

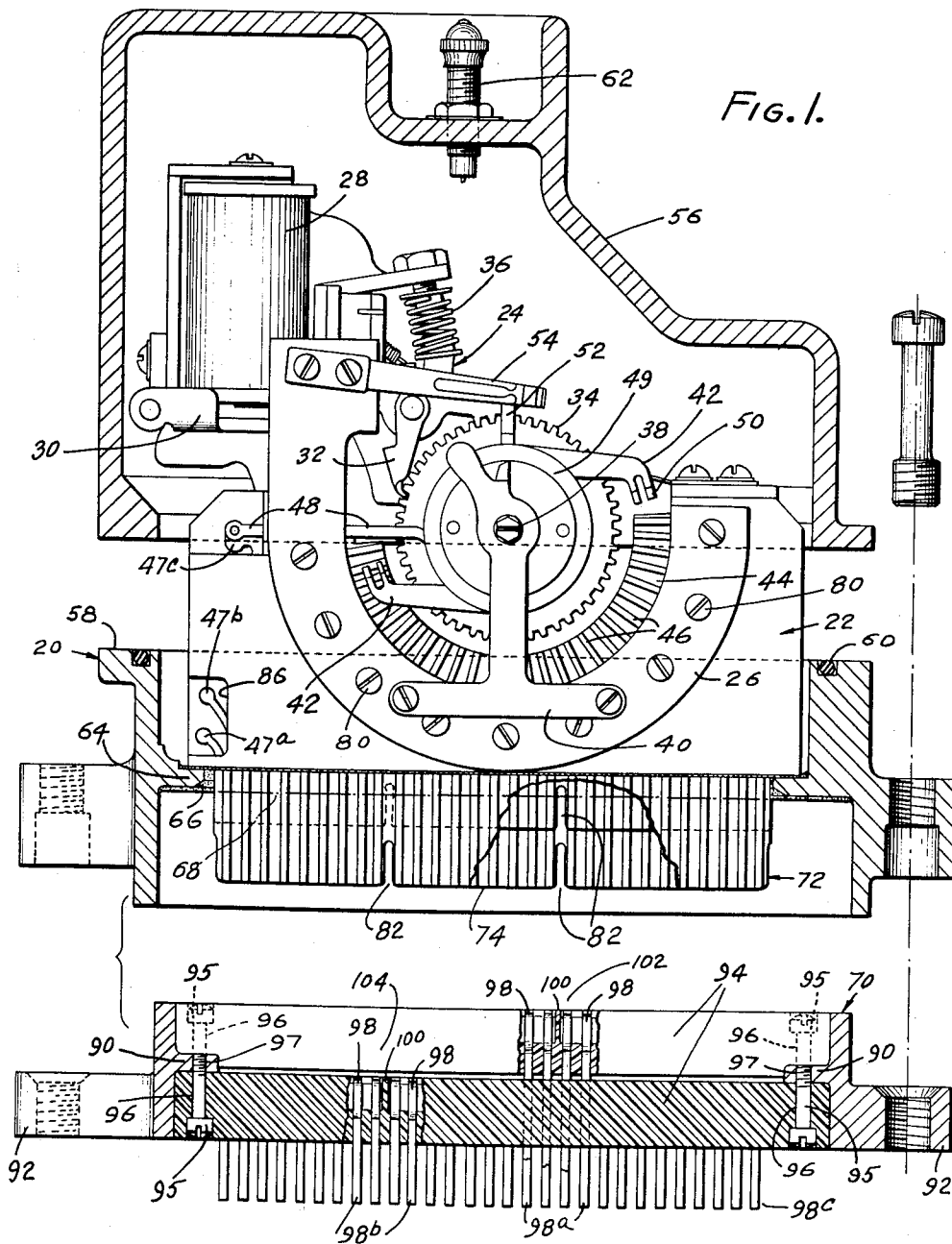
April 16, 1963

H. A. MCGEE
STEPPING SWITCH

3,086,096

Filed Feb. 5, 1957

4 Sheets-Sheet 1



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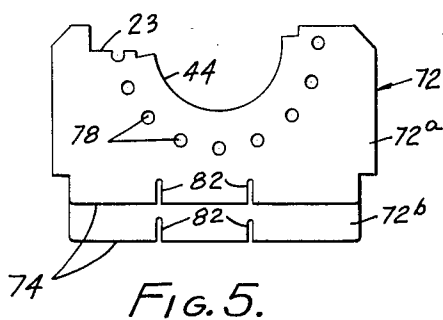
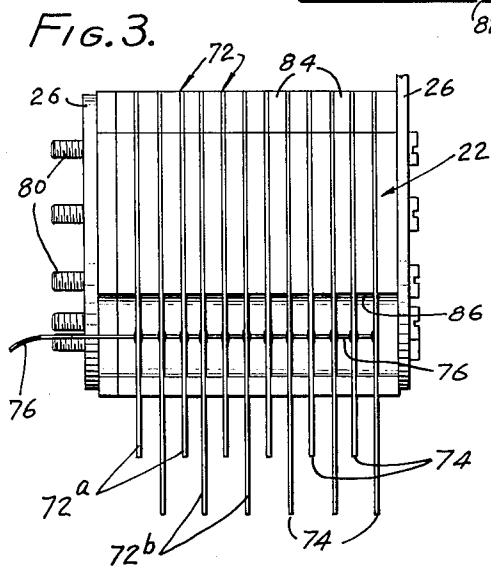
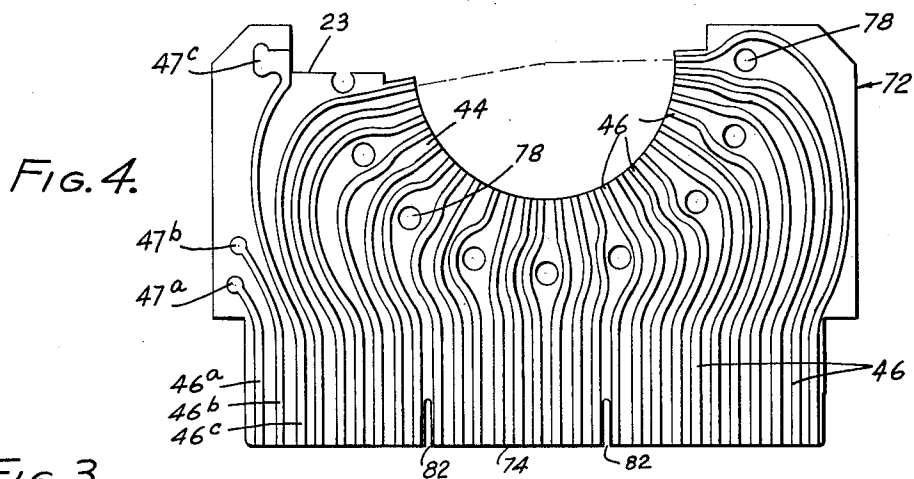
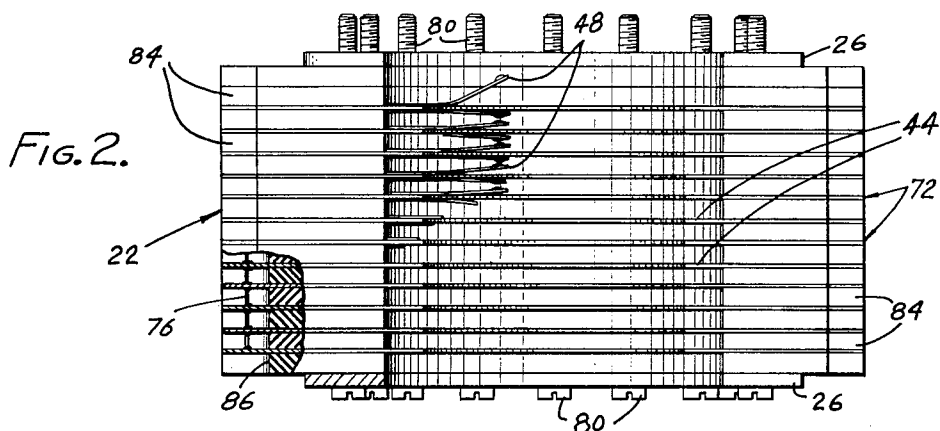
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4 Sheets-Sheet 2



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4 Sheets-Sheet 3

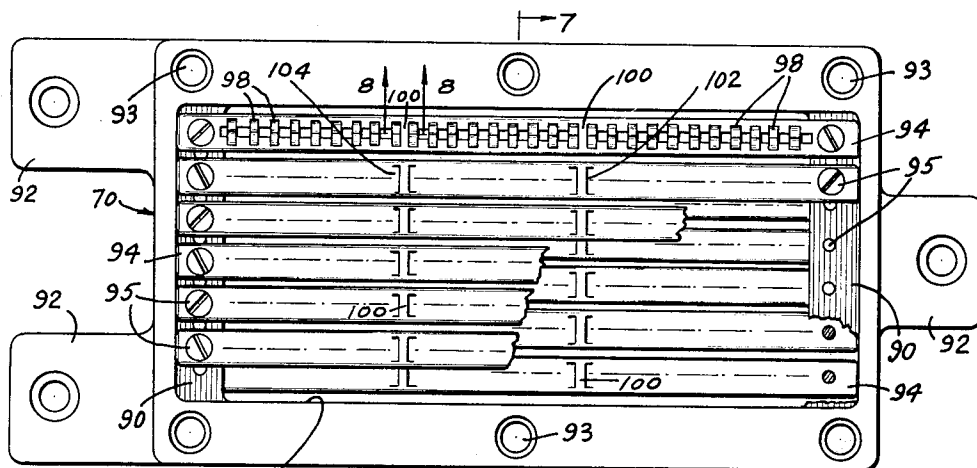


FIG. 6.

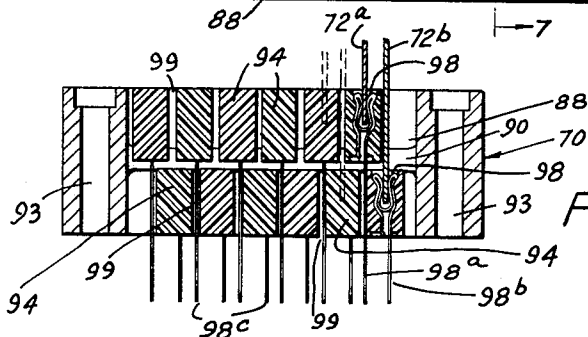


FIG. 7.

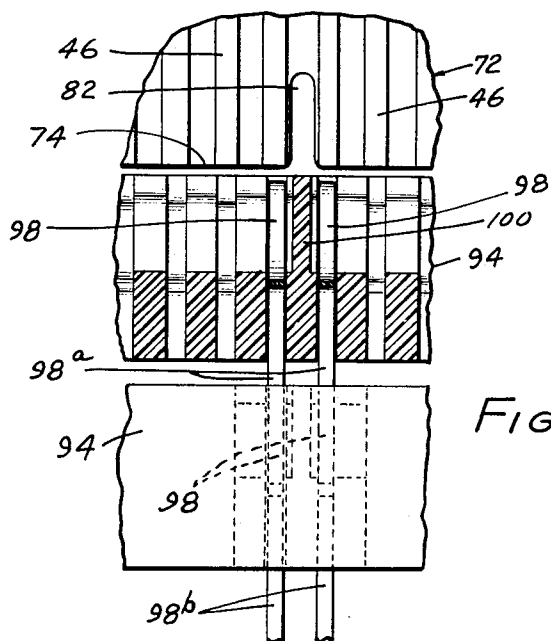


FIG. 8.

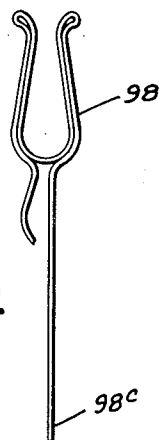


FIG. 9.

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3,086,096

STEPPING SWITCH

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15 Claims. (Cl. 200—105)

My invention relates generally to electrical switches, and more particularly to solenoid-operated stepping switches as used in the electrical communication art or other allied electronic fields.

Such solenoid stepping switches, as used in the prior art, were generally of a skeleton character with provisions for mounting on racks where any number of such switches could be mounted in side-to-side relationship without any provision being furnished for sealing or encasement.

Other disadvantages of such prior art stepping switches included the comparatively large dimensions of the insulating blanks supporting the contacts employed in such switches; the undesirability of assembling more than a comparatively few banks or rows of switch contacts due to space and weight limitations; the susceptibility of the contacts working loose from their respective blanks, thus interfering with the operation of the wiper blades; and the difficulties encountered in the replacement of defective switches due to the multiplicity of soldered connections made directly to the switch contacts.

The improvements to such stepping switches contemplated by my invention comprise, among others, means to encase and hermetically seal such switches from contaminating atmospheres; the use of printed circuit techniques in producing banks or rows of contacts which cannot work loose or away from their supporting structures; the provision of means in producing switches that employ printed circuit cards but which have a predetermined number of banks or rows of contacts in the same space as occupied in prior art switches; and plug-in connector means whereby a defective switch can be easily removed and simply replaced without the necessity of unsoldering and soldering a plurality of electrical connections.

For a better understanding of my invention together with other and further improvements and advantages thereof, reference may be had to the following description taken in connection with the accompanying drawings. While the invention is described with reference to certain specific embodiments thereof and with respect to the incorporation therein of certain combinations of features, it is to be understood that my invention may be embodied in other forms, many of which may incorporate only some of the improvements or features present in the specific embodiments of my invention described hereinafter.

In the drawings, wherein like reference characters denote like parts throughout the various figures:

FIGURE 1 is a partially exploded side elevation, partly in cross-section, of the complete stepping switch;

FIG. 2 is a plan view of the contact row block partly in cross-section, and showing some of the fixed wiper members carried thereby;

FIG. 3 is an end elevation of the contact row block;

FIG. 4 is a side elevation of one of the printed circuit cards furnishing the contacts of one bank or row;

FIG. 5 is a side elevation of two adjacent banks showing their staggered relationship;

FIG. 6 is a plan view, partly in cross-section, of the connector block;

FIG. 7 is an end elevation, partly in cross-section, of the connector block taken on the line 7—7 of FIG. 6;

FIG. 8 is an exploded view showing details of the invention;

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FIG. 9 is an enlarged side elevation of one of the individual terminal receptacles used in the connector block; and

FIGS. 10 to 13 inclusive are views of another embodiment of my invention.

Referring to FIG. 1, which discloses my improved solenoid-operated stepping switch, the base or supporting unit 20 supports the contact card block 22, which in turn supports and is surmounted by the stepping mechanism 24 of a conventional stepping switch. This latter part has actually been bodily lifted from a conventional commercial stepping switch and adapted to perform its usual functions in my improved switch. Being conventional, little time and effort will be spent in its description. Suffice it to point out that this stepping mechanism is generally supported by the end plates 26 and comprises a solenoid 28 with its movable armature 30. This armature carries the pivoted pawl 32 which meshes with and induces rotary motion in a counterclockwise direction only in the ratchet wheel 34. Return spring 36 is supported by the general framework of this stepping mechanism and operates to return the armature 30 to its unenergized position, thus moving the ratchet wheel one notch in the counterclockwise direction. Ratchet wheel 34 is affixed to a shaft 38 which is journaled in the shaft brackets 40, which in turn are affixed to the end plates 26.

Shaft 38 carries a plurality of rotary wiping arms 42 which contact their individual banks or rows 44 of electrical switch contacts 46. Electrical circuits are completed to the rotary wiping arms 42 by means of spring metal pole blades or stationary wiping arms 48 and slip rings 49. As is well known, there is a corresponding set of stationary wiping arms supplied for each set of rotary wiping arms. Electrical contacts 46 are connected to an external electric circuitry, as will be more clearly set forth hereinafter. It will be further noted that the wiping contacts 50 of the electrically connected rotary wiping arms 42 and the rows of electrical contacts 46 are so disposed that only one set of wiping contacts can contact the switch contacts at any one time. This disposition is to insure that of all the electrical circuits connected to the individual contacts of one bank or row of electrical contacts, only one circuit will be energized at a time.

Post 52 carried by shaft 38 is provided to coact with leaf switch 54 so as to close a circuit to produce an electrical indication when the wiping arms 42 are in a neutral, "home," or off-contact position.

Casing 56, which may be cast or formed of any suitable material, such as aluminum or magnesium, is formed to correspond in shape with the upper portion of the stepping mechanism 24. This casing may be secured to the base or supporting unit 20 by means of screws, bolts, or other suitable fastenings (not shown). The mating surface 58 of the supporting unit 20 is provided, as shown, with a sealing member 60. This sealing member may be an O ring, as shown, or may be any other form of suitable gasket for effecting an air-tight seal between the supporting unit 20 and the casing 56. Casing 56 is furnished with a Schrader type valve 62 which may be used to introduce any suitable gas, such as dry nitrogen, under pressure. Such gas under pressure not only serves to suppress sparking at the contacts, but effectively prevents moisture-laden atmospheric air or other contaminating gas at atmospheric pressure from seeping into the encased unit.

Base 20 is provided with a shouldering partition 64 which is apertured to receive the contact card block 22. A chamfer 66 is provided around the lower edge of the aperture in the partition 64 for the purpose of receiving a sealing material, such as certain types of suitable resins or plastics, which sealing material not only acts as an efficient seal, but also mechanically secures the entire

operating switch mechanism to the base 20. No other means of fastening has been found necessary, thereby effecting a considerable saving of weight and space usually devoted to more cumbersome mechanical fastenings. This sealing material covers the whole lower surface of the block 22, as indicated by the dash-and-dot line 68. The adherence of this plastic seal to the block 22 and to the shouldering partition 64 affords the sealing means and mechanical connection previously mentioned.

Connector block 70 is normally secured to an instrument panel and serves as a receptacle for the plug-in contact cards, as will be more fully described. Base 20 may be secured to connector block 70 by means of screws, bolts, or other types of quick-disconnect fastenings as may be found most suitable to effect the plug-in features of my improved stepping switch.

As shown particularly in FIGS. 1, 2, and 4, each bank or row 44 of electrical contacts 46 is formed on a printed circuit contact card 72. This printed circuit contact card comprises sandwich formation of a thin deposit of copper or other suitable metal laid on both sides of a sheet of fiber-glass or other suitable insulating material. The circuit layout is then photoengraved on both sides of the desired card configuration, which finally results, in this instance, with the remaining strips of copper laid out on both sides in accordance with the desired initial circuitry. In this case, the strips are so formed and disposed as to result in an arcuate row 44 of electrical contacts 46 adapted to be contacted by the rotary wiping arms 42. Other equivalent ways for printing the cards may be employed, such as actually brushing or painting the conductive strips onto the surfaces thereof. Furthermore, the electrical contacts 46 may be plated with rhodium or other similar metal for the purpose of resisting the normal wear occasioned by the wiping contacts of the rotary wiping arms 42. The remainder of the copper strips could be plated with gold, silver, or other suitable metal for superior electrical conducting qualities. The arcuate row 44 does not extend to a full half-circle. This configuration is required, as previously mentioned, so that wiping arms 42 which are diametrically opposite each other can contact only one circuit at a time in each bank.

It should be further noted that notch 23 is provided in the upper left-hand corner of each printed circuit contact card so that only one set of rotary wiping arms 42 is in contact with the card at any one time. Obviously, this provision results in a considerably decreased amount of friction occasioned by the wiping contacts of the rotary wiping arms 42 with the switch contacts 46.

At the lower edge of the card 72, the contact strips 46 terminate in a straight line or edge 74. It will be noted that the three strips on the left, 46a, 46b, and 46c, do not terminate on the arcuate row 44. Strip 46a terminates in a solder-connection point 47a. These points may be used for attachment of the necessary electrical connections to the solenoid circuit, the leaf switch 54, and other switching or relay means which may be connected into the mechanical functioning of the stepping switch. Strip 46b leads to solder-connection point 47b which may be used for a ground connection. Such ground connection is made by means of a wire or rod 76 extending through the cards and soldered to the connection points 47b, as shown in FIG. 3. Strip 46c terminates in solder-connection point 47c. The connection points on stationary wiping arms 48 are soldered or otherwise suitably connected to the solder-connection points 47c. It should be noted, therefore, that all electrical connections to the stepping switch are made through the electrical contact strips 46 at the lower straight edge 74 of the contact card. This arrangement and disposition of all electrical leads being brought through one, comparatively massive, effective sealing member simplifies the sealing problem and insures that the working members of the switch can be effectively sealed against exterior contamination.

Contact card 72 is further provided with proper holes 78 which match the corresponding holes in the end plates 26 and accept the screws 80 passing therethrough. The rear end plate 26 is preferably threaded to retain these screws 80. Contact card 72 is provided with two cut-out slots 82. As will be described later, these slots are used for precision alignment purposes. It will be seen from FIGS. 3 and 5 that these cards 72 are made in two heights. It should be reiterated that opposite sides of each contact are mirror images; in other words, strip 46c and solder-connection point 47c are backed up with a similar strip and connection point on the other side of the insulating sheet. Likewise each of the other strips 46 is duplicated on the two opposite surfaces of the card.

Block 22 is assembled from a plurality of contact cards 72 and insulating, or dielectric, spacers 84 held between the end plates 26. Twelve contact cards with the corresponding number of spacers are shown, but any number could be used as might be found desirable. It will be noted that alternate long and short cards are used. This staggered array with its corresponding form of plug-in connection enables printed circuit contact cards to be used without increasing the overall width or thickness of a multiple-bank stepping switch. For this reason, stepping mechanisms of prior art relays can be employed without change in dimensions. The spacers 84 are provided with semicircular cut-outs to match the end plates 26 and are also made with a notched cut-out 86 so that electrical connections can be made to solder-connection points 47b and 47c.

It can be appreciated at this point that contact card block 22 with its end plates 26 and shaft brackets 40 forms a very solid and compact support for the solenoid and associated moving parts. The whole unit is thus very sturdy and not affected by undue vibration or shock.

Furthermore, the printed card supported electrical contacts 46 are of much sturdier construction than the unsupported ones of the prior art and are not susceptible to being bent or otherwise misaligned so as to prevent the proper operation of the wiper arms 42.

Connector block 70, as shown in FIGS. 1 and 6 to 9, comprises a block casting of generally rectangular configuration. This block may be formed of any suitable metal or plastic substance. It possesses a rectangular aperture 88 and inwardly extending end abutments 90 formed in each end about midway through the aperture. External ears 92 are provided for securing the connector block to the base or support unit 20. Holes 93 are formed in the block for securing it to an instrument panel or other similar structure.

End abutments 90 serve as supports for a plurality of terminal receptacle strips 94 which are disposed in two layers, one above the abutments and one below the abutments. Suitable fastening means, such as screws 95, are provided for securing the receptacle strips 94 to the abutments. Clearing holes 96 are provided in the receptacle strips, and tapped holes 97 are provided in the abutments for this purpose. The number of terminal receptacle strips used corresponds to the number of contact cards assembled in the contact card block 22.

Each terminal receptacle strip 94 consists of an elongated strip of plastic or other suitable insulating material formed with apertures shaped to receive the individual terminal receptacles 98. These latter parts are formed of Phosphor bronze or other equally effective spring-like material and may be plated with nickel, silver, or gold, as may be desired. As shown in FIG. 7, these individual terminal receptacles are made in two lengths, as at 98a and 98b. This is done so that the terminal ends 98c will lie in a single plane for facility in making further electrical connections. Transverse ribs 100 are formed in the terminal receptacle strips 94, which are sized so as to accept the slots 82 in the contact cards 72.

With respect to FIG. 7, the individual terminal re-

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ceptacles 98 are so shaped as to receive the edge of the card 72 and make spring contact with the copper strips on each side thereof. The shorter cards 72a mesh with the upper row of terminal receptacle strips, while the longer cards 72b extend downwardly through the gaps 99 left between the strips in the upper row and mesh with the terminal receptacles in the lower row of receptacle strips. It can be easily seen that this staggering of the contact cards and the staggered double row of receptacle terminal strips provides a plug-in feature of great compactness.

Inasmuch as the individual terminal receptacles are spaced so as to coincide with the spacing of the copper strips at the edge 74 of the printed circuit card 72, the corresponding parts must be made to coincide exactly. This feature is accomplished by means of the ribs 100 formed in the terminal receptacle strips 94 and the slots 82 in the card 72. This positive means of coincidence is more clearly illustrated in FIG. 8. It will be noted further, in FIG. 6, that one transverse row 102 of ribs 100 is spaced a certain distance from one end of the connector block 70, while the other transverse row 104 of ribs 100 is spaced a differing distance from the other end of the connector block 70. This provision insures that the contact card block 22 with its cards 72 can be inserted in only one correct plug-in contact.

FIGS. 10 to 13 illustrate another embodiment of my invention, wherein the stepping mechanism of the stepping switch with its energizing solenoid is substantially identical with the corresponding parts shown in FIG. 1. In this embodiment, however, the casing is made up of plates and formed sheet metal. Sheet metal cover 106 is secured to base plate 108 by means of lugs and screws 109. A rubber gasket 107 is provided around the generally rectangular lower edge of the cover 106 to afford efficient sealing means between the cover and its supporting plate 108 and sealing plate 112. Cover 106 is provided with a Schrader type valve (not shown) for introducing gas or dry air under pressure. The stepping mechanism 24 is supported by sheet metal brackets 110 affixed to the base plate 108 by screws 111. Screws 113 fasten the stepping mechanism 24 to the supporting brackets 110.

The printed circuit contact cards 72 are substantially identical to those used in the apparatus of FIG. 1. In this instance, however, the insulating spacers 85 used between the cards are arcuate in shape, conforming generally to the shape of end plate 26, as shown in FIG. 1. This construction is shown by the dotted lines 27. The assembled block of cards and spacers is held between the end plates 26 and 26a by means of screws 89 and nuts 81. The spaced cards protrude through the generally rectangular aperture 116 of base plate 108. Dotted line 44a in FIG. 10 indicates the rows of switch contacts as shown at 44 in FIG. 1.

In order to support the spaced contact cards more rigidly and to provide an efficient seal, a sealing plate 112 of plastic or other similar insulating material is provided. This sealing plate 112 has the same general dimensions as base plate 108 and is secured to the upper side thereof by means of the screws 111. A number of slots 115, corresponding to the number of contact cards assembled in the contact card block, are milled or formed into the sealing plate 112. These slots are dimensioned so as to receive the protruding portions 75 of the contact cards 72 with a tight fit. After assembly, the unit may be turned with the protruding portions 75 of the contact cards 72 extending upwardly. Casting plastic or other suitable material is then poured into the remainder of the aperture 116 in the base plate 108 and in and around the cards 72 where they extend through the sealing plate 112. This combination of the sealing plate 112 and the casting plastic or resin provides a very efficient sealing arrangement as well as a rigid support for the spaced contact cards.

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Connector block 70a is very similar to the corresponding part 70 shown in FIG. 1, except that it is of built-up construction utilizing metal plates instead of the casting shown at 70 in FIG. 1. Base plate 118 carries two transverse end plates 119 which are used to secure the connector block 70a to the base plate 108 of the switch and contact card unit. Screws 120 and tapped holes 121 are provided for this purpose. The end plates 119, in conjunction with the pair of side plates 114 secured to base plate 108, also serve to form an unsealed enclosure for protecting the plug-in features of my invention.

Transverse supports 122 are secured by screws to base plate 118 and support abutment plates 123. These abutment plates 123 serve the same purpose as abutments 90 in FIG. 1 in providing a supporting member for the upper and lower rows of terminal receptacle strips 94a. These latter strips 94a are substantially identical to the similar parts previously described.

The plug-in features of this embodiment are similar to those previously described in connection with FIGS. 1 to 9 except that the means of registering the contact strips along the lower edge of the card with the individual terminal receptacles in the strip 94 are not shown. If no ribs 100 are formed in the receptacle strips 94a, the contact cards 72a need not be provided with slots. However, such slots and ribs may be readily incorporated in the form of stepping switch illustrated in FIGS. 10 to 13 so as to insure proper connection of switch contacts on the cards to the terminal receptacles.

In the specific arrangements shown, coincidental registration of the contact cards with their proper receptacle strips is accomplished by varying the distances at the two ends of the plates 108, 112, and 118. Thus, the distance 124 at the rightward end of these plates, as shown in FIGS. 10-12, inclusive, is made greater than the distance 125 at the leftward end. Because of this variation in spacing, the plug-in switch unit with its protruding contact cards can be placed only one way on the connector block 70a. The latter may be secured to an instrument panel or other similar supporting structure.

Although only two specific forms of my invention have been described herein in detail, it will be obvious that the invention is not limited thereto, but is capable of a variety of mechanical embodiments. Various changes will now suggest themselves to those skilled in the art which may be made in the material, form, details of construction, arrangement of the elements, and methods of manufacture without departing from the principles of my invention. Reference should be made, therefore, to the appended claims to ascertain the scope of the invention.

I claim:

1. In a multiple-bank stepping switch, in combination:
 - a plurality of printed circuit contact cards assembled with a plurality of insulating spacers and end plates, said insulating spacers insulating said contact cards from each other and said end plates, said assembly of said contact cards, spacers, and end plates comprising a contact card block;
 - a plurality of rotary wiping arms;
 - means to actuate said wiping arms;
 - an arcuate row of switch contacts printed on each contact card for cooperation with said wiping arms along one edge;
 - a row of terminal contacts printed on each card along another edge;
 - electrical conductive means connecting each of said switch contacts with a corresponding terminal contact;
 - means to connect said terminal contacts to a plurality of external electrical circuits;
 - a base formed to receive said contact card block;
 - a cover for said switch supported by said base; and
 - sealing means cooperating with said block, said base, and said cover to form a hermetically sealed chamber, said sealing means between said block and said

base constituting the sole mechanical support for said actuating means and said contact card block in said base.

2. A multiple-bank stepping switch as claimed in claim 1 in which said contact card block comprises printed circuit contact cards of two different heights in alternate relationship whereby the terminal contact edges of said cards protrude by two different lengths, being alternately long and short.

3. A multiple-bank stepping switch as claimed in claim 1 wherein said rotary wiping arms are adapted to make contact with both sides of each printed circuit contact card and the electrical circuitry printed on said printed circuit contact cards is duplicated on both sides of said cards.

4. A multiple-bank stepping switch as claimed in claim 1 wherein said rotary wiping arms comprise two pairs of wiping contacts disposed at an angle of one hundred eighty degrees from each other and adapted to contact both sides of each said printed circuit contact card, and wherein said printed circuit contact cards are formed so as to prevent more than one pair of wiping contacts from contacting said contact card at any one time.

5. A multiple-bank stepping switch as claimed in claim 1 wherein said printed circuit contact cards carry points of electrical connection other than said arcuate row of contacts; and electrical conductive means connecting each of said points with a corresponding terminal contact included in said row of terminal contacts whereby all electrical connections to said actuating means enter said hermetically sealed chamber through the terminal contacts carried along the corresponding edges of said printed circuit contact cards.

6. A multiple-bank stepping switch as claimed in claim 1 wherein said electrical conductive means connecting each of said switch contacts with a corresponding terminal contact comprises a part of the printed circuitry formed on each of said contact cards.

7. A multiple-bank stepping switch as claimed in claim 1 wherein each contact card carries a stationary wiping arm for contacting the respective rotary wiping arms and electrical conductive means connect each stationary wiping arm to a terminal contact included in said row of terminal contacts carried by each contact card along an edge thereof.

8. In a multiple-bank stepping switch having means to actuate a plurality of electrically connected pairs of rotary wiping arms, in combination:

a plurality of long and short printed circuit contact cards assembled with a plurality of insulating spacers and end plates, said insulating spacers insulating said contact cards from each other and said end plates;

a plurality of rotary wiping arms;

means to actuate said wiping arms;

said assembly of contact cards, spacers, and end plates comprising a contact card block having alternately long and short contact card edges protruding therefrom in staggered relation;

an arcuate row of contacts printed on each contact card for cooperation with said wiping arms along one edge;

a row of terminal contacts printed on each card along another edge;

electrical conductive means connecting each of said switch contacts with a corresponding terminal contact;

stationary wiper arms carried by each contact card for contacting each set of rotary wiper arms;

means to connect said terminal contacts to a plurality of external electrical circuits;

a base formed to receive said contact card block;

a cover for said switch supported by said base; and

sealing means cooperating with said printed circuit contact cards, said base, and said cover to form a hermetically sealed chamber enclosing said actuating

means and a portion of said block, said sealing means between said cards and said base comprising a slotted plate of insulating material carried by said base, said slots being dimensioned and numbered to closely receive the protruding edges of said cards, and hardenable fluid sealing means cooperating with said base, said slotted plate, and said cards to form a portion of said hermetic seal.

9. A multiple-bank stepping switch as claimed in claim 8 wherein said means to connect said terminal contacts to a plurality of external circuits comprises a connector block adapted to be removably secured to said base, said connector block including a base member, and a plurality of terminal receptacle strips supported by said base member, said terminal receptacle strips being formed of insulating material and adapted to receive the protruding edges of said cards and a plurality of individual terminal receptacles carried by each of said strips, said individual terminal receptacles being adapted to grippingly receive the individual terminal contacts along the edge of said cards and terminal ends formed on said individual terminal receptacles for connecting said receptacles to an external electrical circuit.

10. A multiple-bank stepping switch as claimed in claim 9 wherein the plurality of terminal receptacle strips supported by said base member include upper and lower rows of strips adapted to receive the staggered shorter and longer contact card edges protruding from said base.

11. A multiple-bank stepping switch as claimed in claim 9 wherein the terminal ends of said individual terminal receptacles terminate in a single plane.

12. A multiple-bank stepping switch as claimed in claim 9 wherein alignment means are provided in connection with said base and said connector block for positive single end-to-end relationship of said base and connector block.

13. A multiple-bank stepping switch as claimed in claim 9 wherein said contact cards and said terminal receptacle strips are provided with alignment means for precision alignment of said terminal contacts on said cards with said individual terminal receptacles.

14. A multiple-bank stepping switch as claimed in claim 12 wherein said alignment means comprises transverse ribs carried by said terminal receptacle strips and slots formed in the terminal contact edges of said cards, said slots cooperating with said ribs to positively align said contact card terminal contacts with the individual terminal receptacles carried by said terminal receptacle strips.

15. A multiple-position selector switch assembly comprising at least one printed circuit board, a movable wiper arm, and means for driving said wiper arm through a plurality of positions, said printed circuit board comprising an insulator body with a plurality of printed conducting elements on the surface thereof, said wiper arm in adjacent positions of said wiper arm having electrical contact with one end of respective adjacent conducting elements on said board, said conducting elements terminating at the other end in a side-by-side position abutting an edge of said board which is adapted to be removably inserted as a solid unit in a printed circuit socket having terminals corresponding with said conducting elements, a generally rectangular base member sealed around said circuit board at a position back from said edge thereof, said base member projecting slightly beyond all switch assembly components in a plane crosswise of said circuit board, and provisions in said base member for airtight attachment thereto of a case cover to enclose all but the pluggable edge conductors in a sealed space.

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