April 15, 1958 J. SCHAEFER 2,831,074

ELECTRICAL SWITCH AND CIRCUIT

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Fig. 1.

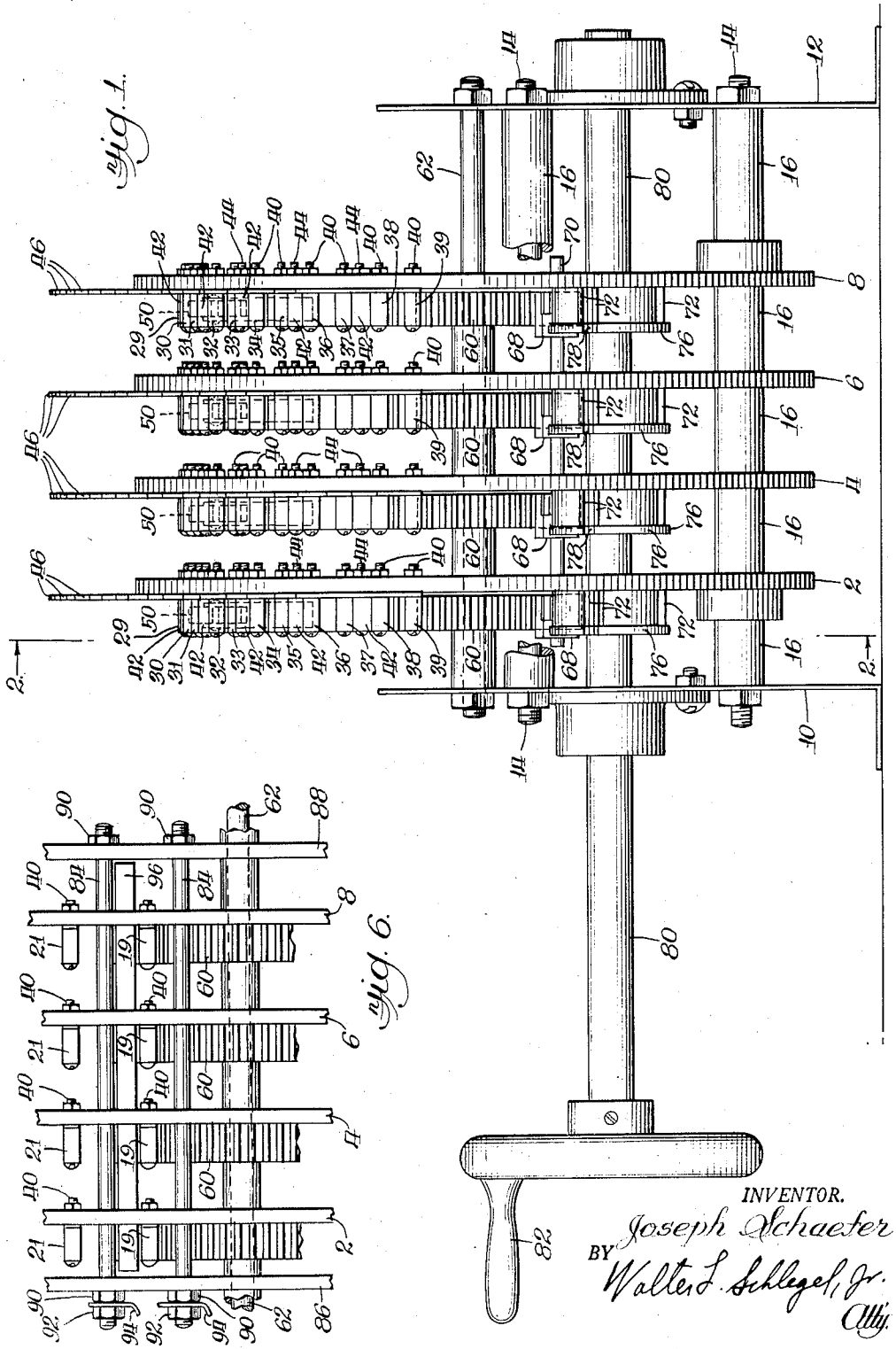

Fig. 9.

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Fig. 2.

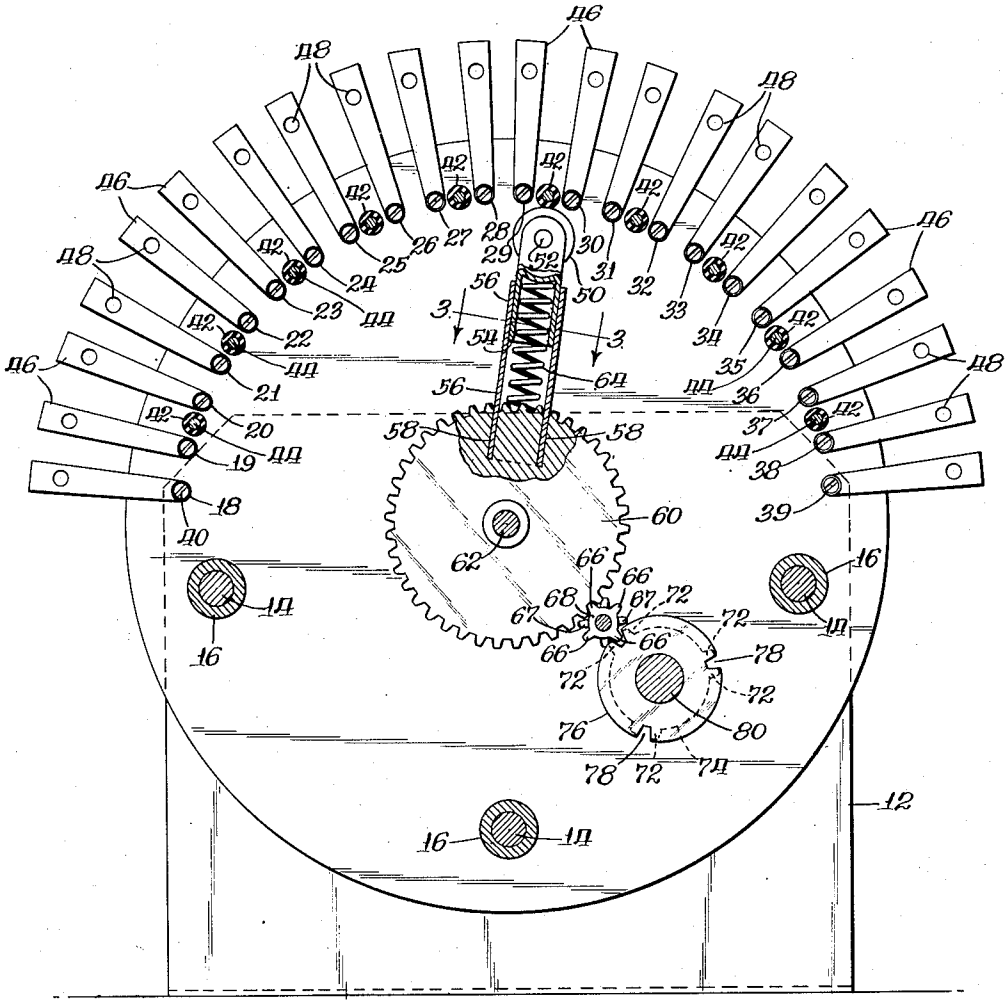

Fig. 4.

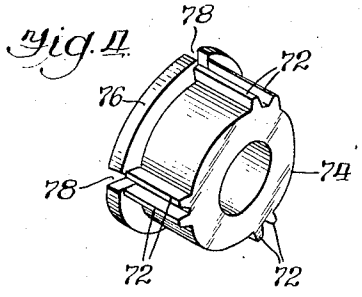

Fig. 3.

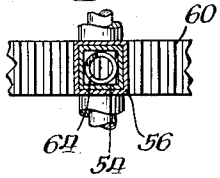

Fig. 5.

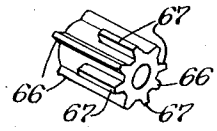

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Fig. 8.

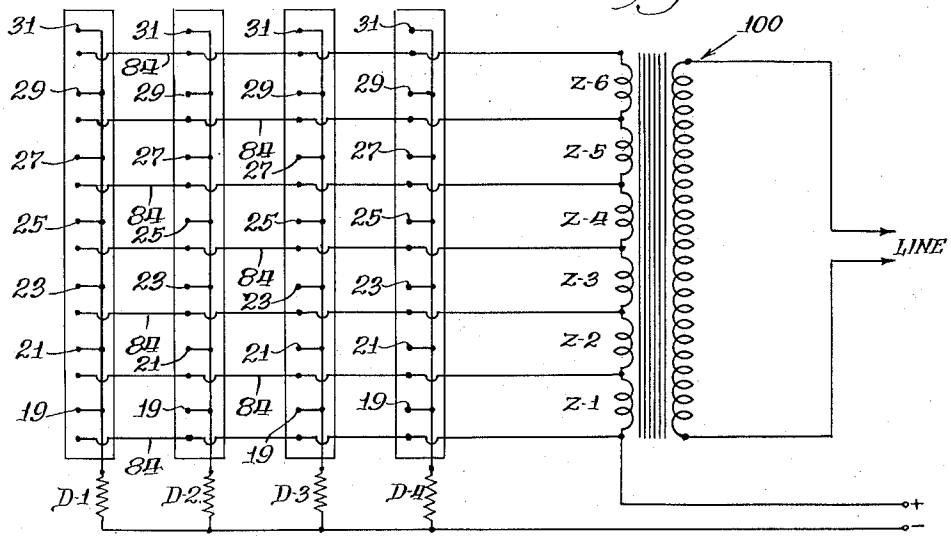
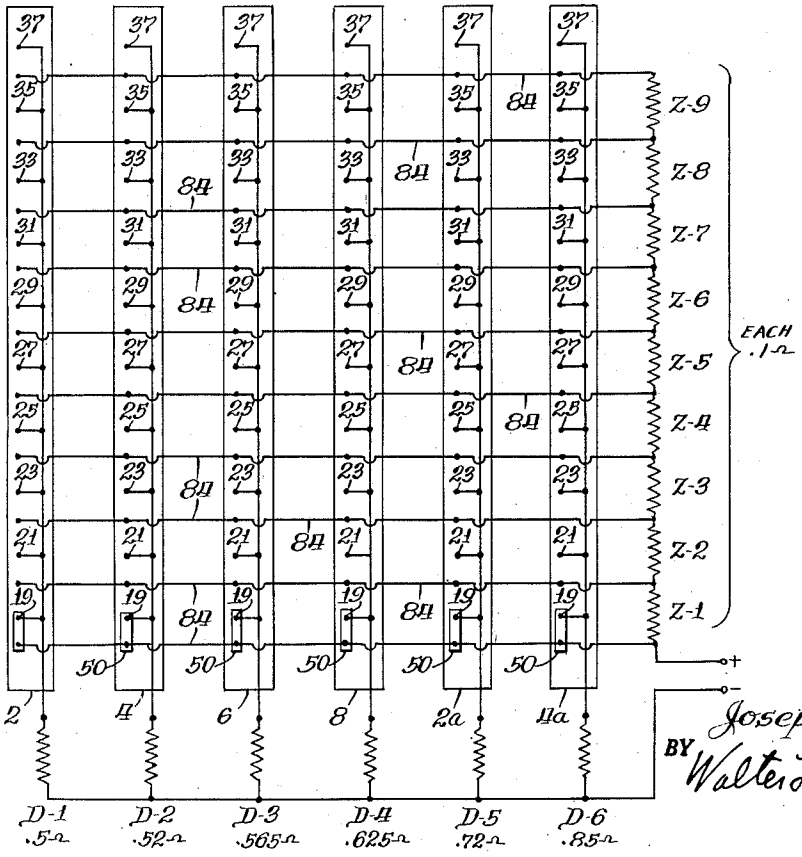


Fig. 7.



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2,831,074

ELECTRICAL SWITCH AND CIRCUIT

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Application January 11, 1954, Serial No. 403,312

11 Claims. (Cl. 200—9)

This invention relates to electrical circuits and more particularly to a novel impedance system wherein current at high voltages may be safely conducted across small contacts arranged to divide the current flow, and to a novel switch having a plurality of such contacts, certain of which are sequentially moveable to selectively energize devices in independent circuits associated therewith or to selectively control the voltage and current flow in one or more electrical circuits.

A primary object of the present invention is to devise a switch, such as above described, which is of economical compact, and sturdy construction capable of long life in service, and which utilizes a minimum number of parts to achieve the desired functions.

A more specific object of the invention is to provide a plurality of moveable contacts sequentially operable to open and close circuits through any desired number of fixed contacts associated with each moveable contact.

Another object of the invention is to devise moveable contacts in the form of rollers which are spring pressed to "make" position and which are locked in each "make" position thereof until positively actuated by an operator to a different "make" position.

Still another object of the invention is to afford an unusually compact switch, such as above described, wherein each moveable contact is rotatable to its various "make" positions.

A further object of the invention is to mount the spring associated with each moveable contact in a cage or barrel which is open at both ends, one end being removeably received within slots of an actuator gear, so that the spring seats against the gear and urges the moveable contact into tight engagement with related fixed contacts.

A different object of the invention is to devise an electrical impedance system for dividing current flow and directing such flow through a plurality of resistances in such manner as to accommodate selection of any desired total resistance.

The foregoing and other objects and advantages of the invention will become apparent from a consideration of the following specification and accompanying drawings, wherein:

Figure 1 is an end elevational view of a preferred embodiment of a switch embodying my invention;

Figure 2 is a sectional view on line 2—2 of Figure 1;

Figure 3 is a sectional view on line 3—3 of Figure 2;

Figure 4 is a perspective view of a drive gear or spool for one of the moveable contacts;

Figure 5 is a perspective of a pinion gear for transmitting driving force from a drive gear to its related actuator gear for a moveable contact;

Figure 6 is a fragmentary end view similar to Figure 1, but showing a modification of the switch;

Figure 7 is a wiring diagram of a novel rheostat circuit in which the switch is used as a sequential tap switch; and

Figure 8 is a wiring diagram of another novel circuit in which the switch is utilized as a voltage regulator for a transformer.

Describing the invention in detail, the novel switch comprises a plurality of insulator plates illustrated at 2, 4, 6, and 8, although any desired number may be utilized. These plates are mounted on side panels 10 and 12, as for example by three bolt and nut assemblies 14 having spacers 16 to maintain desired spacing between the plates.

Each plate carries pairs of fixed electrical contacts 18 to 39, respectively, in the form of cylinders anchored by screw and nut assemblies 40. Insulator cylinders 42, similarly anchored by screw and nut assemblies 44, are positioned between the pairs of fixed contacts and are preferably of larger diameter than the contacts for a purpose hereinafter discussed.

Each contact 18 to 39 is provided with a connector fin or blade 46 preferably compressed between the contact and its supporting plate by the associated screw and nut assembly 40. The blades 46 are perforated as at 48, to afford convenient connections to associated leads as hereinafter discussed in connection with Figures 7 and 8. It may be noted in this regard that corresponding contacts of the respective plates may be interconnected by such leads, or if desired all or any desired pairs of contacts may be independently connected to circuits which are to be separately energized and de-energized.

A moveable contact 50 is associated with the fixed contacts 18 to 39 of each plate 2, 4, 6, and 8, said contact 50 being preferably in the form of a roller rotatably mounted as at 52 on a plunger 54 received within a spring tube or cage 56 which is manually press-fitted within slots 58 of an electrically non-conductive actuator gear 60 rotatably mounted on a shaft 62. Gear 60 may be conductive if contact 50 is otherwise insulated from shaft 62, or if the contact 50 is itself connected to a lead and is used to close a circuit with each fixed contact. A compression spring 64 is compressed between the gear 60 and the plunger 54 to urge the roller contact 50 into tight engagement with the related fixed contacts.

Each gear 60 is actuated by teeth 66 and 67 of a pinion gear 68 rotatably mounted on a shaft 70. In the illustrated embodiment of the invention, the teeth 67 are mutilated, so that all teeth 66 and 67 mesh with teeth of the related gear 60, but only the teeth 66 mesh with three pairs of teeth 72 of a drive gear or spool 74 having a flange 76 comprising notches 78 aligned with the spaces between the respective pairs of teeth 72.

By means of this novel construction, two of the unmutilated teeth 66 of pinion gear 68 ride on the flange 76 locking the gear 68 against accidental rotation until one of the teeth 72 engages a mutilated tooth 67 whereupon pinion gear 68 is rotated 90° to actuate its roller contact 50 from a closed or "make" position with respect to one pair of fixed contacts 18 to 39 to a closed or "make" position with respect to the next adjacent pair of fixed contacts 18 to 39.

The gears 74 are keyed to a rotatable shaft 80 and are arranged, as best seen in Figure 1, so that the roller contacts 50 are preferably sequentially actuated. In the illustrated embodiment, 30° rotation of the shaft 80 actuates the roller contact 50 associated with one of the plates, for example plate 2. Rotation of the shaft 80 through another 30° increment in the same direction actuates the roller contact 50 of plate 4. Rotation of the shaft 80 through a third increment of 30° in the same direction actuates roller contact 50 of plate 6. Rotation of the shaft 80 through a fourth increment of

30° in the same direction actuates the roller contact **50** of plate **8**, etc.

Thus it will be understood that the shaft **80** is geared to each pinion gear **68** at a 3 to 1 ratio in the illustrated embodiment, so that one complete rotation of shaft **78** actuates each of the roller contacts **50** three times in a sequential relationship with respect to the other roller contacts **50**, although it will be understood that any desired ratio may be utilized.

The shaft **30** may be provided with a handle **82** or any other suitable actuating means (not shown) for manual or powered rotation of shaft **80** in both directions.

It may also be noted that as each roller contact **50** is actuated it rolls across one of the insulator cylinders **42** which separate the pairs of fixed contacts. For example, as shown in Figure 2, roller **50** has moved from its closed or "make" position relative to a pair of contacts **28** and **29** toward a closed or "make" position with respect to another pair of contacts **30** and **31**. However, the insulator cylinder **42** between contacts **29** and **30** positively prevents any possibility of a short circuit therebetween. This action may be accomplished, as illustrated, by providing insulators **42** of larger diameter than contacts **18** to **39** or by any other construction wherein the insulators **42** are closer than the contacts to the rotational axis of gears **60**.

The contacts of each plate **2**, **4**, **6**, and **8** may be regarded as a bank of contacts, with insulators **42** between the pairs of contacts in each bank.

Figure 6 shows a modification wherein one contact of each pair is integral with corresponding contacts of adjacent insulator plates. For example, a continuous contact rod **84** is substituted for the contacts **18** of Figures 1 and 2, and similar rods are substituted for contacts **20**, **22**, **24**, **26**, **28**, **30**, **32**, **34**, **36**, and **38** of the previous embodiment shown in Figures 1 and 2. The ends of these rods **84** are secured to a pair of insulator plates **86** and **88** as by nuts **90**, and one end of each rod **84** is provided with an additional nut **92** affording convenient means for attaching a lead **94**. Also in Figure 6, the insulator cylinders **42** are replaced by continuous insulator rods **96**, one of which is shown in this figure. All other parts of Figure 6 are identical with those of Figures 1–5 and are identified by corresponding numerals, although Figure 6 is fragmentary to illustrate the above described modifications of the switch shown in Figures 1–5.

The modification of Figure 6 is particularly adapted to the novel rheostat system shown in Figure 7, wherein it will be seen that the contact rods **84** are connected to resistances Z–1 to Z–9 arranged in series. These are preferably the main resistances and should be able to carry the full current in the rheostat.

In the diagram of Figure 7, the insulator plates are shown at **2**, **4**, **6**, and **8**, and two additional plates are shown at *2a* and *4a*. Dividing resistors D–1 to D–6 are connected in parallel with each other, each dividing resistor being connected to the fixed contacts **19**, **21**, **23**, **25**, **27**, **29**, **31**, **33**, **35**, and **37** of one insulator plate. The resistors Z–1 to Z–9 and resistors D–1 to D–6 are shown conventionally and may be simple resistors having fixed resistance values or may be conventional adjustable resistors which may be adjusted to any predetermined value. Within alternating current, reactors may be substituted for resistors to provided voltage or current regulation.

The system shown in Figure 7 depicts a 250 ampere load rheostat (25–250 volts) that uses a six plate sequential switch such as those shown in Figures 1–6. Resistance values are shown in the diagram by way of example, and it will be noted that in order to stay within the current rating of the contacts (nominally 50 amperes) it is preferable to taper the resistance values of the dividing resistors D–1 to D–6, as for example in the manner indicated in Figure 7.

The minimum resistance of the rheostat shown in Figure 7 is 0.1 ohm at step 1 whereat moveable contacts **50** connect the fixed contacts **19** to the related contact rod **84**. Under these conditions current flow across resistors D–1 to D–6 is respectively, 50 amps., 48 amps., 44 amps., 40 amps., 34 amps., and 29 amps.

At step 2 the moveable contact **50** of plate **2** connects the fixed contact **21** thereof to the related contact rod **84**, so that the total resistance in the rheostat is about .105 ohm which is the value of D–1 and Z–1 in series and in parallel with the value of D–2 to D–6 in parallel. Under these conditions current flow across Z–1 is 44 amps. and current flow across D–1 to D–6 is, respectively, 44 amps., 50 amps., 46 amps., 42 amps., 36 amps., and 31 amps.

At step 3 the moveable contact of plate **4** connects its fixed contact **21** to the related contact rod **84**, so that the total resistance in the rheostat is about .114 ohm which is the value of D–1 and D–2 in parallel and in series with Z–1, in parallel with the value of D–3 to D–6 in parallel. Under these conditions, current flow across Z–1 is 81 amps., and current flow across D–1 to D–6 is, respectively, 41 amps., 40 amps., 50 amps., 46 amps., 39 amps., and 34 amps.

At step 4 the moveable contact **50** of plate **6** connects its fixed contact **21** to the related contact rod **84**, so that the total resistance in the rheostat is .129 ohm which is the value of D–1 to D–3 in parallel and in series with **Z–1**, in parallel with the value of D–4 to D–6 in parallel. Under these conditions, current flow across **Z–1** is 119 amps., and current flow across D–1 to D–6 is, respectively, 42 amps., 40 amps., 37 amps., 51 amps., 46 amps., and 38 amps.

At step 5, the moveable contact **50** of plate **8** connects its fixed contact **21** to the related contact rod **84**, so that the total resistance in the rheostat is .148 ohm, which is the value of D–1 to D–4 in parallel and in series with Z–1, in parallel with the value of D–5 and D–6 in parallel. Under these conditions, current flow across Z–1 is 157 amps., and current flow across D–1 to D–6 is, respectively, 43 amps., 42 amps., 38 amps., 34 amps., 51 amps., and 44 amps.

At step 6, the moveable contact **50** of plate **2***a* connects its fixed contact **21** with the related contact rod **84**, so that the total resistance in the rheostat is .172 ohm, which is the value of D–1 to D–5 in parallel and in series with Z–1, in parallel with D–6. Under these conditions, current flow across Z–1 is 199 amps., and current flow across D–1 to D–6 is, respectively, 46 amps., 45 amps., 41 amps., 37 amps., 32 amps., and 51 amps.

At step 7, the moveable contact of insulator plate **4***a* connects its fixed contact **21**, with the related control rod **84**, so that the total resistance in the rheostat is .20 ohm, the value of D–1 to D–6 in parallel and in series with Z–1. Under these conditions, current flow across Z–1 is 250 amps., and current flow across D–1 to D–6 is, respectively, 50 amps., 48 amps., 44 amps., 40 amps., 34 amps., and 29 amps.

The above values are approximate, and successive steps in the rheostat would have the same current division and voltage values if the current is maintained at 250 amps.

The maximum total resistance value in the system of Figure 7 is reached when the sequential operation of contacts **50** finally engages all contacts **50** with the fixed contacts **37** and the related contact rod **84**, so that the total resistance value is 1.0 ohm, which is the value of D–1 to D–6 in parallel and in series with the value of Z–1 to Z–9 in series.

By proper adjustment of the resistance values and ratios of Z–1 to Z–9 and D–1 to D–6, the current in the contacts can be held to a maximum permissible value that they can safely make and break. The voltage across resistors D–1 to D–6 is the voltage which is broken by the contacts. Increasing the number of series resistors Z–1 to Z–6 (as for example by using all of the odd numbered contacts of Figures 1 and 2), and decreasing values

of D–1 to D–6 results in smaller voltage drop that the contacts must break.

In this manner, a heavy current rheostat may be provided with small contacts by subdividing the heavy current into a larger number of smaller parallel currents.

Figure 8 is similar to Figure 7, and corresponding parts are identified by corresponding numerals; however in the circuit of Figure 8, the resistors are replaced by transformer taps Z–1 to Z–6 of a conventional insulating or potential transformer 100 to produce a voltage regulator therefor. In this arrangement, four insulator plates and four dividing resistors D–1 to D–4 are used; however more may be added if desired. Similarly, the novel system may be utilized as a voltage regulator for an auto transformer.

What is claimed is:

1. A switch comprising a plurality of substantially cylindrical contacts having substantially parallel axes, said contacts being arranged in pairs, a movable substantially cylindrical roller contact simultaneously engageable at points spaced angularly about its rolling axis with the contacts of each pair, spring means for urging said roller contact against said first mentioned contacts, and means for moving said roller contact from pair to pair of said first mentioned contacts, said moving means insulating the roller contact against electrical conduction other than between said cylindrical contacts, the rolling axis of said roller contact being substantially parallel to said axes, whereby the roller contact is releasably locked in line contact with the cylindrical contacts of one pair by the action of said spring means.

2. A switch of the class described comprising a plurality of banks of fixed electrical contacts, the contacts of each bank being substantially cylindrical and being arranged in a plurality of pairs, moveable contacts associated with respective banks for selectively closing electrical circuits across the pairs of fixed contacts, each movable contact comprising a substantially cylindrical roller surface simultaneously engageable with the contacts of each related pair at points spaced angularly about the rolling axis of said surface, and means for sequentially actuating said movable contacts and for insulating them against electrical conduction other than between the related fixed contacts, the rolling axis of each movable contact being substantially parallel to the axes of its related fixed contacts, and spring means for urging each movable contact against its related fixed contacts, whereby each movable contact is releasably locked in line engagement with the fixed contacts of the related pair by the action of said spring means.

3. A switch of the class described comprising a plurality of spaced insulator plates, a plurality of pairs of fixed cylindrical contacts carried by each insulator plate, a movable contact having a substantially cylindrical surface associated with each insulator plate for interconnecting the fixed cylindrical contacts of each pair of contacts carried by said insulator plate, and means for sequentially actuating the moveable contacts of respective insulators and for insulating the movable contacts against electrical conduction other than between the related fixed contacts, the rolling axis of each movable contact being substantially parallel to the axes of its related fixed contacts, and spring means for urging each movable contact against its related fixed contacts, whereby each movable contact is releasably locked in line engagement with the fixed contacts of the related pair by the action of said spring means.

4. A switch of the class described, comprising an insulator carrying a plurality of fixed, substantially cylindrical contacts spaced from each other and arranged in pairs, a plurality of substantially cylindrical insulators carried by the first mentioned insulator and arranged one between each pair of said fixed contacts, a movable contact having a substantially cylindrical roller with its rolling axis approximately parallel to the axes of said fixed contacts and to the axes of said cylindrical insulators, the axis of each cylindrical insulator being closer to said rolling axis when engaged with said roller than the axes of the fixed contacts immediately adjacent said engaged cylindrical insulator, to prevent undesirable electrical contact as the roller rolls from one pair to another of said fixed contacts, and spring means for urging said roller toward said fixed contacts and toward said cylindrical insulators.

5. A switch of the class described comprising a plurality of spaced insulators, electrically non-conductive actuator gears associated with respective insulators and having toothed perimeters, spring cages recessed in said toothed perimeters of said actuator gears, respectively, a plunger in each cage, a spring in each cage compressed between the related plunger and the related gear, a roller rotatably mounted on each plunger, fixed contacts on each insulator approximately equidistantly spaced from the rotational axis of the related gear, said fixed contacts having arcuate surfaces engageable with the related rollers, and means for sequentially driving said gears comprising pinion gears meshed with said toothed perimeters of respective actuator gears, and driving gears operatively associated with said pinion gears.

6. A switch of the class described comprising a plurality of pairs of substantially cylindrical contacts arranged with their axes approximately parallel and approximately equidistant from an axis, a member rotatable on said axis, a roller interlocked with said member for rotational movement therewith, said roller having a substantially cylindrical surface, and spring means carried by said member for urging the roller surface along angularly spaced points thereof against the contacts of each pair as said member rotates and means for rotating said member and for insulating it against electrical conduction other than between the pairs of fixed contacts, the rolling axis of said roller being substantially parallel to the axes of said contacts, whereby the roller is releasably locked in line contact with one pair of said contacts by said spring means.

7. In a switch of the class described, a plurality of insulator plates, pairs of contacts carried by each plate, an actuator gear associated with each plate, a moveable contact actuated by each gear to selectively interconnect the contacts of the related pairs, and means for sequentially operating said gears comprising pinion gears having teeth, all of which are meshed with those of the respective actuator gears, alternate teeth of each pinion gear being mutilated, and a drive gear having at least one pair of teeth adapted to mesh with the other teeth of said pinion gear, the drive gear teeth associated with each pinion gear being misaligned with the drive gear teeth associated with the other pinion gears, whereby said actuator gears are sequentially actuated.

8. A switch according to claim 7, wherein each drive gear comprises a collar engageable with said other teeth of the related pinion gear to lock the latter against accidental rotation.

9. A switch comprising a plurality of spaced insulators disposed in substantially parallel planes, pairs of spaced substantially cylindrical contacts carried by each insulator and having their axes approximately normal to the plane thereof, cylindrical roller contacts associated with respective insulators, each roller contact having a substantially cylindrical surface simultaneously engageable at points spaced angularly about its rolling axis with the contacts of each related pair, and means for sequentially actuating said roller contacts, said last mentioned means insulating the roller contacts against electrical conduction other than between the related cylindrical contacts, the rolling axis of each roller contact being substantially parallel to the axes of its related cylindrical contacts, and spring means for urging each roller contact against its related cylindrical contact, whereby each roller contact is releasably locked in line contact with the cylindrical contacts of a pair by the action of said spring means.

10. In a switch of the class described, a plurality of fixed contacts arranged in a plurality of series, an actuator gear associated with each series, a movable contact actuated by each gear to engage the contacts of the related series, and means for sequentially operating said gears comprising pinion gears having teeth, all of which are meshed with those of the respective actuator gears, alternate teeth of each pinion gear being mutilated, and a drive gear having at least one pair of teeth adapted to mesh with the other teeth of said pinion gear, the drive gear teeth associated with each pinion gear being misaligned with the drive gear teeth associated with the other pinion gears, whereby said actuator gears are sequentially actuated.

11. A switch according to claim 10, wherein each drive gear comprises a collar engageable with said other teeth of the related pinion gear to lock the latter against accidental rotation.

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