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(54) Electrical switch having interdigitated and through poles.

(57) An electrical switch is provided having first and second interdigitated poles and a through pole passing therebetween. Each of the first and second poles have multiple fingers spaced-apart and coplanar with one another. The through pole meanders through, is spaced-apart from and coplanar with the fingers of the other poles, and does not box in the other poles of the switch. In a keypad embodying an array of switches, the poles of each switch are connected to conductive traces that are brought out to an edge of the keypad. The traces are formed on one surface of the keypad. The through pole allows one or more of the poles of the switches in the keypad to be interconnected and brought to the edge of the keypad while remaining on the same surface of the keypad, thereby permitting the use of a single electrical connector for coupling the switches to other circuitry.

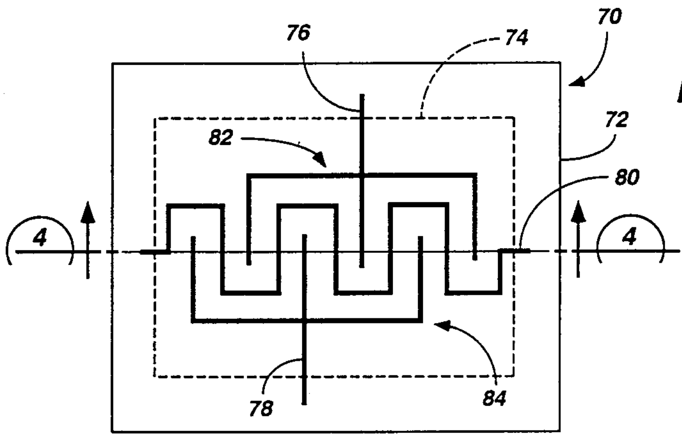

Fig. 3

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Background of the Invention

This invention relates generally to switches used in electric circuits and, more particularly, to mechanical switches having multiple poles.

Mechanical switches, as the term is used herein, refers to switches that require some sort of physical movement (hence the term mechanical) in order to operate the switch. These switches may be operated either manually or automatically. Examples of mechanical switches include membrane, rotary, pushbutton, slide and toggle switches. Mechanical switches typically consist of a shorting bar and one or more spaced-apart poles connected to electric circuits. Operating the switch causes the shorting bar to either make or break contact with the poles, thereby completing, interrupting, or otherwise changing the connections of the electric circuits.

Typically, the poles of single and double pole switches are placed on one surface or layer of the switch. It is desirable to do this because it simplifies switch construction. By having the poles on one surface, connecting the poles to electric circuits is greatly simplified. However, prior art switches having three or more poles, usually have the poles located, at least partially, on more than one layer of the switch. Sometimes, for example, the shorting bar acts as the third pole in a three pole membrane switch. The disadvantage associated with this type of pole arrangement is that the poles are on different layers and must somehow be combined on one layer so that they can be easily terminated at a single connector. Jumpers can be used to place the poles on one surface or multiple connectors could be used. Unfortunately, both approaches increase the complexity and cost of manufacturing the switch.

Another example of three pole switch construction found in the prior art is where all three poles are located on one layer spaced apart from the shorting bar. In a keypad incorporating an array of this type of switch, in which there are common poles, it is difficult to route the poles so that they do not cross over other poles. Either hard-wire jumpers are used at pole crossings or one of the traces will be formed on another surface of the layer to avoid crossing another pole. In the latter situation, plated through holes are used to continue the trace when it transitions to the other side of the switch layer. Once again, hardwired jumpers and through holes increase the complexity and cost of the switches. Obviously, if the switch has more than three poles, the cost and complexity of this type of construction becomes even greater.

Accordingly, there is a need for a switch that can be used in an electric circuit and that is simple and inexpensive to manufacture. The present invention, directed to an electric switch having a through pole located on the same surface as other switch poles, is designed to achieve these results.

Summary of the Invention

As will be appreciated from the foregoing summary, the present invention provides an electrical switch comprising first and second interdigitated poles located on a support member and a third pole passing therebetween to form a through pole also located on the support member such that the third pole does not box-in the first and second poles. A conductive member is in a movable relationship with the poles and support member, such that movement of the conductive member causes it to make or break contact with the poles.

In accordance with further aspects of the present invention, a keypad incorporating a plurality of the switches includes a plurality of interdigitated first and second poles located on a keypad support member and a third pole passing therebetween to form a through pole also located on the keypad support member. A plurality of conductive members associated with the plurality of switches are in movable relationship with the poles and keypad support member, such that movement of any of the conductive members causes it to make or break contact with the poles of the associated switches on the keypad support member.

As will be appreciated from the foregoing summary, the present invention provides an electrical switch having interdigitated poles and a through pole passing therebetween and a keypad comprising such switches.

Brief Description of the Drawings

The foregoing and other advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following description of a preferred embodiment taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a plan view of a keypad illustrating a typical pole layout for a prior art three-pole membrane switch;

Fig. 2 is a plan view of a keypad illustrating another typical pole layout for a prior art three-pole membrane switch;

Fig. 3 illustrates the pole layout of a three pole switch according to a preferred embodiment of the present invention;

Fig. 4 is a sectional view of the switch of Fig. 3 taken along section line 4-4;

Fig. 5 illustrates the pole layout of a four pole switch according to a preferred embodiment of the present invention;

Fig. 6 is a plan view illustrating a portion of a keypad comprising an array of three pole switches of the type depicted in Fig. 3 having a single common pole configuration;

Fig. 7 is a plan view illustrating a portion of a keypad comprising an array of switches of the type depicted in Fig. 3 having a double common pole configuration;

Fig. 8 is an elevational view of the keypad of Fig. 7 taken along line 8-8; and,

Figs. 9 and 10 are plan views illustrating important features of three-pole switches having interdigitated and through poles according to alternative embodiments of the present invention.

Description of the Preferred Embodiment

Fig. 1 illustrates a portion of a prior art keypad 10 encompassing conventional three-pole membrane switches 14 and 114 connected in a single common pole configuration. The top layer of keypad 10 is removed for purposes of clarity and to better illustrate important features of the switches. Switch 14 includes three poles 16, 18 and 20. Pole 16 is in the form of a shoring pad affixed to the underside of the top layer of the keypad (removed) and is represented by a dashed outline. As oriented in Fig. 1, poles 18 and 20 are located on the top surface of base layer 12, directly behind pole 16 and are spaced apart from pole 16. Pole 16 is brought out to the edge of the keypad by conductive trace 26, also located on the underside of the top layer of the keypad (and therefore represented as a dashed line). Poles 18 and 20 include interdigitated fingers 22 and 24, respectively, and are brought out to the keypad's edge via traces 28 and 30, respectively. Likewise, switch 114 includes poles 116, 118 and 120 similarly situated in keypad 10. Poles 118 and 120 are brought out to an edge via traces 128 and 130. Pole 116 is connected in common to pole 16. More particularly, pole 116 is connected to trace 26 via trace 126.

The operation of prior art switches 14 and 114, is well understood by persons having ordinary skill in the electrical field, and therefore is not discussed in detail herein. Briefly, however, by pressing down on the top of switch 14, pole 16 is brought into contact with poles 18 and 20 and causes an appropriate response in electrical circuits (not shown) that are connected to traces 26, 28 and 30. Switch 114 works in a similar manner.

In a keypad utilizing multiple switches of the sort illustrated in Fig. 1, all of the traces are typically brought to one edge of the pad for termination onto a connector for connection to other electric circuits. As discussed above, and represented in Fig. 1, trace 26 is on a different layer than traces 28, 30, 128 and 130. If the traces are not somehow brought to the same surface of the same layer, it will be necessary to use two connectors (i.e., one connector for the traces on each layer). As can be appreciated, it is undesirable to use two connectors because they increase the number of components in the keypad, thereby raising its complexity, and cost. Alternatively, the traces may be jumpered to one layer so that only one connector is required. Jumpers are undesirable, however, in that they add to the complexity of manufacturing the keypad and increase its cost.

Fig. 2 illustrates another prior art keypad 40 incorporating conventional three-pole membrane switches 42 and 142 connected in a single common pole configuration. As will be discussed below, the pole layout of switches 42 and 142 is different than in the membrane switches of Fig. 1. Once again, for reasons of clarity, the top layer of the keypad is removed. In switches 42 and 142, all three poles of each switch are located on the same layer 41 of the keypad. More specifically, switch 42 consists of poles 44 and 46 with interdigitated fingers 52 and 54, respectively. Third pole 48 lies outside and boxes in the other poles. Poles 44, 46 and 48 are brought out to the edge of the keyboard via traces 60, 62 and 64, respectively. Likewise, switch 142 includes poles 144 and 146 that have interdigitated fingers 152 and 154, respectively, and are brought out to the edge of the keypad via traces 160 and 162, respectively. Third pole 148 is connected in common with pole 48 via trace 58.

Third poles 48 and 148 include multiple jumpers 56 and 156 so as to avoid touching the other poles. The jumpers may be discrete wires soldered to the traces. Alternatively, the jumpers may consist of plated through holes and traces on the other surface of the base layer 41. In the latter case, jumpers 56 and 156 may be formed as traces on the underside of layer 41 and connected to the trace forming the third pole via plated through holes in layer 41. In any event, however, jumpers are undesirable in that they add to the complexity of manufacturing the keypad and thereby increase the cost of the keypad.

Turning now to Fig. 3, there is illustrated a three-pole membrane switch 70 according to a preferred embodiment of the present invention. Switch 70 includes a top layer (not shown in this figure for reasons of clarity, but illustrated in Fig.4) and base layer 72. Shorting pad 74 is preferably formed on the underside of the top layer of the switch and is represented by a dashed outline. Base layer 72 has located thereon three poles 76, 78 and 80. Poles 76 and 78 include spaced apart, interdigitated fingers 82 and 84, respectively. Third pole 80, which forms a through pole of switch 70, is spaced apart from poles 76 and 78 and meanders on base layer 72 such that it passes between the interdigitated fingers of poles 76 and 78. In this regard, pole 80 passes through switch 70. Shorting pad 74 is normally spaced apart from poles 76, 78 and 80, such that when an operator presses the membrane switch, the shorting bar is brought into contact with all three poles.

As is readily apparent from Fig. 3, interdigitated fingers 82 and 84 and the meandering path of through pole 80 provide a high density contact area for shorting bar 74. The high density layout of the switch poles ensures proper contact when the switch is pressed, even if only a relatively small area of the shorting bar makes contact with the poles. For example, even if an operator presses down on a corner of the switch or uses an object such as a pen to depress the switch, the poles are close enough together that the shorting bar will be brought into contact with all three poles.

In accordance with a preferred embodiment of the present invention, the poles are formed by any one of the number of conventional printed circuit board processes, such as photo-etching or vapor deposition, for example. The poles are preferably silver traces, but may consist of any electrically conductive material formed, mounted or otherwise attached to an electrically insulating substrate making up base layer 72. Base layer 72 may be rigid or flexible and, for example, may consist of mylar or polyester.

Fig. 4 is a section view of switch 70 taken along section line 4-4 in Fig. 3. As discussed above and further illustrated in Fig. 4, base layer 72 supports interdigitating fingers 82 and 84 of poles 76 and 78, respectively, and through pole 80. Shorting pad 74 is affixed, mounted or otherwise attached to top layer 71 and is spaced apart from the poles and base layer 72 by spacer 73. As mentioned above, switch 70 may be operated in a conventional manner by pressing down on top layer 71 and thereby bringing shorting pad 74 into contact with the three poles (76, 78 and 80) on base layer 72.

Fig. 5 illustrates a four pole membrane switch 70' according to the preferred embodiment of the present invention. Since switch 70' is substantially identical to switch 70 (Fig. 3), with the exception of a fourth pole, the common elements between the two figures are numbered similarly, with the exception being that the reference numbers in Fig. 5 are primed. As previously mentioned, the sole difference between switches 70 and 70' is that the latter has a fourth pole, represented as through pole 86. Through pole 86, like through pole 80', is spaced apart from, and meanders through, the fingers 82', 84' of poles 76' and 78', respectively. All four poles are located on base layer 72'.

As should be readily apparent from Figs. 3 and 5 and the above discussion, an electrical switch according to the preferred embodiment of the present invention includes at least one through pole that meanders between the fingers of two other poles of the switch. As a result, the poles are located on the same surface of a supporting, or base, layer of the switch. In the case of a membrane switch, the poles are essentially coplanar since they reside on the same surface of a substantially flat substrate. It is to be understood, however, that electrical switches other than membrane switches may utilize the present invention. For example, rotary switches having poles on a printed circuit board could also benefit from the pole layout of the present invention.

Illustrated in Fig. 6 is a keypad 200 having an array of three-pole membrane switches of the kind depicted in Fig. 3 and discussed above. The switches are connected in a single common pole configuration, such as might be found in applications where, for example, an interrupt signal is to be supplied to a microprocessor every time one of the switches is pressed. As will become better understood from the following discussion, all three poles of the switches are located on one layer of the keypad and as a result all poles may be readily terminated at a single connector at the edge of the keypad.

As shown in Fig. 6, keypad 200 comprises a base layer 202, an array of three pole membrane switches 204-230, and conductive traces bringing switch poles to an edge of the keypad. For purposes of discussion, the three poles of each switch 204-230 are labeled "a", "b" and "c". Each pole may be specifically identified by combining the reference number of the switch with the label of the particular pole. For example, pole "a" of switch 204 may be represented as pole 204a and pole "c" of switch 226 becomes pole 226c. The conductive traces are identified by 300 series reference numerals corresponding to each switch. In addition, a trace connected to pole "a" or "b" of a particular switch has the pole designation associated with its reference numeral. For example, the trace connected to pole 204a is designated 304a and the trace connected to pole 226b is designated 326b. The through poles (i.e., the "c" poles in Fig. 6) are connected together, thus forming the single common pole of key pad 200. The trace segments connecting all "c" poles and bringing them to the edge of the keypad are designated collectively as 300c.

As is illustrated in Fig. 6, the poles of the switches are routed to the edge of the keypad without crossing one another or leaving the surface of base layer 202. This is because the meandering nature of through pole "c" does not box in the other poles of the switches, as does the prior art three-pole switch configuration illustrated in Fig. 2

and discussed above. As a result, the traces can be readily connected to a single connector for coupling to other circuits.

Turning to Fig. 7, there is illustrated a keyboard having an array of switches according to a preferred embodiment of the present invention (as depicted in Fig. 3) with a different pole configuration than is illustrated in Fig. 6 and discussed above. For reasons of clarity, like elements of Figs. 6 and 7 have the similar reference numerals, except that the numerals in Fig. 7 are primed. Elements in Fig. 7 that are substantially different are given unique numbers and are not primed.

Key pad 200' includes base layer 202', having located thereon poles a', b' and c' of an array of membrane switches 204'-230'. As with keypad 200 in Fig. 6, the b' poles of switches 204'-230' are brought out to an edge of the keypad via traces 304b'-330b', and through poles (c') of the switches are interconnected and brought out to the edge via trace 300c'.

Keypad 200' differs from the switch in Fig. 6 in that it has a second pole of the switches connected in common. Specifically, the a' poles of switches 204'-230' are interconnected and brought out to the edge of the keypad via trace 300a. Hence, the switches of keypad 200' have a double common pole configuration. As is readily clear from Fig. 7, poles of the various switches are located on the same surface of base layer 202' and are brought out to the edge without crossing one another. This is possible because the through pole (c') meanders between, and does not box in, the other poles of the switches.

Turning next to Fig. 8, there is illustrated an elevational view of keypad 200' as viewed from an edge along line 8-8 in Fig. 7. Connector 90 (not shown in Fig. 7) is coupled to the traces that are brought out to the edge of the keypad 200'. The traces (300a, 300c', 304b', 306b', 314b', 324b', 326b', 328b' and 330b') correspond to the traces having the identical reference numerals in Fig. 7. Connector 90 is preferably an elastomeric type of interconnector having conductors imbedded within the elastomeric material for connecting the keypad to other electric circuitry. More specifically, connector 90 includes imbedded conductors that correspond to the traces at the edge of the base layer. Conductors 400a, 400c', 404b', 406b' - 414b', 424b', 426b', 428b' and 430b' are embedded in conductor 90 and are in contact with the traces on base 202' when the connector is in place on the keypad. For example, trace 300a is connected to conductor 400a, trace 300c' to conductor 400c', etc. Elastomeric interconnectors are preferred in many applications, in part, because they are relatively inexpensive, and are readily adaptable to Z-axis manufacturing techniques. However, it is understood that connector 90 is not limited to elastomeric interconnectors and may be any type of connector suitable for use with electrical conductors.

Figs. 9 and 10 illustrate alternative embodiments of the present invention. Elements appearing in Figs. 9 and 10 that are substantially the same, or perform substantially the same function, as elements in the switch shown in Fig. 3, are numbered the same, except that the reference numerals include either an "a" (Fig. 9) or a "b" (Fig. 10). For reasons of simplicity, and to avoid duplication, some elements of the switches are omitted, such as the supporting base layer, but is to be understood that such elements form a part of the switches depicted in Figs. 9 and 10. In Fig. 9, poles 76a and 78a have interdigitated fingers 82a and 84a forming planar, concentric open circles. Through pole 80a is planar with, and meanders between, the other poles. In Fig. 10, poles 76b and 78b have interdigitated fingers 82b and 84b forming a planar, zig-zag pattern with through pole 80b being planar with, and meandering between, the other poles.

In summary, the switch of the present invention, having one or more through poles meandering through interdigitated poles is well suited for use in a keypad having an array of switches connected in either a single or double common pole configuration. A switch according to the present invention permits the poles and traces connected thereto to be located on the same surface of one supporting layer and to be brought out to an edge of a keypad for termination at a single connector.

While preferred and alternative embodiments of the present invention have been illustrated and described, it will be appreciated that various changes can be made without departing from the spirit and scope of the invention. For example, the poles of the switch could have numerous configurations other than those illustrated and discussed herein. Likewise, the number of poles may vary and are limited primarily by physical limitations of the switch. Also, while the preferred and alternative embodiments of the present invention have been discussed in terms of membrane switches, it is to be understood that the present invention may be practiced with other kinds of switches, such as rotary, toggle, and slide switches. Consequently, the invention can be practiced otherwise than as specifically described herein.

Claims

1. An electrical switch comprising:

(a) a support member;

(b) a first pole being electrically conductive and located on said support member;

(c) a second pole being electrically conductive and located on said support member and spaced apart from said first pole;
(d) a third pole being electrically conductive and located on said support member and passing between said first and second poles; and,
(e) an electrically conductive member spaced apart from and in movable relationship with said support member, such that movement of said conductive member causes said conductive member to make contact with said first, second and third poles.

2. An electrical switch according to claim 1, wherein:
(a) said first pole includes a first plurality fingers; and,
(b) said second pole includes a second plurality of fingers interdigitated with said first plurality of fingers.

3. An electrical switch according to claim 2, wherein said third pole is a through pole spaced apart from and meandering between said first and second plurality of fingers of said first and second poles.

4. An electrical switch according to claim 3, wherein said first, second and third poles are coplanar.

5. An electrical switch according to claim 3, wherein at least one of said first and second plurality of fingers is three fingers.

6. An electrical switch comprising:
(a) a plurality of spaced-apart and interdigitated pole members;
(b) at least one through pole member passing between and spaced-apart from said plurality of pole members; and,
(c) contacting means for making simultaneous electrical contact with said plurality of pole members and said at least one through pole member.

7. An electrical switch according to claim 6, wherein said at least one through pole member includes at least two spaced apart through pole members.

8. A key pad comprising:
(a) a keypad support member; and,
(b) a plurality of electrical switches located on said keypad support member, each of said plurality of electrical switches having at least two poles with a through pole passing therebetween and a plurality of conductive members adjacent and spaced-apart from said at least two poles and through pole of each of said plurality of electrical switches, such that each of said plurality of conductive members is operable to simultaneously contact said at least two poles and through pole of one of said plurality of electrical switches.

9. A keypad according to claim 8, further comprising:
(a) a plurality of conductors located on said keypad support member and having a first end coupled to said poles of said plurality of electrical switches and a second end extending to an edge of said keypad support member.

10. A keypad according to claim 9, wherein said first end of one of said plurality of conductors is coupled to a plurality of said through poles.

11. A keypad according to claim 10, wherein said plurality of electrical switches are membrane switches and said plurality of conductors are conductive traces formed on said keypad support member.

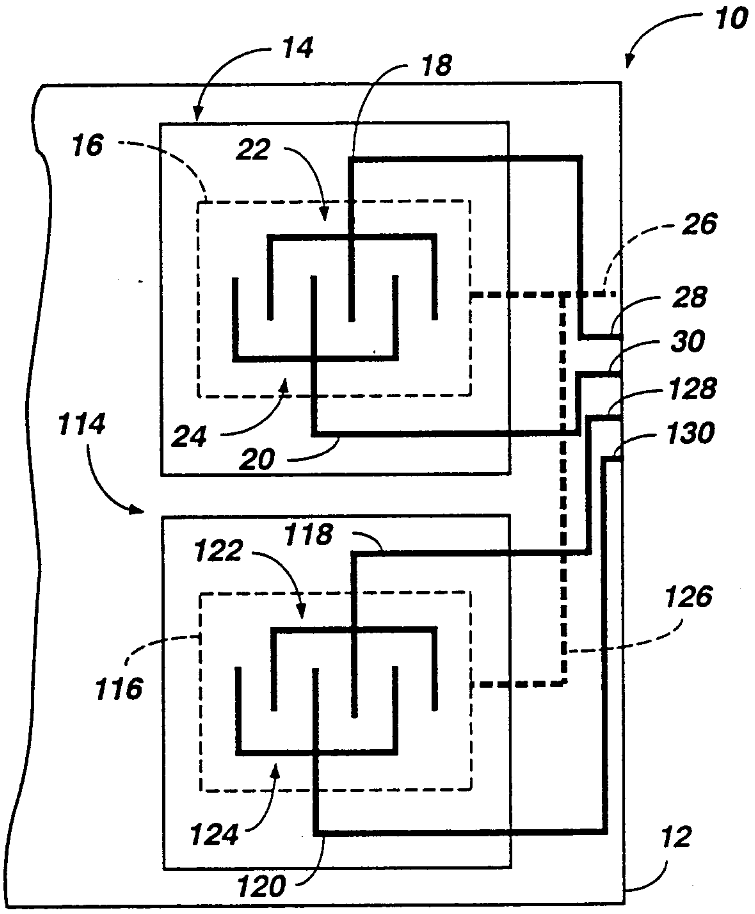

Fig. 1
(PRIOR ART)

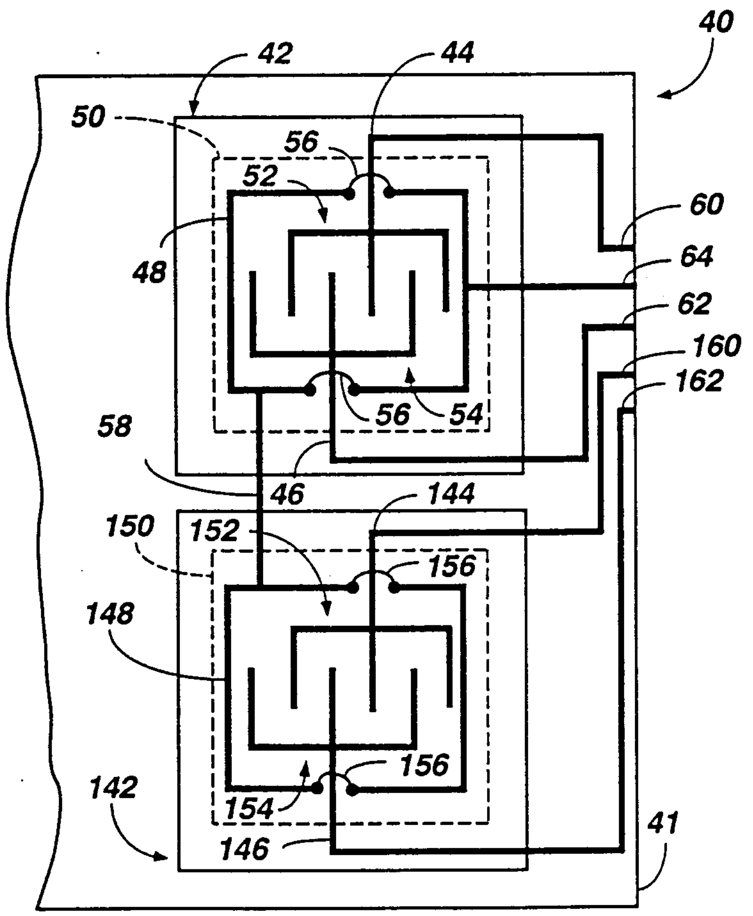

Fig. 2
(PRIOR ART)

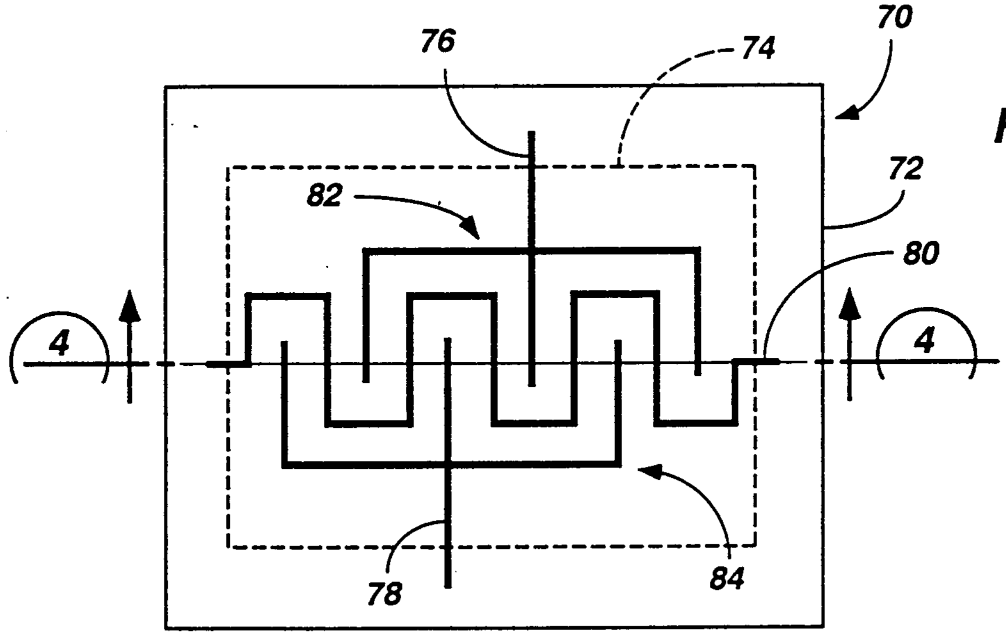

Fig. 3

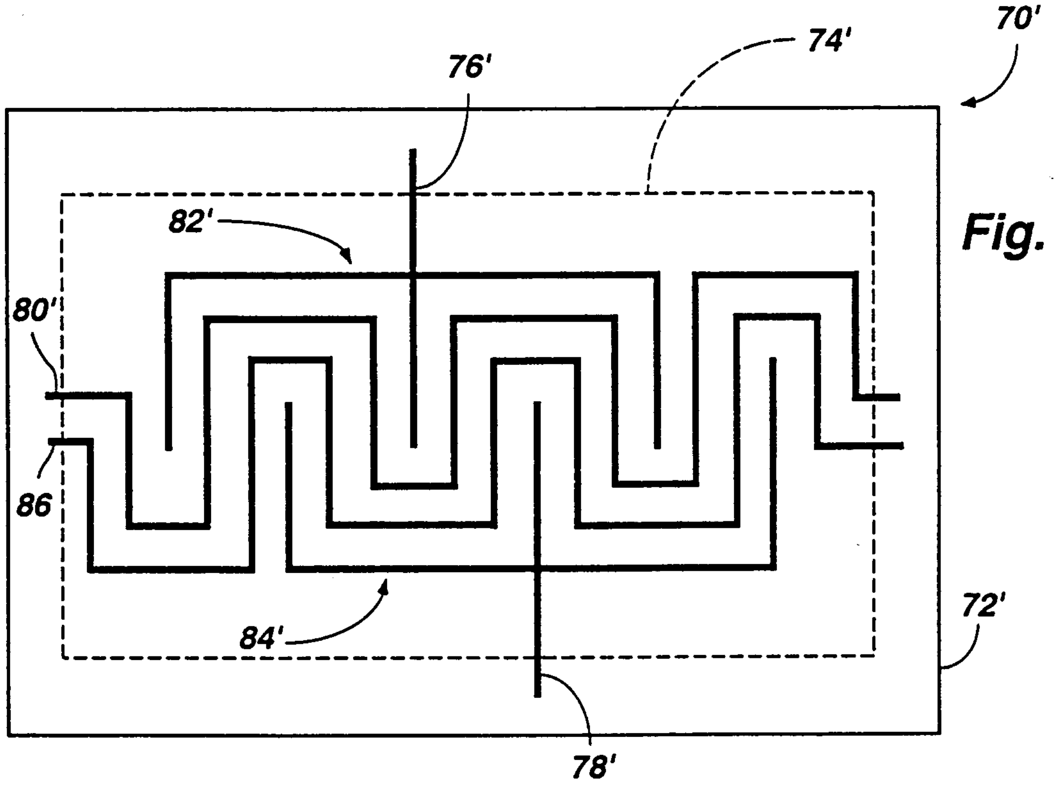

Fig. 5

Fig. 6

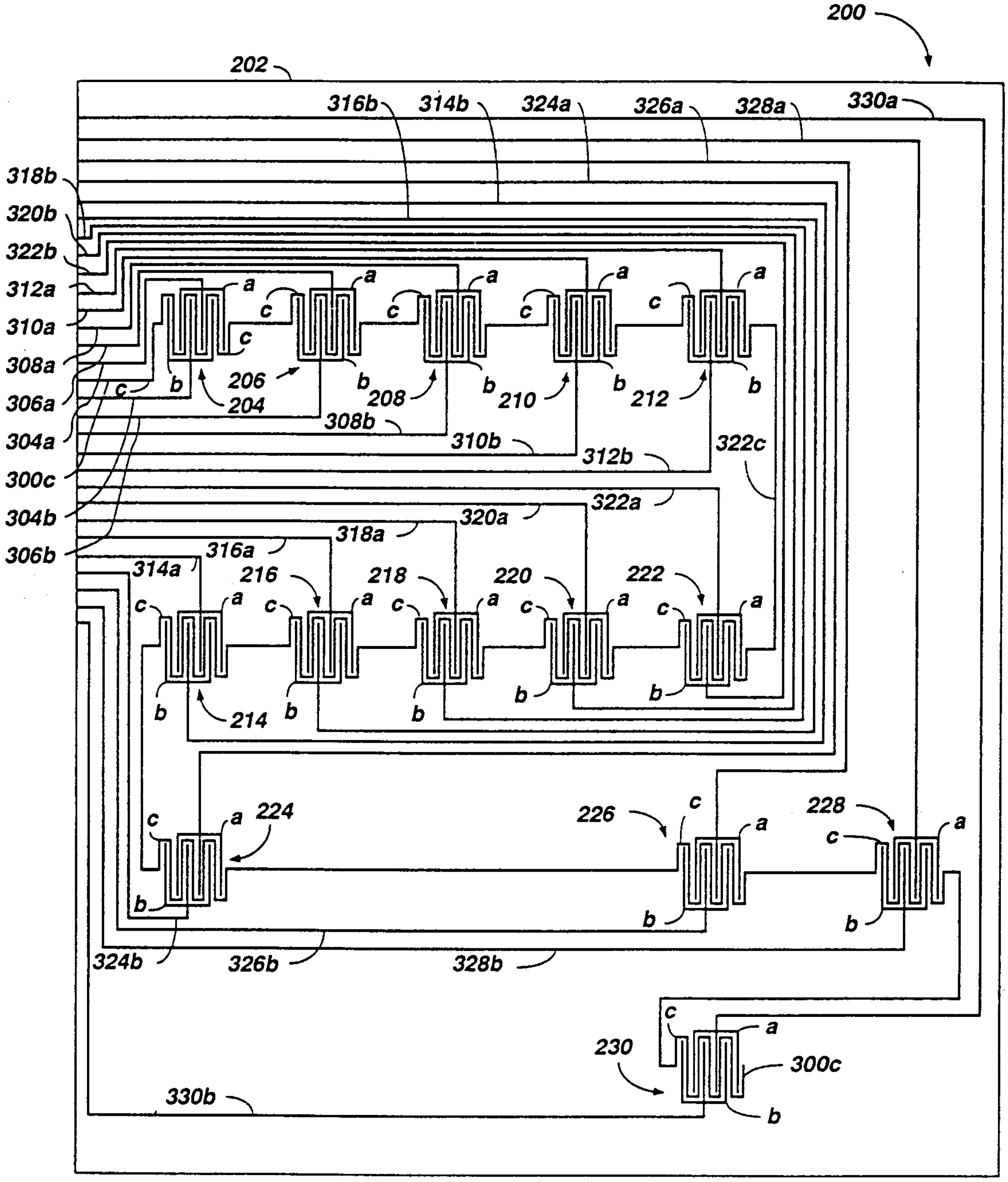
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Fig. 7

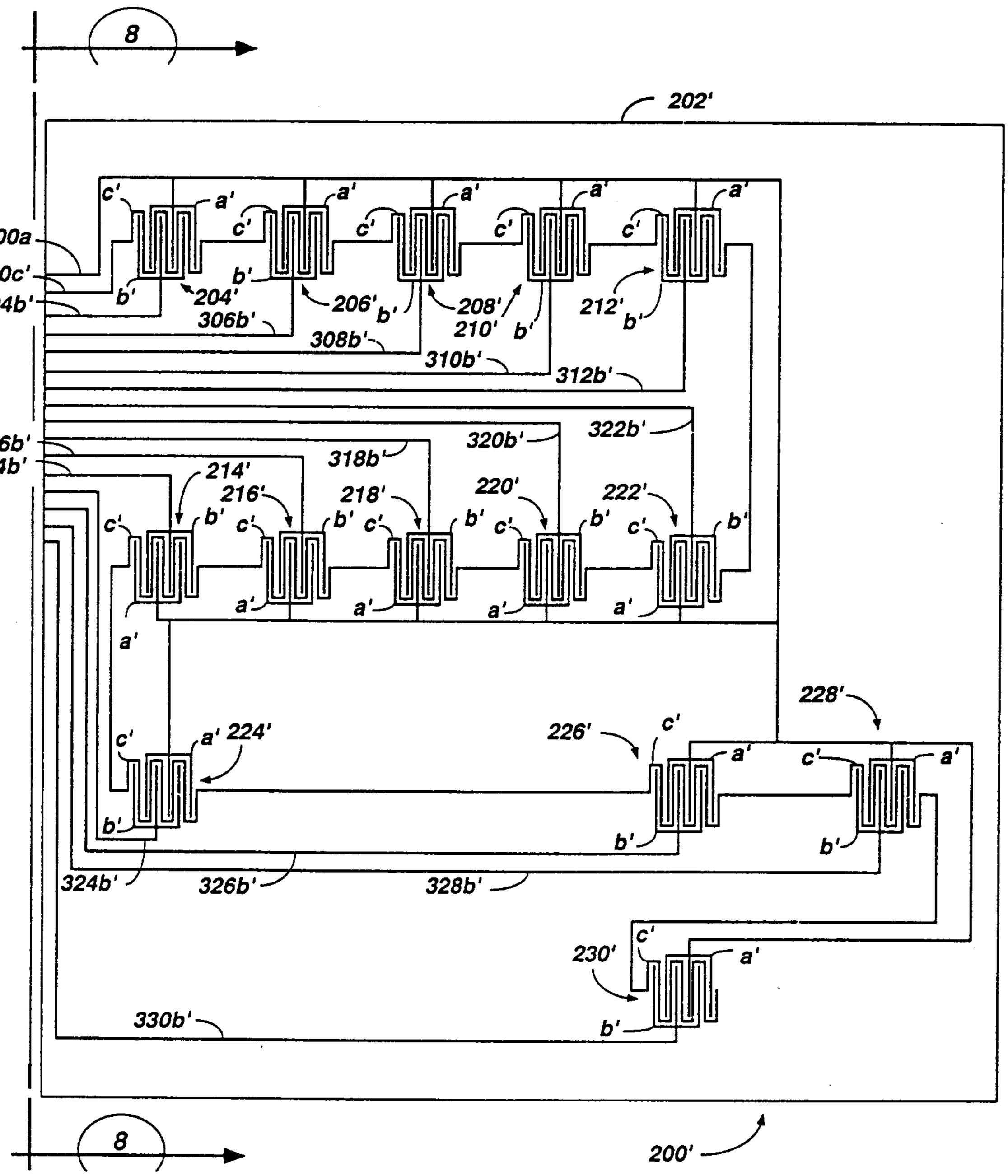
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Fig. 4

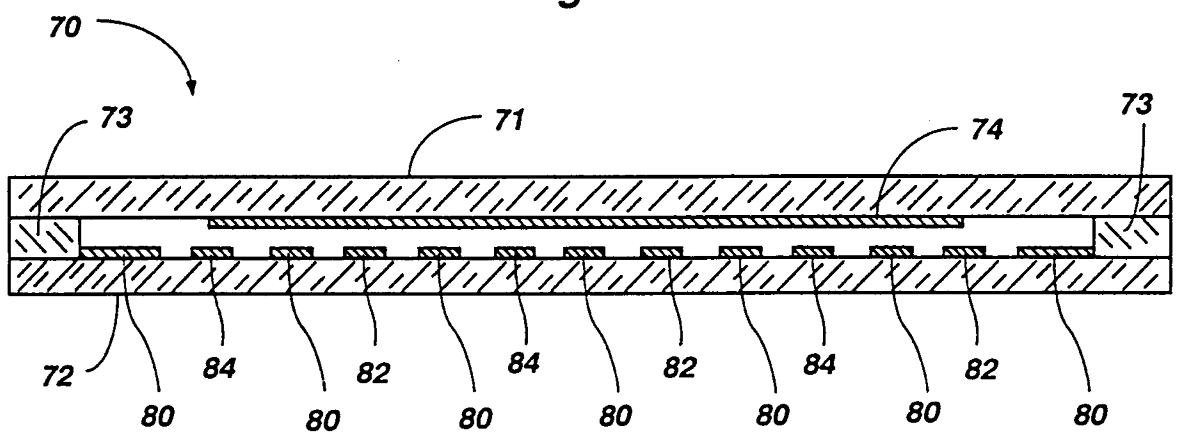
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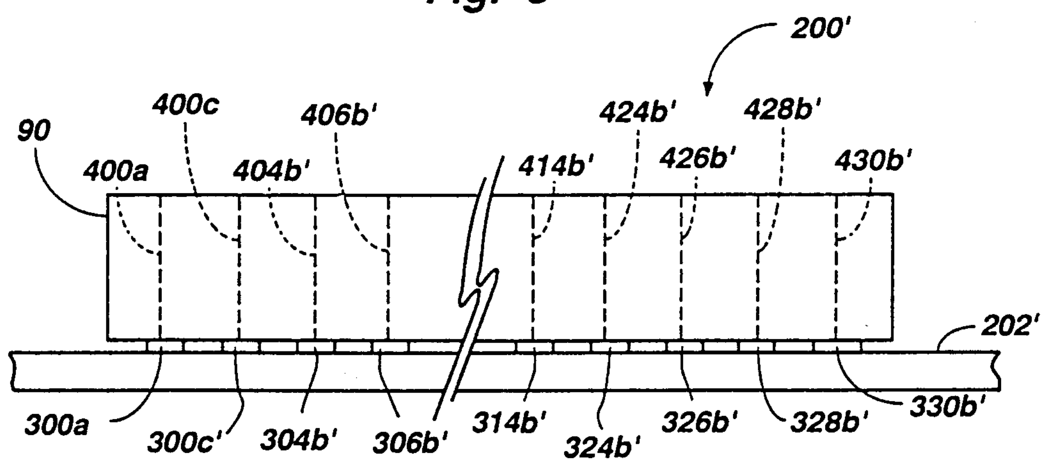
Fig. 8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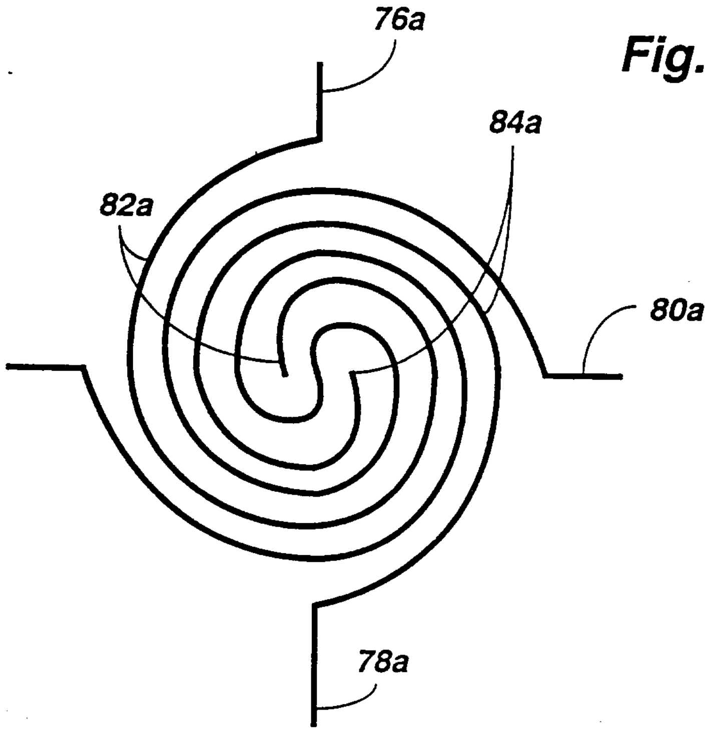

Fig. 9

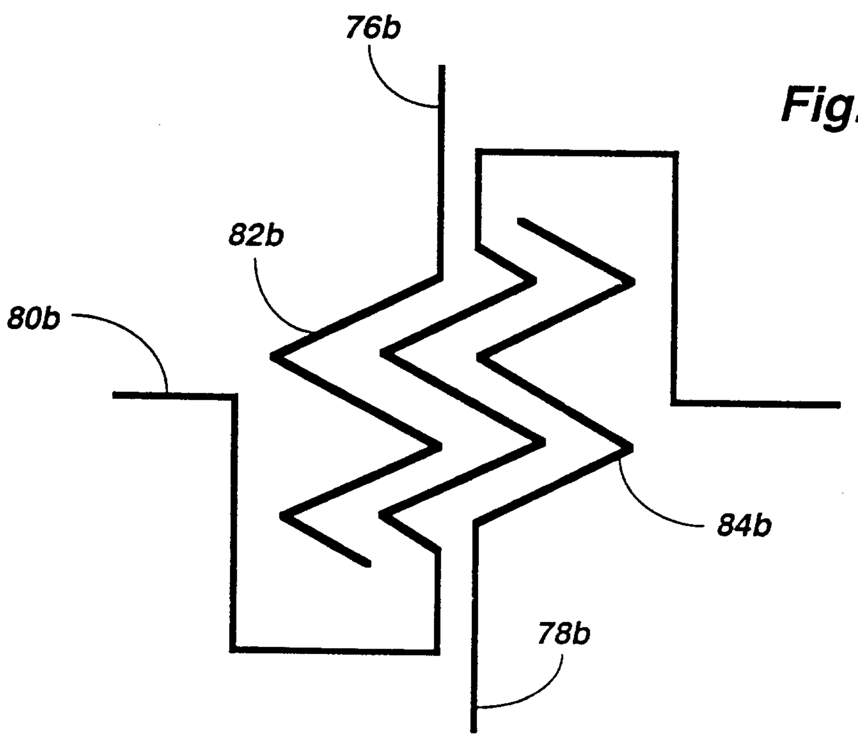

Fig. 10