing connection 96 carrying a nut 97 in supporting position against the base portion 80 of the core member while permitting movement of the shaft 92 within the core member.

Referring to Figs. 2 and 3, an armature member is illustrated as secured to the lower end of the shaft 92. The armature member comprises

a central hub portion 100 and four outwardly extending leg portions 102 having upwardly extending ends 104, each of which is so curved and tapered as to fit into the tapered gap between the depending legs 82 and 76 of the core member 72 when the coil 84 is energized. In order to decrease the weight, the leg portions 102 of the armature member are machined to have openings 103 therein as illustrated in Fig. 3, a depending pin 105 being positioned on the base portion 80 of the core member for engaging the edge of one of the openings 103 to limit the movement of the tapered ends 104 of the armature member. When the coil 84 is deenergized, the pin 105 so limits the movement of the armature member that the narrow portion of the tapered armature end 104 is positioned in the wide portion of the tapered gap. As the coil 84 is energized, the magnetic pull on the armature end 104 increases to actuate the armature member to a position where the narrow portion of each of the armature ends 104 is within the narrow portion of its cooperating gap formed by the depending legs 82 and 76 of the core member.

As illustrated in Figs. 2 and 3, the armature member is retained in operative position and secured to the shaft 92 by means of the nut 106 which is threaded on the lower end of the shaft 92. In order to provide for returning the armature member to its deenergized position when the coil is deenergized, a coil spring member 108 is provided for biasing the armature member to its deenergized position. As more clearly illustrated in Fig. 3, the coil spring member 108 has one of its ends connected to a projection 110 on the nut 106, the other end of the spring member 108 being connected to a lug 112 which is adjustably secured as by means of the set screw 114 to a metallic band 116 which extends between and is secured to two of the legs of the supporting member 18. By loosening the set screw 114 and moving the lug 112 in a clockwise direction as illustrated in Fig. 3, the bias of the spring member 108 can be increased for applying a larger force to the armature member.

Referring to Figs. 1 and 2, at the upper end of the shaft 92 there is secured a spider member 118 disposed to be rotated as the shaft 92 is rotated. The spider member 118 is secured to the shaft in a friction fit as by means of the screws 120. The outer periphery of the spider member 118 comprises a ring member 122 which carries a plurality of permanent magnets 124 disposed in spaced relation about its periphery. The permanent magnets 124 may be secured to the ring member 122 by any suitable means such as by copper brazing. As illustrated in Fig. 2, two of the permanent magnets 124 are disposed in aligned relation for cooperating with each of the movable contact member assemblies 14 which are in spaced relation about the supporting member 18.

In operation, each of the movable contact member assemblies 14 are positioned about the supporting member 18 by so turning the eccentric screw member 56 referred to hereinbefore that when the coil 84 is energized and the armature member is moved due to the magnetic pull of the core member 72, the spider member 118 is also actuated to move in a clockwise direction, as illustrated in Fig. 1, whereby the permanent magnets 124 are also moved with respect to their associated movable contact assemblies to selectively attract the movable con-

tact members to effect a switching operation. In practice, the movable contact member assemblies 14 are so adjusted with respect to each other that as the permanent magnet assembly is moved in a clockwise direction, one of the spaced permanent magnet assemblies formed of the two spaced magnets will produce a magnetic pull on the soft iron extension 37 of its associated assembly 14 to actuate the contact button 24 into engagement with the fixed contact ring member 16. A slight additional movement in the clockwise direction will cause the spaced permanent magnet assemblies to be moved whereby the contact button 24 of the adjacent movable contact assembly 14 is actuated to engage the fixed contact ring member 16. Slight additional movements of the spider member 118 due to increased energization of the coil 84 will effect the sequential or progressive actuation of the first contact member 24 of each of the contact assemblies 14 about the supporting member 18 to sequentially engage the fixed contact ring member 16.

As the contact button 24 of the last contact assembly 14 is actuated to engage the ring member 16, a further movement of the spider member 118 actuates the two permanent magnets associated with the first contact member assembly 14 to attract the soft iron member 39 to actuate the contact button 26 of the first contact assembly 14 into engagement with the fixed contact member 16.

As the permanent magnets 124 are moved, the guard member 66 cooperates with the two permanent magnets associated with each contact member assembly 14 to short circuit the flux of the permanent magnets. That is, the guard or shield member 66, in effect, bridges its associated permanent magnets 124 and prevents a stray flow of flux to the soft iron extension 37 as the permanent magnets are moved in the direction to actuate the contact button 24 into engagement with the fixed contact member 16. Such bridging of the permanent magnets 124 associated with each contact member assembly 14 prevents premature actuation of the movable contact member 24.

As the permanent magnets 124 are moved into alignment with the soft iron extension 37, the flux of the permanent magnets is suddenly transferred from the guard or shield member 66 to the soft iron extension 37 exerting a sudden magnetic pull thereon and effecting a snap action of the contact button 24 towards its fixed contact member 16. The guard or shield member 68 functions similarly as the permanent magnets 124 are moved from alignment with the soft iron extension 39 of the contact button 26, in that the flux of the permanent magnets is suddenly transferred from the soft iron extension 39 to the guard 68 to effect a quick release of the contact button 24 from its engagement with the fixed contact member 16. It is, of course, understood that for the reverse movement of the permanent magnets 124 with respect to their associated contact member assembly 14, the reverse snap action is effected.

Further movement of the spider member will, in turn, effect a movement of the spaced permanent magnet assemblies whereby a sequential or progressive movement of the contact buttons 26 of the different assemblies 14 into engagement with the fixed contact member 16, is effected. All of the contact members 24 and 26 can, therefore, be actuated into progressive en-

gagement with the fixed contact member 16 by a very slight movement of the spider member 118, it being found in practice that a three degree movement of the spider member 118 will effect the 16 sequential switching operations which can be obtained where 8 of the contact assemblies 14 are utilized as illustrated in Fig. 1.

As the permanent magnets are moved in the clockwise direction, the permanent magnets associated with the first contact assembly 14 in the sequential operation releases the contact button 24 as the permanent magnets associated with the later contact assemblies 14 actuates its associated contact member 24 into engagement with the fixed contact member 16. Usually, the permanent magnets are so spaced and the contact assemblies 14 so adjusted that at no time during the operation of the switching apparatus is there an open circuit, at least one of the contact members 24 or 26 being in engagement with the fixed contact member 16. In Fig. 1, the contact members 24 of four of the assemblies 14 are illustrated as being attracted into engagement with the fixed contact member 16.

As the permanent magnets associated with each of the assemblies 14 is moved from the contact member 24 towards the contact member 26, the magnetic attraction of the permanent magnets on the soft iron member 37 decreases until the bias of the elongated spring member 30 overcomes the magnetic attraction and effects a separation of the contact members 24 and 16 and the spring member is actuated to a position where the set screw 62 prevents further movement of the movable contact member. As the coil 84 is deenergized, the coil spring member 108 effects a counterclockwise movement of the spider member 118, as viewed in Fig. 1, to return the spider member to its initial position.

In addition to the pin 105 which cooperates with the opening 103 in one of the legs of the armature member for limiting the movement of the armature, an adjustable stop 126 is pivotally secured to the yoke 78 of the core member as by means of the screw 128. A set screw 130 is provided for cooperating with the slot 132 in the stop, for setting the stop 126 at a predetermined position in the path of movement of the spider, and for limiting the movement of the spider when the coil is deenergized.

Referring to Fig. 7 of the drawings, the switching apparatus of this invention is illustrated as employed in a regulator for regulating the voltage of a dynamo-electric machine 134. In this instance, the dynamo-electric machine 134 is a generator having armature windings 136 and a field winding 138, the generator being driven by a suitable motor (not shown). As illustrated, one end of the field winding 138 of the generator is connected to a source of power (not shown) through a field rheostat 140, the other end of the field winding being disposed to be connected to the source of power through the contact assembly of the switching apparatus of this invention and a rheostat 142 provided with a plurality of taps corresponding to the number of movable contact members provided on the switching apparatus of this invention. The coil 84 of the switching apparatus of this invention is connected across the armature winding 136 and is disposed to be energized in accordance with a measure of the voltage of the generator, the variable rheostat 144 being provided in circuit with the winding 84 for limiting the current flow therethrough.

Assuming that the generator is driven at a

constant speed so as to provide a substantially constant generator voltage, if for any reason the generator voltage should vary from the predetermined constant voltage, the energization of the winding 84 is varied accordingly. In normal operation, the coil 84 is energized to effect a predetermined rotation of the spider member to position the permanent magnets 124 with respect to the spaced contact assemblies. In Fig. 7, the spaced contact assemblies are illustrated as having the movable contact members 1, 1'; 2, 2'; 3, 3'; 4, 4'; 5, 5'; 6, 6'; 7, 7'; and 8, 8'; respectively. When the winding 84 is energized, the permanent magnets are moved to effect the actuation of at least one of the movable contact members into engagement with the fixed contact members 16 to complete the field winding circuit through at least a portion of the rheostat 142. Thus assuming that the coil 84 is normally energized, the spaced permanent magnet assemblies are in a position, for example, where the movable contact member 1', 8 and 7 are actuated to engage the fixed contact member 16. The sections of resistance between the terminals 1 and 7 of the rheostat 142 are therefore connected in circuit with the field winding 138.

If the voltage of the generator is thereafter decreased as by reason of an increased load, the winding 84 is correspondingly so deenergized that the spring member 108 effects a counterclockwise movement of the spider member 118 and consequently a counterclockwise movement of the spaced permanent magnet assemblies 124 as viewed in Fig. 7 and the contact member 1' is disengaged from the fixed contact member 16. At the same time the permanent magnets associated with the contact assembly formed of contacts 6 and 6' are so moved as to actuate the contact member 6 into engagement with the fixed contact member 16 to short circuit the section of resistance between terminals 7 and 6 of the rheostat 142 and thereby effectively remove such section from the circuit with the field winding to effectively increase the energization of the field and consequently increase the voltage of the generator. Further movement of the spider 118 to progressively actuate the movable contact members 5, 4, and so on, to effectively remove the respective sections of the rheostat 142 from the field winding circuit may be necessary before the field winding is so energized as to increase the generator voltage to the predetermined constant value.

If for any reason the generator voltage should increase, assuming that the contact member 1', 8 and 7 are in engagement with the fixed contact member 16, the winding 84 of the switching apparatus is so energized as to effect a further clockwise movement of the spider 118 and the spaced permanent magnet assemblies carried thereby to effect a progressive movement of the contact members 2', 3', 4' and so on. As the contact members 2', 3' and 4' are actuated to progressively engage the fixed contact member, contact members 7, 8 and 1' are progressively biased to their open circuit position whereby additional sections of the rheostat 142 are progressively connected in circuit with the field winding 138 to decrease the energization of the field winding 38 and consequently effect a decrease in the generator voltage.

Referring to Figs. 5 and 6, this invention is illustrated as applied to a rheostat 146. The rheostat 146 is provided with a case formed of the side walls 148, the base 150 and a cover 152

for fitting thereover. Within the casing a supporting member in the form of a cylindrical body 154 of suitable insulating material, such as fibrous material impregnated with a synthetic resin, is secured to the base 150 of the case as by means of the screws 156.

Positioned about the external periphery of the supporting member 154 are a plurality of movable contact members each of which comprises the contact button 158 secured to an elongated leaf spring member 160. The one end of the leaf spring member 160 is secured to the supporting member 154 as by means of the conducting screws 162 which project through an insulating block 164 to within the cylindrical supporting member 154. The inner end of the screw 162 forms a terminal for the movable conducting member.

In this embodiment, each of the movable conducting members are alike and as in the embodiment illustrated in Figs. 1 through 4, a soft iron extension 166 is secured at the free end of the movable contact member. In this embodiment, a fixed contact member 168 in the form of a ring is also carried adjacent the top of the supporting member 154 disposed to be engaged by the contact buttons 158 of the movable contact members. The fixed contact member 168 is connected to one terminal of a resistance unit 172 by the conductor 169. Although in the embodiment illustrated in Fig. 6 only two of the movable contact members are illustrated, it is to be understood that each of the movable contact members is connected as by a conductor 170 in a predetermined manner to sequentially different sections of the resistance unit 172 which is carried on the base 150 of the casing.

An insulating plate 174 is disposed across and secured to the top of the supporting member 154 as by means of the screws 176, the plate member 174 having a central opening provided therein for receiving the shaft 178 of a manually operated actuating mechanism. As illustrated, a handle 180 is provided on the end of the shaft 178 external of the casing for turning the shaft 178, the other end of the shaft 178 being held in position within the casing as by means of the coil spring 182 and the nut 184 threaded on the end of the shaft 178. Within the casing and seating on the plate 174 is a hub member 186 which is secured to the shaft 178 in any suitable manner, the hub member 186 carrying an arm 188 which, in turn, carries a plurality of permanent magnets 190 for actuating the movable contact members in a predetermined manner. By tightening the nut 184 on the end of the shaft 178, a friction fit between the hub member 186 and the plate 174 is obtained whereby the operating handle and the permanent magnets 190 actuated by movement thereof are retained in any predetermined position to which the operating handle 180 is turned.

As illustrated in Fig. 5, the permanent magnets utilized in this embodiment are of a size to overlap two of the soft iron members 166 whereby at least one of the movable contact buttons 158 is always in engagement with the fixed contact member 168 and an open circuit condition will not exist. When the operating handle 180 is turned in a clockwise direction as illustrated in Fig. 5, the magnetic pull of the overlapping permanent magnet 190 sequentially actuates the movable contact members into engagement with the fixed contact member 168 to progressively connect or disconnect additional sections of the

resistor 172 from any given circuit (not illustrated) depending upon the direction the handle 180 is turned and the sequential manner in which the conductors 170 are connected to the sections of the rheostat 172.

By employing this invention, it is evident that a switching operation may be effected in an efficient manner, substantially no friction being encountered in performing the switching operation. Instead the switching operations are performed directly by energy applied for effecting the switching operation, the work necessary for performing the switching operation being substantially constant. Further with the switching apparatus illustrated in Figs. 1 through 4, a plurality of switching operations may be obtained in a predetermined manner with very little movement of the actuating mechanism.

Although this invention has been described with reference to a particular embodiment thereof, it is, of course, not to be limited thereto except insofar as is necessitated by the scope of the claims attached hereto.

I claim as my invention:

1. In a switching apparatus, in combination, a plurality of movable contact members disposed in spaced relation to one another, a fixed contact member disposed to receive the movable contact members, a permanent magnet disposed to be actuated along a predetermined path, and means for moving the permanent magnet, the permanent magnet effecting a movement of the movable contact members to engage the fixed contact member in a predetermined sequence, the permanent magnet also being of a size sufficient to overlap two of the movable contact members as the magnet is moved along the predetermined path to maintain at least one of the sequentially movable contact members in engagement with the fixed contact member at all times during a movement of the magnet.

2. In a switching apparatus, in combination, a plurality of movable contact members disposed in spaced relation to one another, a support for each of the movable contact members, the supports being normally biased to maintain the contact members in an open circuit position but disposed to be actuated to move the contact members to a circuit closing position, a fixed contact member disposed to receive the movable contact members, a permanent magnet disposed to be actuated along a predetermined path, and means for actuating the permanent magnet, the permanent magnet having sufficient magnetic attraction to overcome the bias of the supports to effect a movement of the movable contact members in a predetermined sequence as the magnet is actuated along its path, the permanent magnet also being of a size sufficient to overlap two of the movable contact members to insure a closed circuit between at least one of the sequentially movable contact members and the fixed contact member at all times during movement of the permanent magnet along the predetermined path.

3. In a switching apparatus, a plurality of movable contact members disposed in spaced relation to one another, a support for each of the movable contact members, the supports being normally biased to maintain the contact members in an open circuit position but disposed to be actuated to effect a movement of the contact members to a circuit closing position, a member capable of being magnetically attracted associated with each of the movable contact members, a fixed contact member disposed to receive the

movable contact members, and means for magnetically attracting the members associated with the movable contact members in a predetermined sequence to actuate the supports and effect a movement of the movable contact members into engagement with the fixed contact member to effect a predetermined switching operation, the means comprising a supporting arm disposed to be actuated through a predetermined path of movement and a permanent magnet carried by the arm, the permanent magnet being disposed to magnetically attract the members associated with the movable contact members in a predetermined sequence as the arm is moved, the permanent magnet also being of a size to overlap two of the members associated with the movable contact members to insure the maintenance of a closed circuit between at least one of the sequentially movable contact members and the fixed contact member at all times during movement of the permanent magnet along the predetermined path.

4. In a switching apparatus, in combination, a plurality of movable contact members disposed in spaced relation to one another, the movable contact members also being arranged in a series of groups, a fixed contact member disposed to receive the movable contact members of the different groups, a permanent magnet associated with each of the groups of movable contact members and disposed to be actuated along a predetermined path, each of the groups being positioned with respect to its associated permanent magnet to provide a predetermined spacing therebetween, the spacing being progressively different for each group of the series, and means for simultaneously actuating each of the permanent magnets with respect to its associated spaced group of contact members, the permanent magnets effecting a movement of the movable contact members to engage the fixed contact member in a predetermined sequence as the magnets are moved.

5. In a switching apparatus, in combination, a plurality of movable contact members disposed in spaced relation to one another, the movable contact members also being arranged in a series of groups, a fixed contact member disposed to receive the movable contact members, a permanent magnet associated with each of the groups of movable contact members and disposed to be actuated along a predetermined path, and means for simultaneously moving each of the permanent magnets, the permanent magnets effecting a movement of the movable contact members to engage the fixed contact member in a predetermined sequence, the groups of the movable contact members and the permanent magnets associated therewith being so disposed that as the magnets are moved they effect a sequential movement of the first contact member of the series of groups before the sequential movement of the second contact member of the series of groups is effected.

6. In a switching apparatus, in combination, a plurality of movable contact members disposed in spaced relation to one another, the movable contact members also being arranged in a series of groups, a support for each of the movable contact members, the supports being normally biased to maintain the contact members in an open circuit position but disposed to be actuated to move the contact members to a circuit closing position, a member capable of being magnetically attracted carried by each of the supports, a fixed

contact member disposed to receive the movable contact members, a permanent magnet associated with each of the groups of movable contact members and disposed to be actuated along a predetermined path, means for simultaneously actuating each of the permanent magnets, the permanent magnets having sufficient magnetic attraction for the member carried by the support to overcome the bias of the supports and actuate the movable contact members to engage the fixed contact member, and adjusting means for each of the groups for positioning each group with respect to its associated permanent magnet that as the magnets are actuated they effect a sequential movement of the first contact member of the series of groups before the sequential movement of the second contact member of the series of groups is effected.

7. In a switching apparatus, in combination, a plurality of movable contact members disposed in spaced relation to one another, the movable contact members also being arranged in a series of groups, a support for each of the movable contact members, an adjustable means for mounting the supports of each of the groups to facilitate the positioning of any one of the groups independently of the others, the supports being normally biased to maintain the contact members in an open circuit position but disposed to be actuated to move the contact members to a circuit closing position, a member capable of being magnetically attracted carried by each support, a fixed contact member disposed to receive the movable contact members, a permanent magnet associated with each of the groups of movable contact members and disposed to be actuated along a predetermined path, means for supporting the permanent magnets, and an electromagnetic means disposed to be energized in a predetermined manner to actuate the support for the magnets to move them, the permanent magnets having sufficient magnetic attraction for the member carried by the support to overcome the bias of the supports and actuate the movable contact members to engage the fixed contact member, each of the groups being so adjusted and positioned with respect to its associated magnet that as the magnets are moved they effect a sequential movement of the first contact member of the series of groups before the sequential movement of the second contact member of the series of groups is effected.

8. In a switching apparatus, in combination, a plurality of movable contact members disposed in spaced relation to one another, the movable

contact member also being arranged in a series of groups, a support for each of the movable contact members, the supports being normally biased to maintain the contact members in an open circuit position but disposed to be actuated to move the contact members to a circuit closing position, a member capable of being magnetically attracted carried by each of the supports, a fixed contact member disposed to receive the movable contact members, two spaced permanent magnets associated with each of the groups of movable contact members disposed to be actuated along a predetermined path, means for simultaneously actuating the permanent magnets, the permanent magnets associated with each of the groups having sufficient magnetic attraction for the member carried by each support to overcome the bias of the supports and actuate the movable contact members to engage the fixed contact member, means associated with each of the groups to shield the members carried by the supports from the permanent magnets to prevent premature operation of the movable contact members, and adjusting means for each of the groups for positioning each group with respect to its associated permanent magnets that as the permanent magnets are actuated they effect a sequential operation of the first contact member of the series of groups before the sequential operation of the second contact member of the series of groups is effected.

9. In a switching apparatus, in combination, a plurality of movable contact members disposed in spaced relation to one another, a support for each of the movable contact members, the supports being normally biased to maintain the contact members in an open circuit position but disposed to be actuated to move the contact members to a circuit closing position, a fixed contact member disposed to receive the movable contact members, a permanent magnetic means disposed to be actuated along a predetermined path, and means for actuating the magnetic means, the permanent magnetic means being disposed to magnetically actuate the movable contact members sequentially to the circuit closing position as the magnetic means is actuated, the permanent magnetic means also being disposed to sequentially actuate a plurality of the movable contact members to and maintain them in a circuit closing position for any given position of the magnetic means along the predetermined path to insure the maintenance of a closed circuit between the contact members.

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