Jan. 4, 1966 J. T. L. BROWN 3,227,839

AND GATE DEVICES

Filed Jan. 24, 1964 2 Sheets-Sheet 1

FIG. 1A

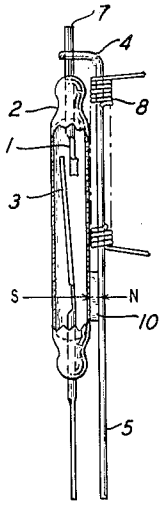


FIG. 1B

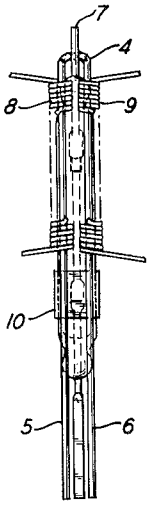


FIG. 2A

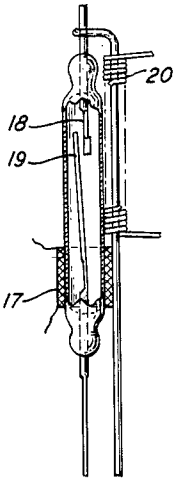


FIG. 2B

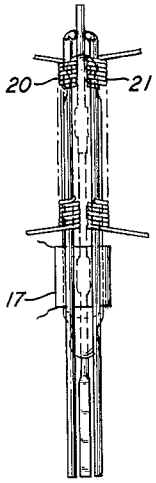


FIG. 1C

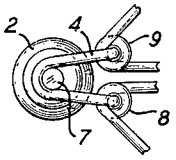


FIG. 3A

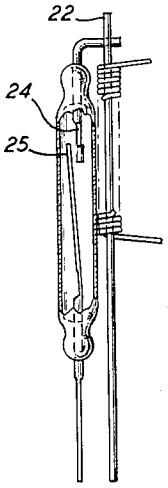


FIG. 3B

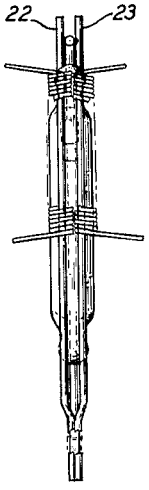


FIG. 4A

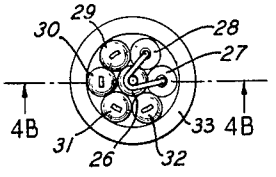
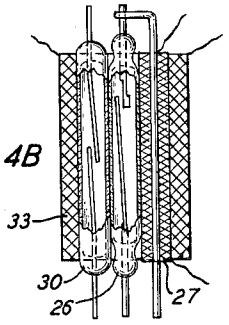


FIG. 4B



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FIG. 5

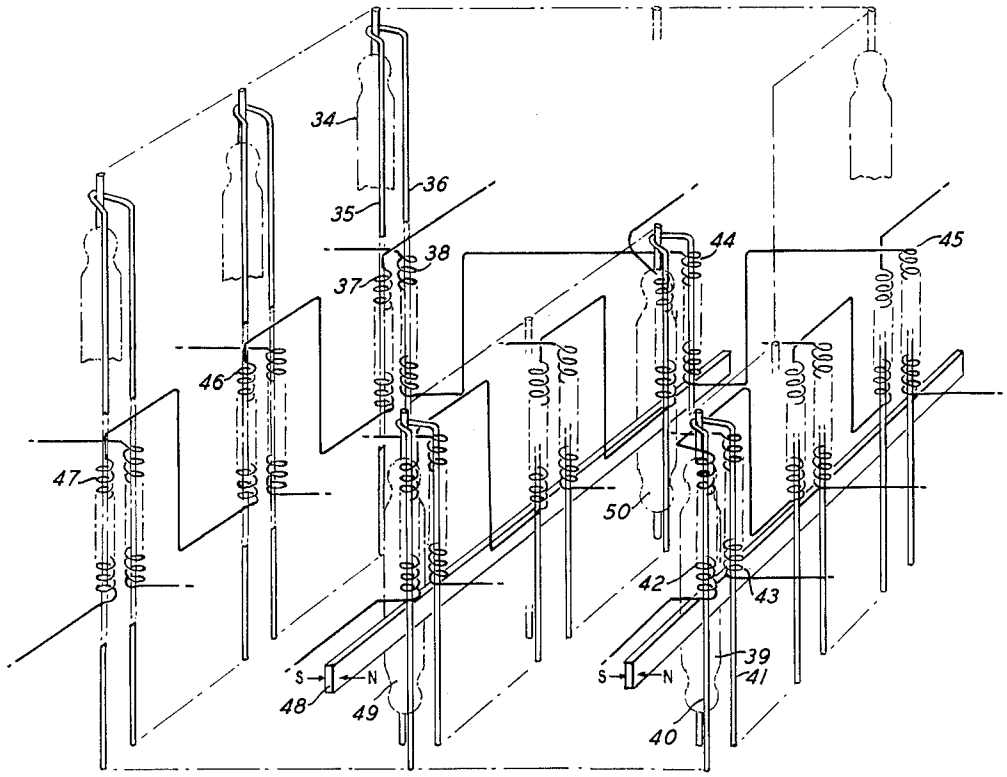


FIG. 6

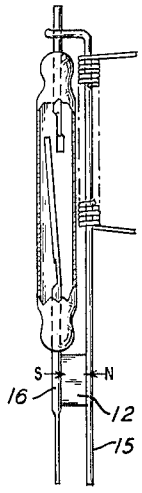


FIG. 7

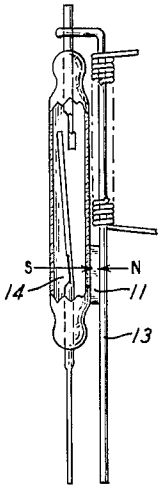
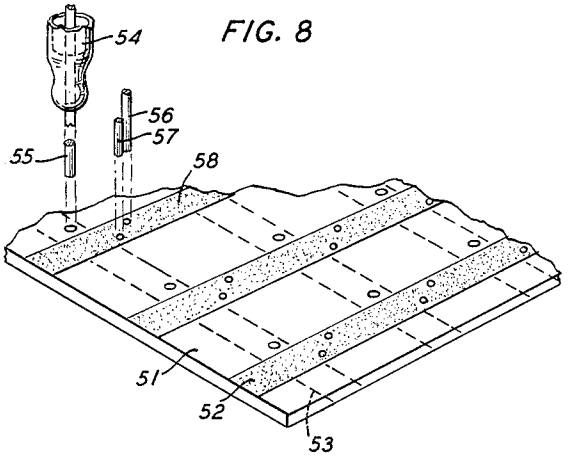


FIG. 8



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3,227,839
AND GATE DEVICES

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Filed Jan. 24, 1964, Ser. No. 339,982
8 Claims. (Cl. 200—87)

This invention relates to electromagnetic relays and particularly to the relays in which the contact maker is sealed in an atmosphere of inert gas in a glass tube, this contact means being inserted into the core of an energizing coil.

The object of this invention is to provide a reed switch crosspoint or AND gate which will be simple, efficient, small and economical having a plurality of input coils all of which must be energized simultaneously to trigger the operation of the contact maker sealed in the glass envelope. These units are small and compact and may be stacked in close array, such as in a crosspoint or coordinate system of contacts.

In accordance with this invention a device for providing AND gate operation is constructed by providing the reed contact means with a short pole piece and a comparatively long armature and affixing to the exterior portion of said pole piece a pair of magnetic cores in the form of wires laid in close proximity to the exterior surface of the glass tube in which the contacts are sealed. Thin walled or single layer energizing coils are then slipped over these wire cores whereby a relay is provided which will respond to the simultaneous energization of both said coils, will not respond to the separate energization of either of said coils and which will release in response to the reverse energization of either or both of said coils.

Means are provided to introduce sufficient magnetic force into the magnetic circuit of the device when the contacts are closed to hold or latch them in this position. Thus the contacts may be moved to a closed position by a short momentary or pulsed energization of the input coils and the closure of the contacts having been attained will be maintained by the latching means until a separate unlatching operation is performed. The magnetic force may be introduced by the use of a permanent magnet, by an electromagnet, or through remanence in the coil cores.

The reluctance of the magnetic circuit of the switch is lower when the contacts are closed than when they are open and the latching force, while sufficient to hold the contacts closed once they have been moved to that closed position, is insufficient to bring them together when they are parted.

A feature of the invention is the construction of the magnetic arrangement of the contact and core unit of the device in a multiple magnetic circuit configuration, the magnetic path of the normally open contact being arranged in parallel with the magnetic paths provided by the two or more cores of the input coils. These cores are constructed of small diameter wires and each has substantially the same magnetic characteristics as the magnetic path provided by the reed switch contact unit when its contact is closed. The two or more input coil cores being magnetically in parallel, one not energized provides a magnetic shunt for another so that when less than the total number of input coils are energized while the now higher reluctance reed switch magnetic path is open insufficient magnetomotive force is provided to cause the operation of this contact means. However, after this contact has been closed, the magnetomotive force provided by the latching means now drives a sufficient field in a magnetic circuit consisting of the closed contact reed

device in series with a path provided by the cores of the input coils in parallel with each other. Hence the energization of a single one of such input coils will provide this loop circuit with a sufficient force to overcome the latching force.

A feature of the invention is the use of small diameter coils about small diameter cores for the inputs of the device whereby the inputs have cross sectional dimensions substantially the same as the reed contact unit. From this feature of construction another feature is derived, the use of self supporting input coils requiring no cores or spool heads. Thus where the ratio of the inside to the outside diameter of the coil can be made large enough the coil becomes self-supporting, leading to an economical construction of the device. Where the coil constant N^2/R, the square of the number of turns divided by the resistance, is relatively high the effectiveness of the coil, that is the power required to produce a given number of ampere turns, becomes more favorable.

A feature of the invention is the use of permanent magnetic material in a thin strip placed between the ends of the cores and the end of the contact unit or even the exterior portion of the armature sealed in the glass envelope and being so magnetized that it is substantially poled in series with the cores and the armature. Conventional magnetic material available for this use comes in thin strips substantially one sixteenth inch in thickness, has some of the characteristics of rubber, is substantially flexible and may be magnetized so that one face is north and the other south, thus making a very short but very large cross sectioned magnet.

Another feature of the invention is the construction of the core and contact assembly as a unit. The armature forms one electrode of the contact means and the two wire cores (or either one of them) affixed to the pole piece forms the other electrode of the contact means. These wire cores are constructed of an alloy having substantially the same thermal expansion characteristics as the glass tubing in which the pole piece and armature are sealed. One conventional alloy of this nature having a very high curie point, where through heat it loses its ferromagnetic nature and becomes paramagnetic, has better than fifty percent of nickel and may be heat treated to have high permeability. For another form of the present invention, where, as will be explained hereinafter, latching is performed through the development of remanence, an alloy known as vanadium permendur and having close to fifty percent of cobalt may be heat treated to have a high coercive force while still having the desired thermal expansion characteristics.

A feature of the invention is the use of two coil cores lying side by side and separated only by a thin walled or single layer coil on each whereby the reluctance of one when the other is energized acts to substantially magnetically short circuit the other thereby reducing the intensity of the field available to operate the contacts to an amount insufficient for that purpose. Hence the contacts will not respond to the energization of either coil alone, but will respond when the two coils are simultaneously energized.

This principle may be extended to provide an AND gate having a larger plurality of inputs so that a device having, by way of example, three inputs may be constructed with three cores each covered by a single layer coil and affixed to the pole piece of the contact means and which will respond only when all three cores are simultaneously energized. Such a device may be used for a cubic crosspoint array.

Another feature of the invention is the use of a magnetizing coil placed in the magnetic circuit of the contacts which is connected in series with the electrical cir-

cuit of the contacts thereby providing a latching force which is effective so long as there is a flow of current through the said closed contacts. In accordance with this feature the latched contacts may be released by the stoppage of the flow of current through the contacts as well as by the reduction in the magnetic force used to latch the device.

Another feature of the invention is the construction of the operating input cores of hardened alloy whereby they are given a considerable value of coercive force and the contacts are latched by remanence. Again this remanent field is insufficient to move them into closed position once they have been parted.

In accordance with the last feature, the cores on which the input coils are placed are magnetically joined at each end to provide close coupling. If only one input coil is energized then a virtually complete magnetic circuit responsive to that one coil is formed by the core which is energized with a return path through the other so that there is little or no force for the magnetic reed contact. Such a configuration of cores insures that all the input coils must be simultaneously energized.

In addition to the magnetic joining of the input coil cores at both their ends, an increased close coupling may be achieved by slipping a copper tube constituting substantially a single turn winding over the grouped inputs of the device so that it is not only imperative that all inputs must be energized simultaneously to produce an operation of the contacts, but a release may be effected by an operation of any one of said input coils regardless of direction. Due to this close coupling it is only when all input coils are energized in the same direction simultaneously that any magnetomotive force is contributed to the magnetic circuit of the contacts.

Another feature of the invention is the formation of input coils for a plurality of units with a continuous length of wire whereby a network of coils may be constructed and into which the contact and core units may be inserted at a later stage or wherein a contact and core unit may be readily replaced.

Another feature of the invention is the construction of the contact and core unit wherein the cores are affixed to the external portion of the pole piece of the contact unit thus affording both an electrical closed circuit and a magnetic closed circuit at this junction of the cores and the pole piece thus providing a unit which may be placed in or replaced in the network of operating electrical circuit means without disturbing the latter. Thus the contact and core unit offers easy access to a complete operating device by a single one way movement by the insertion of the ends of the cores into the thin layer self-supporting windings for the energization thereof. In accordance with this feature, the two ends of the cores which are constructed to be in contact with each other are touching but not secured one to the other so that through resilience their ends may be pulled far enough apart to slip into the preformed energizing coils and will come together again to form the close coupling desired when latching is achieved through remanence.

Another feature of the invention resides in the use of a complete single contact unit for each contact to be closed. These switch units are small in size and, since the coils may be fabricated from a continuous conductor having self-supporting coils, a large number of these units may be stacked in close array. Since the single contact unit is economical to construct, it becomes a matter of economy to use a plurality of complete units rather than a more complicated construction to provide multiple contact operation.

Another feature of the invention is the use of the latching coil for encompassing and operating a plurality of slave reed switches. The AND gate switch along with a plurality of such slave switches are inserted in a coil which is then wired in series with the AND gate device so that when this is operated through the simultaneous energization of all its inputs the latching force provided serves also to operate the said slaves. Here again it may be noted that the number of inputs for the AND gate device and the number of slave switches operated by the latching coil is a matter of engineering, these numbers in principle being unlimited.

In accordance with the last named feature an arrangement alternative to the use of a separate AND gate device unit for each contact to be closed is provided. Thus a crosspoint device controlling four circuits in a cubic array may be provided. This may use the AND circuit device having three inputs exclusively for the control of the latching coil while the coil in turn controls the operation of four slave switches.

Other features will appear hereinafter.

The drawings consist of two sheets having thirteen figures, as follows:

FIG. 1A is a side view with the envelope partly broken away to give a clear view of the contact arrangement within, and FIG. 1B is a front view of the same AND gate device of the present invention of the type in which a small piece of permanent magnet is used for latching purposes;

FIG. 2A is a side view with the envelope partly broken away to give a clear view of the contact arrangement within, and FIG. 2B is a front view of the same of the AND gate device of the present invention of the type in which an additional coil wound about some part of the magnetic circuit is electrically connected in series with the contact means for latching purposes;

FIG. 1C is a top view of the device of the previously described figures showing how the ferromagnetic material for the cores of the input coils is wound about the external portion of the pole piece of the contact means and how the single layer input coils are wound about these cores;

FIG. 3A is a side view with the envelope partly broken away to give a clear view of the contact arrangement within, and FIG. 3B is a front view of the same AND gate device of the present invention of the type in which the cores of the input coils are constructed of hard magnetic material so that latching is achieved by remanence;

FIG. 4A is a top view and FIG. 4B is a section of an AND gate device in which the latching coil of FIGS. 2A and 2B is made large enough to accommodate not only the AND gate contact means and its plurality of input coils, but a plurality of sealed magnetic reed switches nested therewith whereby such slave switches may also be operated by the latching coil;

FIG. 5 is a schematic representation of a plurality of AND gate devices in a coordinate array, indicating how the contact and core devices may be slipped into the input coil after these self-supporting coils have been fixed in such crosspoint arrangement;

FIG. 6 is a side view similar to FIG. 1A showing how a piece of permanent magnet material may be placed to become part of the magnetic circuit of the device between the cores of the input coils and the external portion of the armature of the sealed reed contact;

FIG. 7 is a similar view showing how a thin piece of permanent magnet material may be placed further up along the cores of the input coils and against the outside of the envelope in which the contacts are sealed, and

FIG. 8 is a perspective view of a printed circuit plate with an indication of how the AND gate device may be fitted in to the conducting strips on the top and on the bottom of the plate of insulation in a coordinate arrangement.

The AND gate device of the present invention consists of a normally open contact means consisting of a pole piece 1 sealed into one end of an envelope 2 and an armature 3 sealed into the other end thereof. A piece of magnetic material 4, bent into a hair pin shape and having two legs 5 and 6 form cores for the input coils of the device. This core material is affixed, as by welding,

to the external portion 7 of the pole piece 1, whereby both a closed electrical circuit and a closed magnetic circuit is afforded between the ferromagnetic cores 5 and 6 and the pole piece 1. Each core is slipped into a thin walled or single layer coil 8 or 9 constituting the input coils for the device. Only when all the input coils are simultaneously energized will the normally open contact between the pole piece 1 and the armature 3 become closed. The coils 8 and 9 are constructed of wire having a thin layer of insulation thereon so that there is no electrical connection made, by way of example, between the coil 8 and the core 5. It may also be noted that the number of ferromagnetic cores affixed to the pole piece 7 may be larger than two, in the manner conventional in AND gate construction.

In order to provide AND gate operation whereby the contact of the device may be closed by pulse operation of the inputs and thereupon becoming latched in operated position, various means for latching the operated contacts are provided, the choice of such means being an engineering consideration. In FIGS. 1A, 1B, as well as FIGS. 6 and 7, the use of a thin piece of permanent magnetic material 10 is shown. This material may be of a thin rubber-like material, conventionally used in household appliances, and a strip as thin as one sixteenth of an inch will retain a permanent field sufficiently intense to latch the contacts in closed position. This material may be magnetized so that its opposite faces form the two poles of the magnet, as indicated in FIG. 1A and FIGS. 6 and 7, whereby this source of magnetomotive force is placed in series relation in the magnetic circuit including the armature and pole piece of the sealed contacts and the input cores.

The permanent magnet material 11 shown in FIG. 7 may be thin so as to be placed between the cores 13 and the envelope 14 of the contact unit, or may be somewhat thicker as the piece 12 shown in FIG. 6, and placed between the cores 15 and the external portion 16 of the armature. In both cases this source of magnetomotive force is effectively within the magnetic circuit of the AND gate device.

FIGS. 2A and 2B differ from the showing of FIGS. 1A and 1B in that for the permanent magnetic material used for latching purposes, a coil 17 interlinked with the magnetic circuit of the device is employed. This coil may be electrically connected in series with the contacts 18 and 18 so that when such contacts have been driven to their closed position by the simultaneous energization of the input coils 20 and 21, this coil 17 will become energized and will hold the contacts in their operated positions. This arrangement has the advantage that the AND gate device may be released by a simple opening of the circuit of the latching coil at any given point.

It may be noted that the cores 5 and 6 may be constructed of a magnetic material in the form of an alloy having nearly equal portions of nickel and iron, which may be heat treated to have high permeability, has a very high curie point and has thermal expansion characteristics substantially matching those of the enevelope in which the contacts are sealed.

In accordance with another form of the invention in which latching is achieved through remanence, the ferromagnetic cores may be constructed of a hard magnetic material, such as vanadium permendur, which has a high coercive force. Therefore, if the cores 22 and 23 are bent so as to come into physical contact one with the other at their free ends, a closed magnetic circuit is effectively formed when only one of the inputs is energized. In such circumstances there is little or no magnetomotive force to energize the contacts 24 and 25 and the remanence of the cores 22 and 23 will thereafter be in opposite sense. However, if the two coils are energized, the two cores 22 and 23 will act as one and since both are poled alike the remanent force afforded by the pair will be sufficient to hold the contacts 24 and 25 closed. These contacts may be closed by a reverse energization of the two input coils or by an energization of either in either direction. The two input cores may be merely sprung together at their lower ends so that they may be parted temporarily while the cores are being threaded into the coils. As a variation the entire device may be conventionally slipped into a piece of tubing, such as copper tubing, to substantially provide a single turn winding thereabouts to provide even closer coupling.

FIGS. 4A and 4B show a nest of a contact means 26 and its two inputs 27 and 28 together with four magnetic reed contact units 29, 30, 31 and 32 covered by a coil 33 which may be electrically connected in series with the contact unit 26. This contact may be operated through the simultaneous energization of the coils 27 and 28 so that the slave contact devices 29, 30, 31 and 32 will thereupon be operated.

The AND gate devices of the present invention are small and compact and may be stacked in close array, as indicated in the perspective schematic showing of FIG. 5, where the wiring of the input coils is shown as fixed and where some of the contact and core units are shown as poised above their input coils, and others shown in their final positions. Thus the contact and core unit 34 is shown about to be pushed downwardly with its cores 35 and 36 being inserted in their coils 37 and 38 respectively. At the other positions the contact and core unit, such as 39 with its cores 40 and 41, are pushed home with the cores fully inserted in the coils 42 and 43 respectively.

In this coordinate array each unit may have an input coil connected in a horizontal array, such as the coils 38, 44 and 45, and another input coil connected in what may be termed a vertical array, such as the coils 37, 46 and 47. To provide the latching, long strips of magnetizable material may be arranged in the array of AND gate devices, such as the strip 48, common to the units 49 and 50. FIG. 5 is schematic in nature and does not show any actual foundation to which the coils are fixed, but such means are conventional and not necessary to an understanding of the invention. Such a foundation may be constructed of a plastic and may have grooves cut therein to provide a positioning means for the strips 48 and 49. Below such plastic foundation there may be a slab of insulating material 51 (FIG. 8) having horizontal and vertical printed circuit strips 52 and 53 whereby the contact and core ends may be connected into a coordinate array when pushed home as the unit 39 in FIG. 5 is shown. In FIG. 8, a unit 54 is indicated with its armature 55 about to be pushed downwardly for electrical connection to the strip 53 of the printed circuit and its cores 56 and 57 about to be pushed downwardly for electrical connection to the strip 58 of the printed circuit. Firm electrical connections may be made in any conventional manner.

What is claimed is:

1. An electromagnetic AND gate device consisting of a sealed reed normally open contact device having an envelope with a pole piece sealed into one end thereof and an armature sealed into the other end thereof, a plurality of ferromagnetic cores affixed to the external portion of said pole piece, and affording both a closed electrical circuit and a closed magnetic circuit between said pole piece and each of said cores, an input coil wound about each said magnetic core, said input coils being constructed as single layer self-supporting coils into which said cores may be slipped whereby the reed unit may be replaced without disturbing the wiring connections to said input coils.

2. An electromagnetic AND gate device consisting of a sealed reed normally open contact device having an envelope with a pole piece sealed into one end thereof and an armature sealed into the other end thereof, a plurality of ferromagnetic cores affixed to the external portion of said pole piece and affording both a closed

electrical circuit and a closed magnetic circuit between said pole piece and each of said cores, an input coil wound about each said magnetic core said input coils being constructed of insulated magnet wire and herein self-supporting whereby said cores may be slipped into said coils and whereby the said reed unit may be replaced without disturbing the wiring connections to said input coils.

3. An electromagnetic AND gate consisting of a sealed reed switch normally open contact device having a cylindrical envelope with a ferromagnetic switch terminal emerging from each end thereof, two ferromagnetic cores of limited cross-sectional area, each connected electrically and magnetically to one of said switch terminals and physically positioned along and close to said switch envelope, a separate and individual input coil wound about each said core, whereby energization by direct current of either of said input coils alone will develop insufficient flux in the said magnetic circuit comprising said core and said reed switch to cause the operation thereof and further whereby simultaneous energization by direct currents in aiding polarity in both said input coils will develop sufficient flux in the said magnetic circuit comprising said cores and said reed switch to cause the operation thereof.

4. An AND circuit device as set forth in claim 3, characterized by the use of input core coils in the form of single layer cylinders.

5. An AND circuit device as set forth in claim 4, characterized by the use of wires for said input coil cores of a diameter closely approaching the inside diameters of said coils whereby said coils may be slipped in place over said cores.

6. An AND circuit device as set forth in claim 5, characterized by the construction in which both cores are affixed to the same switch terminal, whereby the fabricated unit consisting of the said switch and the two input coil cores affixed thereto may be slid in or out of position in two fixed coils.

7. An AND circuit device as set forth in claim 3, characterized by the use of magnetic material for said input coil cores having sufficient coercive force to hold said switch closed after operating input to both said coils is discontinued.

8. A group of AND circuit devices each as set forth in claim 4, characterized by a construction in which the corresponding coils of a set are in a continuous length of wire.

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J. J. BAKER, *Assistant Examiner.*