July 30, 1968 P. A. DENES ETAL 3,395,316

ELECTRIC SWITCH WITH CONTACT PROTECTOR

Filed Feb. 17, 1966 2 Sheets-Sheet 1

FIG. 1.

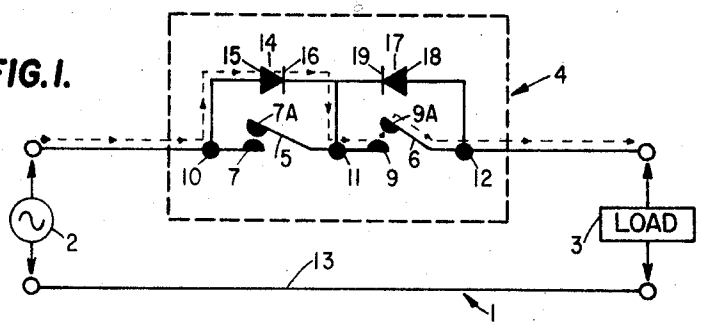


FIG. 2.

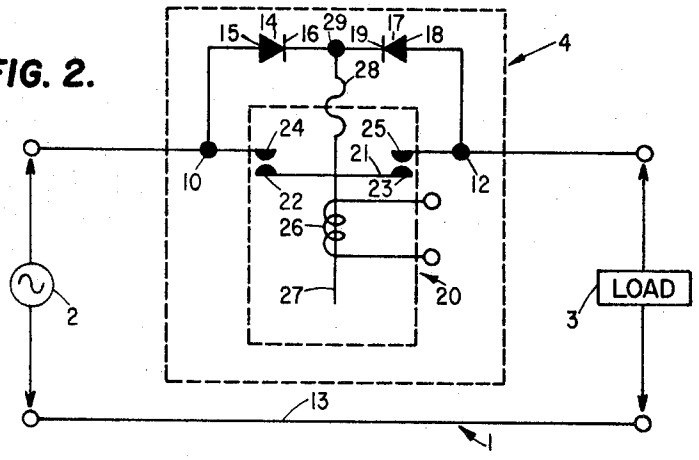
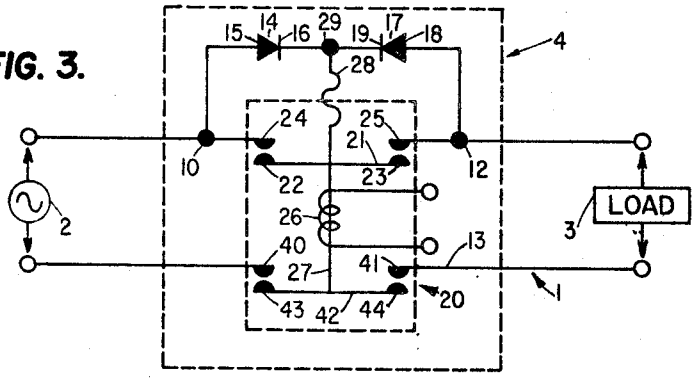


FIG. 3.



INVENTORS
PETER A. DENES
JOHN L. HAYDU
EUGENE S. LESZT
BY Thomas C. Schatzel

July 30, 1968 P. A. DENES ET AL 3,395,316

ELECTRIC SWITCH WITH CONTACT PROTECTOR

Filed Feb. 17, 1966 2 Sheets-Sheet 2

FIG. 4.

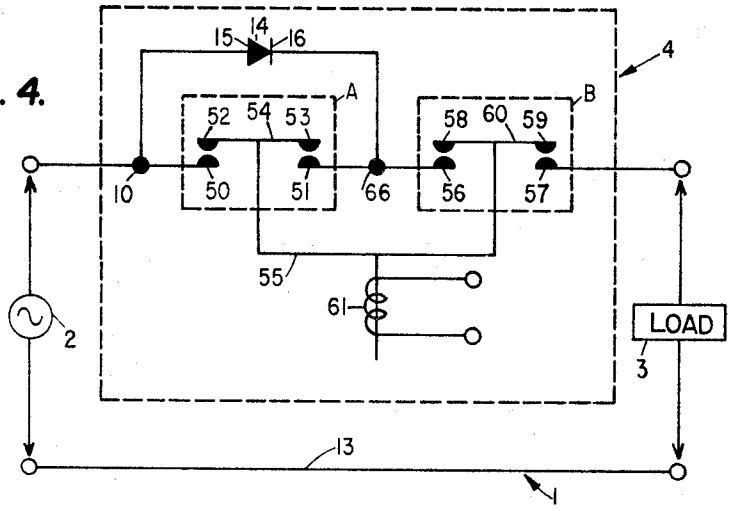
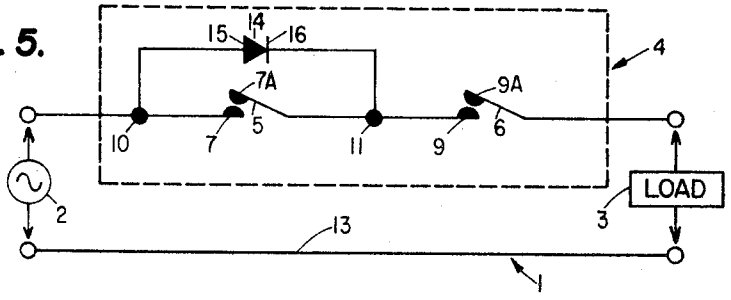


FIG. 5.



INVENTORS
PETER A. DENES
JOHN L. HAYDU
EUGENE S. LESZT
BY Thomas E. Schatzel

United States Patent Office 3,395,316
Patented July 30, 1968

3,395,316

ELECTRIC SWITCH WITH CONTACT PROTECTOR

Peter A. Denes, Albuquerque, N. Mex., John L. Haydu, Milwaukee, Wis., and Eugene S. Leszt, Alhambra, Calif., assignors to Allen-Bradley Company, Milwaukee, Wis., a corporation of Wisconsin

Filed Feb. 17, 1966, Ser. No. 528,288
2 Claims. (Cl. 317—11)

ABSTRACT OF THE DISCLOSURE

Contact protecting means for an A.C. electrical switch including double break contacts to form at least two air gaps in series. At least one unidirectional current conducting device arranged to shunt the opened controls in parallel with one gap and providing a low impedance path for one-half cycle of an A.C. current source and a high impedance path during the other one-half cycle.

The present invention relates to a combination of an alternating current switch with contact protecting means designed to close and open an electrical circuit path between an electrical source and an electrical load and to limit arcing between open switch contacts to a specified time. More specifically, the invention pertains to a switching means which when fully open establishes at least a double break with the path to form at least two air gaps in series and protecting means including a unidirectional current conducting device extending between the opened contacts in parallel with one gap and which unidirectional current conducting device provides a path shunting the associated gap, said path being of low impedance for one-half cycle of the alternating current source and of high impedance during the other one-half cycle.

Any given size alternating current electrical switch can switch "off" within a given time period, e.g. a half cycle only of a limited current value. The limit of the current is determined by the switch construction. Current values above the limit maintain an arc which frequently exists for a time duration of several half cycles. Such a long duration of an arc tends to deteriorate the contacts and frequently leads to complete switch destruction. Thus, it is desirable to substantially eliminate arcing or limit it to the shortest time possible—preferably to one or two half cycles. To extinguish the arc, prior art devices frequently utilize complex, space consuming arc chutes and other arc squelching arrangements. In some devices the contacts are opened a wide distance to distinguish the arc. However, this requires a large mechanical structure which consumes space and demands large amounts of energy for operation plus a sturdy mechanical structure to withstand the impact of the closing contacts.

The present invention provides a switch and unidirectional conducting device in combination in which arcing across a given pair of contacts is substantially eliminated or limited to a short time period. Depending on the embodiment, the arc may be eliminated within one or two one-half cycles of the power source. Advantages of this invention include a shorter distance between the opened contacts which aids longer contact wear and a smaller electromagnet for opening and closing the contacts when used in connection with an electromagnetic contactor. Thus, for a given application, the switch can be miniaturized and simplified over designs heretofore available.

In general, the present invention pertains to an electrical switching means designed to provide double break contacts with a center tap between the breaks. The double break arrangement provides a pair of air gaps in series upon operating the switching means to an open position.

To realize the double break, the switching means may include a pair of single break switches connected in series or a contactor having double break contacts actuated by an electromagnet. Such electromagnetic contactors are commonly used for repeatedly establishing and interrupting an electric power circuit. Shunting one or both air gaps of the switching means is a unidirectional conducting device. The device may be in the form of a power rectifier, such as a silicon or germanium diode. For example, if a diode is placed across each gap with the polarities of the diodes being opposite to one another, each diode alternatively provides a low impedance path around its associated gap on alternate half cycles of the power source. When the switch is operated to open the circuit, one gap is flanked by a low impedance path so that the associated contacts can initially open without current flowing therethrough, and thus without arcing or ionizing the gap. Concurrently, due to the high impedance flanking the second air gap, an arc may be formed across that gap causing it to be ionized. However, during the next one-half cycle, the previously ionized gap has a low impedance path around it though the associated unidirectional contacting device is now blocking the current, as is the associated gap which was not pre-ionized. Thus, the current will not flow during the second one-half cycle and arcing is substantially eliminated or limited to a one-half cycle of the source, depending on what point of the cycle the contacts initially open.

In the event the embodiment is designed such that only one air gap is flanked by a unidirectional path, arcing is substantially eliminated or limited to one-half cycle or two one-half cycles depending on whether the undirectional conducting device is conducting or blocking when the contacts are initially opened.

Another embodiment may include switching means designed such that the associated gaps differ in their respective opening time by one-half cycle. One gap is created during one-half cycle of the signal and the other gap during the next one-half cycle. In this embodiment a unidirectional conducting device across one gap will result in eliminating or limiting arcing to one-half cycle of the power source.

The foregoing features, advantages and mentioned embodiments of the invention will further appear in the description to follow. Reference is made in the description to the accompanying drawings which form a part hereof and in which there is shown by way of illustration and not of limitation specific embodiments in which the invention may be practiced.

In the drawings:

FIG. 1 is a schematic wiring diagram of a pair of single break switches designed to establish and interrupt an electrical circuit connecting an A.C. source with a load, each of said switches being flanked by a diode in accordance with the principles of this invention.

FIG. 2 is a schematic wiring diagram similar to FIG. 1, wherein an electromagnetic contactor with double break contacts is substituted for the switches of FIG. 1.

FIG. 3 illustrates a modification of FIG. 2 wherein provisions are incorporated to disconnect the reverse currents of the diodes.

FIG. 4 is a schematic wiring diagram illustrating an electromagnetic contactor having two contact arrangements in which the opening time of the arrangements differ by one-half cycle with respect to each other, one of said contact arrangements being flanked by a diode.

FIG. 5 is a schematic wiring diagram similar to FIG. 1, in which only one switch is flanked by a diode.

FIGS. 1–5 illustrate various embodiments incorporating the principles of the present invention. In each the electrical circuit is referred to by the general reference

character 1. The various embodiments are adapted for connection with an A.C. power source 2 and are loaded by an electrical load designated by a block diagram 3. Intermediate the source 2 and the load 3 is an interrupter network designated by the general reference character 4, which for illustrative purposes is surrounded by a broken-line diagram.

In FIG. 1, the interrupter network 4 includes a pair of single break switches 5 and 6. The switch 5 includes a stationary contact 7 and a movable contact 7*a*, whereas the switch 6 comprises a stationary contact 9 and a movable contact 9*a*. The contact 7 joins the source 2 at a junction point 10. The contact 7*a* is connected to junction point 11 as is the contact 9 of the switch 6. The contact 9*a* joins a junction point 12 common with one side of the load 3. The other side of the load 3 is connected to the source 2 by means of a line connection 13. Shunting the switch 5 is a unidirectional conducting device in the form of a diode 14. The diode 14 has an anode element 15 connected to the terminal 10 and a cathode element 16 connected with the junction 11. Shunting the switch 6 is a unidirectional conducting device in the form of a diode 17. The diode 17 has an anode element 18 connected with the terminal 12 and a cathode element 19 connected with the terminal 11. Though the embodiment illustrates use of a pair of unidirectional conducting devices in the form of single diodes, similar results may be realized through use of a single, double side diode.

The embodiment of FIG. 1 is designed such that upon simultaneous opening of the contacts of the switches 5 and 6, arcing is substantially eliminated or limited to one-half cycle of the A.C. source. For explanation of operation of the embodiment of FIG. 1, it should first be assumed that the switches 5 and 6 are closed to provide a continuous circuit path between the source 2 and the load 3. Upon opening of the switches the circuit path is interrupted. As will hereinafter become evident, the polarity of the power source signal when interruption initially occurs is immaterial. However, assuming that interruption occurs during the half cycle when the diode 14 is conducting, the diode 14 will provide during this half cycle, a low impedance path around the switch 5 between the terminals 10 and 11. Consequently, the current will elect the path of the diode 14 rather than attempt to cross the gap between the contacts 7 and 8. (Hereinafter the gap between the contacts 7 and 7*a* will be referred to as gap 7–7*a*, the gap between the contacts 9 and 9*a* as gap 9–9*a*, etc.) Thus, no arcing will occur across the gap 7–7*a*, and the air gap will not become ionized. At the same time, the diode 17 is blocking and offers a high impedance path around the switch 6. The path across the contacts 9 and 9*a* offers the least impedance and accordingly, an arc exists across the gap 9–9*a*. Also, as a result, the gap 9–9*a* will be ionized. To illustrate the current path when the diode 14 conducts, it may be assumed that the lowest impedance path between the source 2 and load 3 is that indicated by the broken line path illustrated in FIG. 1.

During the next one-half cycle, the diode 17 conducts and offers a low impedance path. During this half cycle, the diode 14 blocks as does the gap 7–7*a* since the gap was not pre-ionized during the previous one-half cycle. In order to break down an arc over an air gap which has not been pre-ionized, an extremely high voltage, e.g. approximately 2000 volts per millimeter is necessary. Thus, during the second one-half cycle, the arc is substantially non-existent as the path between the source 2 and the load 3 is "open" owing to the blocking of the diode 14 and the non-preionized gap 7–7*a*. During the third one-half cycle, though the diode 14 could conduct, the diode 17 and the air gap 9–9*a* are insulating. During the second one-half cycle sufficient time will have elapsed for the gap 9–9*a* to regain substantially its full dielectric strength. (It has been found that an air gap regains approximately 90% of its dielectric strength within 7 milliseconds which is less than one-half cycle of a standard 60 c.p.s. or 50 c.p.s. source 2.) Thus, the gap 9–9*a* is substantially de-ionized prior to the third one-half cycle and arcing will have been limited to the first one-half cycle.

The previous discussion has assumed the switches 5 and 6 to be initially opened when the diode 14 is conducting. However, the same results are realized if the switches 5 and 6 are initially opened when the diode 17 is conducting since the arrangement of the interrupter network 4 is symmetrical. In this case, the diode 17 initially provides a low impedance path and the diode 14 blocks. Thus, the gap 9–9*a* of the switch is substantially shorted and the gap 7–7*a* of the switch 5 may open under arcing conditions. During the next one-half cycle, the gap 7–7*a* is "shorted" by the diode 14 and the gap 9–9*a* blocks since it was not pre-ionized.

It may be noted that by extinguishing the arc by means of the diodes, the contact movement in creating the gaps 7–7*a* and 9–9*a* may be very short. With the present structure, the gap is only a function of the voltage applied to the switch, whereas in switch assemblies omitting the diodes, the gap is a function of both the voltage and current to be interrupted. Also, the longest time that the diodes will carry the current is only one-half cycle during the circuit interruption and consequently, they can be relatively reduced in size.

The embodiments of FIG. 2 is similar to that of FIG. 1 with the exception that the two switches 5 and 6 of the interrupter network 4 are replaced by a standard electromagnetic contactor diagrammatically illustrated as contained within the broken-line block diagram designated by the general reference character 20. Elements of FIG. 2 common with those of FIG. 1 carry the same reference numerals. The contactor 20 is a double-break contactor having a movable contact carrier in the form of a spanner 21 carrying a pair of contacts 22 and 23 and arranged to engage a pair of stationary contacts 24 and 25, respectively. Actuation of the movable contact spanner 21 and its contacts 22 and 23 is controlled by a solenoid comprising a coil 26 encircling an armature member 27 which is mechanically connected to the contact spanner 21. Actuation of the armature member 27 is controlled by excitation of the coil 26, which excitation may be supplied from an auxiliary source (not shown). Also joining the contact spanner 21 is a flexible electrically-conductive lead 28 arranged to provide a continuous electrical connector between the spanner 21 and a junction point 29. The lead 28 flexes responsive to movement of the armature member 27. The junction point 29 also provides a common connection between the lead 28, the diode 14 at the cathode 16 and the diode 17 at the cathode 19. The anode element 15 is tied to a junction point 10 which is electrically common to the contact 24 and one side of the A.C. source 2. The anode element 18 is tied to the junction point 12 which is electrically common to the contact 25 and one side of the load 3.

When the contactor 20 is in the "closed" state, the contact 22 engages the contact 24 and the contact 23 engages the contact 25. In the closed state the diodes 14, 17 and the flexible lead 28 are short circuited. When the contactor 20 is in the "open" state, i.e. a gap 22–24 exists between the contacts 22 and 24, and/or a gap 23–25 exists between the contacts 23 and 25, one of the diodes 14 or 17, depending on the instantaneous polarity of the source 2, is conducting and carrying current. Assuming that the contacts open when the diode 14 is conducting, the gap 22–24 opens without arcing and the gap 23–25 opens with consequent arcing. During the following one-half cycle when the diode 17 conducts, the arc across the gap 23–25 is extinguished and the current is interrupted. Since the gap 22–24 was not pre-ionized, it has full dielectric strength and no arc appears across it. Likewise the diode 14 is now blocking. During the third one-half cycle, the diode 17 is again blocking as is the gap 23–25, since as previously mentioned in connection with FIG. 1,

de-ionization is substantially accomplished within approximately 7 milliseconds, which is less than one-half cycle for a 50 c.p.s. or 60 c.p.s. power source. Again, since the arrangement of the contactor **20** and diodes **14** and **17** is symmetrical, arcing is also substantially eliminated or limited to one-half cycle if the diode **17** is conducting when the switch contacts initially open.

In an open state, a small reverse current may flow through the diodes **14** and **17**. In many cases, this small current is tolerable. If, however, complete switching "off" is necessary, a further interruption may be made in series with the diodes when the main contacts are "open." Such an arrangement is shown in the embodiment of FIG. 3 which is a modification of FIG. 2. All elements common to those of FIG. 2 carry the same reference numerals in FIG. 3. In FIG. 3, the electromagnetic contactor **20** carries an additional set of double break contacts interrupting the line **13** and including a pair of stationary contacts **40** and **41** and a carrier in the form of a contact spanner **42** carrying a pair of contacts **43** and **44**. The spanner **42** is mechanically joined to the armature **27**. The contact relationship between the contacts **40**, **41**, **43** and **44** is dependent on the excitation of the coil **26** and coincides with the relationship between the contacts **22**, **23**, **24** and **25**. If the contacts **22**, **23**, **24** and **25** are "open" the contacts **40**, **41**, **43** and **44** are likewise "open." Thus, there is no continuous path for reverse current between the source **2** and the diodes **30** and **31**.

FIG. 4 illustrates another embodiment of the present invention. It provides interruption of the electric current within one-half cycle or two one-half cycles using one diode in combination with a contactor which has its two contacts arranged in such a way that one contact opens about one-half cycle before the other contact. The arcing is limited to one-half cycle on each pair of contacts. In the embodiment of FIG. 4, the interrupter **4** includes an electromagnetic contactor carrying two double-break contact arrangements. The arrangements are designated by the broken-line diagrams A and B. The arrangement A includes a pair of stationary contacts **50** and **51** and a pair of movable contacts **52** and **53** which are joined by a contact carrier in the form of a contact spanner member **54**. The spanner **54** is mechanically joined to an armature member **55**. The contact arrangement B includes a pair of stationary contacts **56** and **57** and a pair of movable contact spanner member **60**. The spanner member **60** is mechanically connected to the armature member **55**. Movement of the armature member **55** is dependent upon the excitation of a coil **61**. The coil **61** may receive excitation from an auxiliary source (not shown). Shunting the contact arrangement A is the diode **14**. The anode **15** of diode **14** is connected to the junction point **10**, electrically common to the contact **50** and one side of the source **2**. The cathode **16** is connected to a junction **66** electrically common to the contacts **51** and **56**.

Assuming in the embodiment of FIG. 4 that "opening" of the contact arrangement B is delayed one-half cycle with respect to the opening of the contact arrangement A, the diode **14** will be conducting when the arrangement A initially "opens," no arc occurs across the gap **50–52** or the gap **51–53** since they are "shorted." The gaps **56–58** and **57–59** do not arc as they are not "open." In the next one-half cycle when the diode **14** is blocking and the contact arrangement B is "open," an arc across the gaps **50–52** and **51–53** is non-existent since they were not ionized during the previous one-half cycle. Also, the gaps **56–58** and **57–59** open without arcing because the diode **14** is blocking as are the gaps **50–52** and **51–53** since the current was interrupted within the first one-half cycle. If, on the other hand, the diode **14** is blocking when the contact arrangement A initially "opens," there may be an arc across the gaps **50–52** and **51–53**. However, the arc is substantially non-existent during the next one-half cycle when the diode **14** is conducting and the contact arrangement B is "open." The contact arrangement B may "open" with an arc. In the third one-half cycle, the contact arrangement A does not re-ignite because during the preceding half-time period de-ionization took place and it regained its dielectric strength. The diode **14** is blocking and hence no arcing takes place across the contact arrangement B. Consequently, arcing across the gap of any pair of contacts is substantially limited to one-half cycle and the gap recovers by de-ionization during the succeeding one-half cycle.

FIG. 5 is illustrative of another embodiment similar to FIG. 1 in which the two points of interruption may occur simultaneously, but in which only one gap is flanked by a unidirectional conducting device. In this arrangement arcing is substantially eliminated within one-half cycle or two one-half cycles depending on whether the unidirectional conducting device is blocking or conducting when circuit interruption initially occurs. Assuming the switches **5** and **6** "open" when the diode **14** is conducting, the gap **7–7*a*** is "shorted" so that it "opens" without arcing and consequent ionization. The gap **9–9*a*** "opens" with an arc. However, during the next one-half cycle, the diode **14** and the gap **7–7*a*** are both insulating and thereby no arcing will follow. If the diode **14** is blocking when the switches **5** and **6** initially "open," arcing may be realized across the gap **7–7*a*** and the gap **9–9*a*** so that both gaps will be preionized. During the next half cycle, the diode **14** "shorts" the gap **7–7*a***, thereby deionizing it. But arcing may be evident across the gap **9–9*a*** since it is not yet necessarily de-ionized. However, on the third one-half cycle, both the diode **14** and the gap **7–7*a*** are insulating so that arcing is limited to two one-half cycles of the signal source.

In the foregoing, discussion has been limited to single phase switching. However, it will be obvious to those skilled in the art that the invention can be used for multiphase switching.

In the illustrative embodiments, the switch and associated unidirectional conducting devices may carry more electrical components than presently known circuit interrupters. However, for a given application, the overall device according to this invention may be smaller, more economical and more reliable. The present device permits elimination of arc extinguishing plates and chutes and other arc extinguishing devices; a shorter contact distance between opened contacts; smaller electromagnets where electromagnetic contactors are used; smaller arc chambers owing to the smaller arc energies; less erosion of the contacts and longer life for a given switch.

We claim:

1. An electrical switch with contact protecting means for opening and closing an electrical circuit relationship between an electrical source and an electrical load comprising, in combination:

switching means including a double break contactor providing a first pair of contacts, a carrier carrying a second pair of contacts, and means for moving said carrier with respect to said first pair of contacts for alternatively establishing and interrupting the electrical circuit relationship between said first and second pair of contacts, said means providing a first air gap between one contact of said first pair of contacts and one contact of said second pair of contacts and a second air gap between the other of said contacts of said first pair of contacts and the other contact of said second pair of contacts when the electrical circuit is interrupted;

a first unidirectional electrical conducting device extending between and electrically shunting one of said air gaps when the circuit is interrupted, said unidirectional device being arranged to accept current from said source when the current is of one polarity and block current flow of the opposite polarity; and

a second unidirectional electrical conducting device extending between and electrically shunting the other of said air gaps when the circuit is interrupted, said second unidirectional device designed to accept cur-

rent of said source when the current is of one polarity and block current flow of the opposite polarity, the accepting and blocking states of the unidirectional devices being opposite to one another such that upon interruption of the circuit one of said unidirectional devices provides a low impedance path around the associated gap while the other of said unidirectional devices offers a high impedance path around its associated gap.

2. The electrical switch with contact protecting device of claim 1 in which the switching means includes an electromagnetic contactor and in which the means for moving said carrier comprises an armature and an electromagnet, said armature joining said carrier and said electromagnet, the excitation of said electromagnet determining the position of said armature and the circuit relationship between said first and said second pair of contacts.

References Cited

UNITED STATES PATENTS

1,669,493	5/1928	Slepian	317—11
2,201,595	5/1940	Szabo	317—11
3,223,888	12/1965	Koppelmann	317—11

FOREIGN PATENTS

638,981	7/1932	Germany.

MILTON O. HIRSHFIELD, *Primary Examiner.*

J. D. TRAMMELL, *Assistant Examiner.*