United States Patent [19]

Ash

[11] **3,811,102**

[45] **May 14, 1974**

[54] **RELAY**

[75] Inventor: **Leonard P. Ash,** Anaheim, Calif.

[73] Assignee: **Babcock Electronics Corporation,** Costa Mesa, Calif.

[22] Filed: **July 22, 1971**

[21] Appl. No.: **165,253**

[52] **U.S. Cl.** **335/106,** 335/133, 335/151, 335/202

[51] **Int. Cl.** **H01h 50/16**

[58] **Field of Search** .... 335/106, 107, 131, 133, 335/202, 196; 317/101 CC; 174/68.5

[56] **References Cited**

UNITED STATES PATENTS

3,579,158	5/1971	Kutyla	335/151
3,171,918	3/1965	Killion	335/202
3,141,939	7/1964	Mink	335/202
3,246,096	4/1966	Jacobson	335/133
3,553,729	1/1971	Mori et al.	335/106

Primary Examiner—Harold Broome
Attorney, Agent, or Firm—Niewnow & Frater

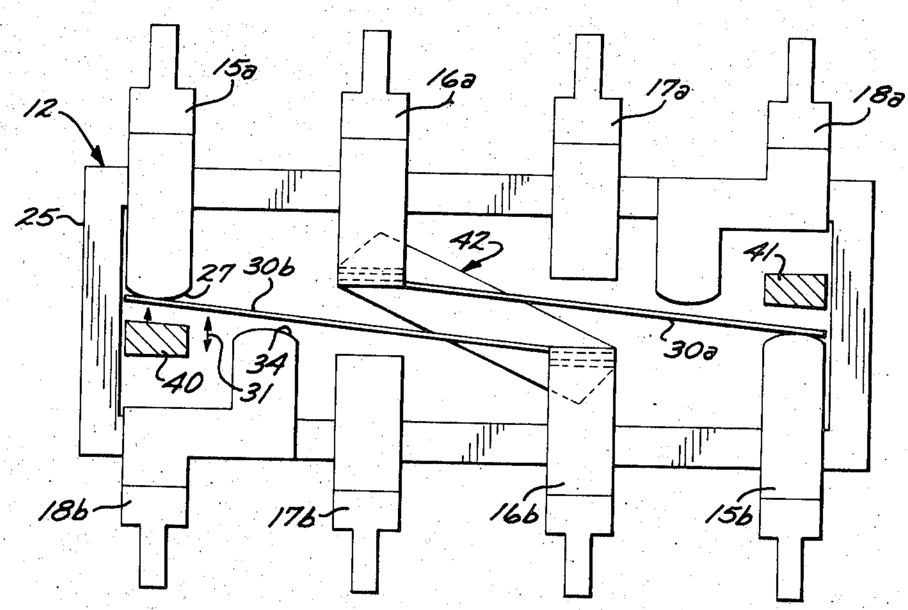
[57] **ABSTRACT**

The present invention relates to an improved relay and more particularly relates to a miniaturized relay that is ideally adapted for use with present day printed circuit boards. The disclosed relay is a unit (hermetically sealed, if so desired) that snaps into place at a desired location of a printed circuit board; the terminals of the relay also serving as mechanical holding devices.

Electrically, the disclosed relay may operate in several different switch modes, with a variety of input/output terminals and has the inherent characteristic that if a dual pole switching mode is used, the poles tend to operate more simultaneously than in prior art relays.

Mechanically, the relay has a novel terminal construction that is efficient from both a manufacturing and an assembly point of view. Moreover, the disclosed relay is extremely economical to build.

7 Claims, 6 Drawing Figures



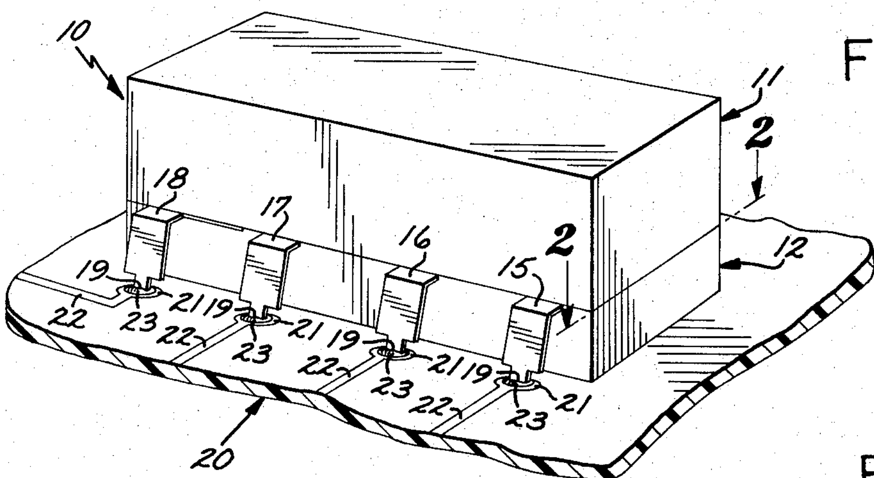


FIG. 1

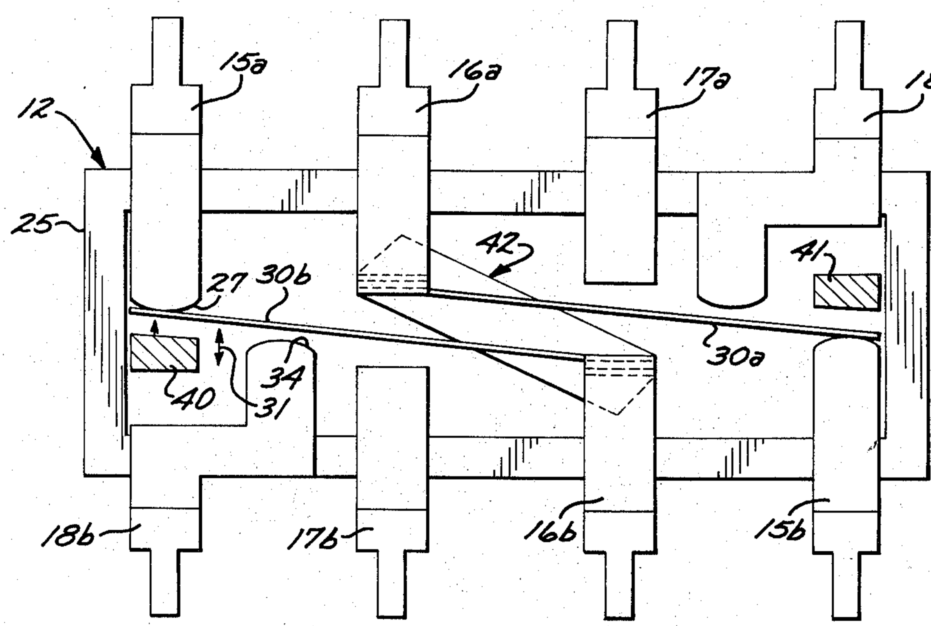


FIG. 2

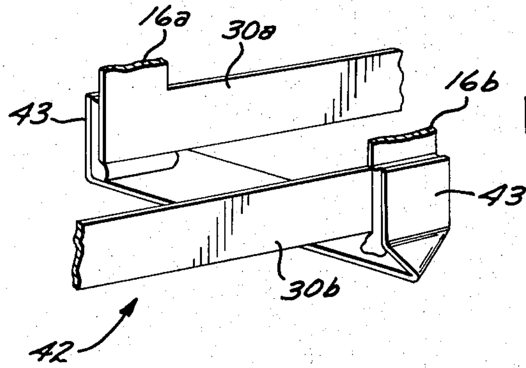


FIG. 3

INVENTOR.
LEONARD P. ASH
BY
Nienow & Frater
ATTORNEYS

FIG. 4

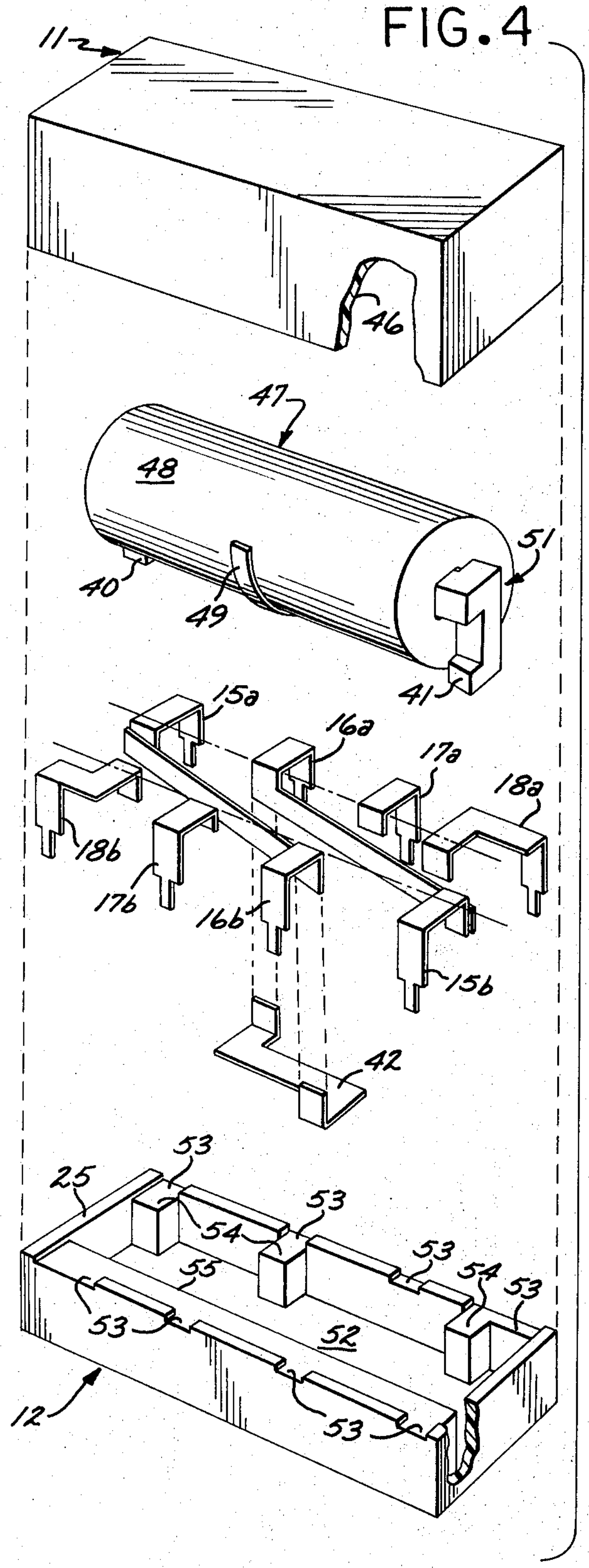
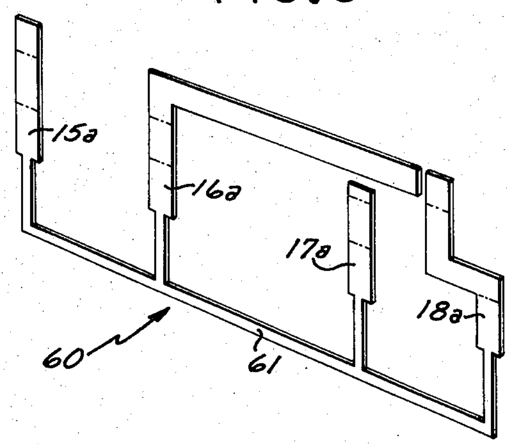


FIG. 5



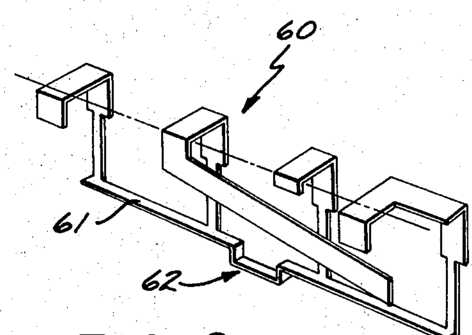


FIG. 6

INVENTOR.
LEONARD P. ASH
BY
Nienow & Frater
ATTORNEYS

RELAY

BACKGROUND

As is known to those skilled in the field of electricity, there is a great need for devices that will complete or will interrupt an electrical circuit and as a result of this need, many such devices have been produced — a class of such devices being known under the general name of "switches."

A particular type of switch has to be operated remotely and one such remotely operated switch is known as a "relay." Relays are valuable for a wide variety of conditions, functions, current carrying capabilities, voltage ratings, life times, operating requirements, etc.

As the field of electricity-and especially the field of electronics-advances, there is a constantly increasing need for ever small, ever lighter weight, and even more compact relays; especially for use in the so-called printed circuit boards that are becoming so widely accepted in the field of electronics.

It should be noted that relays which are destined for use with these printed circuit boards are usually designed for minute electrical currents, and for low voltages. Therefore, the requirements for these relays become quite different than for prior art relays. For example, insulation and heating effects are no longer a serious problem; but, on the other hand, ease of installation compactness, light weight, and reliability become ever more important.

OBJECTS AND DRAWINGS

It is therefore the principal object of the present invention to provide an improved relay.

It is another object of the present invention to provide an improved electrical relay that is particularly adapted for use with present day printed circuit boards.

It is still another object of the present invention to provide an improved electrical relay that may operate in a wide variety of switching modes.

It is a further object of the present invention to provide an improved electrical relay that is smaller, lighter in weight, and more compact than prior art relays.

It is a still further object of the present invention to provide an improved method of making the terminals and elements of the relay.

The attainment of these objects and others will be realized from a study of the following detailed description, taken in conjunction with the drawings of which;

FIG. 1 shows a pictorial view of the disclosed relay and its method of use;

FIG. 2 shows a top view of the working elements of the relay;

FIG. 3 shows a pictorial sectional view of a portion of the working elements;

FIG. 4 shows an exploded view of the various parts of the relay;

FIG. 5 shows a view of the relay elements in a planar configuration; and

FIG. 6 shows a pictorial view of the relay elements in their multi-planar configuration.

SYNOPSIS

Broadly speaking, the disclosed relay is a miniaturized unit that may be about 0.7 inches long, 0.3 inches

high and 0.2 inches wide; its internal structure permitting it to act as a double-pole double-throw switch. In the finished relay, the various terminals are electrically separate from each other but the assembly process permits these terminals to be part of economical stamping that is then dropped into place in the relay housing. Only then are the terminals electrically and mechanically separated from each other.

The result is a small, light weight, compact, miniaturized relay that is particularly adapted for use with the small currents and low voltages used in present day printed circuit boards.

DESCRIPTION

The Basic Relay

It was pointed out above that present day miniaturized printed wire crcuitry requires even smaller, lighter weight, and more compact relays; and FIG. 1 shows a pictorial view of the disclosed relay connected to such a printed circuit board that contains such printed wire circuitry.

In FIG. 1, relay **10** has a housing that is indicated to have a relay cover **11** and a relay base **12**. Relay **10** comprises (as will be discussed later) a plurality of "relay elements" — such as **15**, **16**, **17**, etc. — that extend from the interior of relay **10**. The outer portions of relay elements **15**, **16**, **17**, etc. act as interconnections or "leads"; and, if desired, these lead ends may be narrowed down as indicated, in order to fit into apertures **19** of a printed circuit board **20** — the printed circuit board **20** having "pads" **21** (usually annulli of electrically conducted material such as copper) that are connected, or are integral with, conductive strips **22** that form the electrically conductive printed wire pattern that gives the name to the printed circuit board. Solder **23** is used to assure good electrical and mechanical connectins between pads **21** and the relay element **15**, **16**, **17**, etc. In this way, the inner-portions of relay **10** are electrically connected to the circuit on the printed circuit board.

Thus, electrical input signals may be applied to relay **10**; and electrical output signals may be obtained from the various terminals of relay **10** — the types of output electrical signals depending upon the particular state of the relay, which may be energized or de-energized remotely and electrically as conditions require.

Electrical Considerations

The electrical characteristics of the disclosed relay will be understood from a study of FIG. 2, which is a top view of the relay looking into the relay from a level corresponding to the junction of the relay cover **10** and the relay base **12** — as indicated in FIG. 1.

Referring now to FIG. 2, it will be seen that relay base **12** comprise a roughly open box configuration, having walls **25**, that enclose a plurality of the above discussed relay elements; these relay elements now being identified with lower case letters for a reason that will become apparent later — i.e., **15*a***, **15*b***, **16*a***, **16*b***, **17*a***, **17*b***, etc. — these relay elements protruding both inwardly and outwardly of the relay base side walls **25**.

The Straight Element

Directing attention first to the left uppermost relay element **15a** of FIG. 2, this will be designated as a "straight thru relay element" (shortened to "straight element") since relay element **15*a*** appears to be straight in FIG. 2, and projects straight through the wall 25 of relay base 12.

These relay elements will all be discussed and illustrated later in much greater detail; but it may be visualized from FIGS. 1 and 2 that straight element 15*a* comprises an outer lead end that is to be connected to the previously mentioned printed circuit board 20; so that the outer lead end extends in a generally downward direction. Straight element 15*a* also comprises a transition portion that provides a transition from the downwardly extending lead end across the top of side wall 25 of the relay base 12, the transition portion of the straight element extending in a generally horizontal direction. The straight element 15a also comprises an interior portion that terminates in a contact surface 27 that may be the end of the horizontal transistion portion, but is preferably a contact surface that extends in a generally downward direction within the relay base 12.

It will be realized from FIG. 2, that if an electrical signal is applied to contact surface 27 of straight element 15*a*, the electrical signal will be available at the outer lead end or output terminals, that is electrically connected to the printed circuit board 20.

The Switching Element

Attention is again directed to FIG. 2, this time to one of the lower relay elements 16b; this relay element is to be called the "switching element" because (in a manner to be discussed soon) a portion of relay element 16*b* acts as a switch.

It may visualized from FIGS. 1 and 2, that the switching element 16*b* comprises an outer lead end that is to be connected to the previously mentioned printed circuit board 20; so that the outer lead extends in a generally downward direction. Switching element 16*b* also comprises a transistion portion that provides a transistion from the downwardly extending lead end across the top of side wall 25 of the relay base 12; this transistion portion of the switching element 16*b* extending in a generally horizontal direction within the relay base 12. The switching element 16*b* also comprises an interior portion that terminates in a switch arm 30*b*.

The configuration of the switching element 16*b* resembles a capital "L" lying on its side, and having its short arm bent into an horizontal plane — see 16*b* of FIG. 4; this switching element configuration being designated as a "bent L" that will be further discussed later. Suffice it to say, the now horizontal portion of the bent L configuration forms the transistion portion of the switching element 16*b*, while the base of the bent L configuration forms the switch arm 30*b*.

Because of this construction, which will also be discussed more fully later, switching element 16*b* of FIG. 2 has a switch arm 30*b* that acts as though its proximal end were "pivoted" at switching element 16*b*, while its distal outer end moves as indicated by double ended arrow 31.

It will be noted that, in FIG. 2, the distal end of switch arm 30*b* is in contact with the contact surface 27 of the straight element 15*a*. Therefore, if an electrical input signal were applied to the external lead end of switching element 16*b*, the switching element 16*b* acts as an input terminal; and it transmits the electrical signal along its switch arm 30*b* to the contact surface 27 of the straight element 15*a*. In this way, an input electrical signal applied to the input terminal switching element 16*b* may be made available at the output terminal lead end of straight element 15*a*.

As will be explained later, switch arm 30*b* may be pivoted slightly counterclockwise, as indicated by the double ended arrow 31; so that the distal end of the switch arm 30*b* no longer contacts the contact surface 27. At that time, the input electrical signal applied at switching element 16b will no longer be available at the output terminal lead end of straight element 15*a*.

The above switching arrangement has been presented in terms of a single switch arm 30*b* and one output terminal relay element 15*a*; this switching arrangement being technically known as a "single-pole single-throw" — S.P.S.T. — switch, because a single pole (switch arm 30*b*) may be set (thrown) to or from a single position.

As will be discussed later, switching element 16*b* and its switch arm 30*b* are formed in such a manner that its inherent resiliency and its bias due to the forming processes cause the switch arm 30*b* to normally be with the contact surface 27 of straight element 15*a*. The technical designation for this electrical state is that the circuit is "normally complete;" i.e., the switch at straight element 15*a* is "normally closed"; and the straight element 15*a* is thus a "normally closed" terminal of a switching arrangement.

The Offset Element

Attention is now directed, in FIG. 2, to the lower leftmost relay element 18*b*; this being called an offset relay element, since it has a configuration that is offset relative to the configuration of the straight element 15*a* discussed previously. The reason for the offset will be discussed later.

As may be visualized from FIGS. 1 and 2, the offset element 18*b* comprises an outer lead end that is to be connected to the above mentioned printed circuit board 20; so that the outer lead end extends in a generally downward direction. Offset element 18*b* also comprises a transistion portion that provides a transistion from the downwardly extending portion of the offset element 18*b* extending in a generally horizontal direction. The offset element 18*b* also comprises an interior offsetting elbow that terminates in a contact surface 34 that may be the horizontal end of the elbow, but is preferably a contacting surface that extends in a generally downward direction.

The Switching Operation

It will be noted that, for the relay illustrated in FIG. 2, the switch arm 30*b* does not normally contact the contact surface 34 of the offset element 18b. Therefore, an input electrical signal applied to the input terminal of switching element 16*b* would not be transferred to contact surface 34; and would not be present at the output terminal lead end of offset element 18*b*. The technical designation for this electrical state is that the circuit is normally incomplete, or open; i.e., the switch at the offset element 18*b* is normally open; and the offset element 18*b* is thus a normally open terminal of the switching arrangement.

By means to be discussed later, switch arm 30*b* may be moved appreciably counterclockwise indicated by the double ended arrow 31; so that the distal end of switch arm 30b no longer contacts the contact surface 27, but rather contacts the contact surface 34. At that time, an input electrical signal applied to the input terminal switch element 16b would be applied to the contact surface 34 of the offset element 18b; and will therefore be present at the output terminal lead end of the offset element **18***b*.

In this way, the relay may be used to switch an input signal that is present at switching element **16***b* to either the straight element 15a or the offset element **18***b*; and in a manner to be discussed later, either condition of the relay may be held for any desired length of time.

The above explanation has been presented in terms of a single switch arm 30b and two output terminal elements **15***a* and **18***b*; this switching mode being technically known as a single-pole double-throw — S.P.D.T. — switch because a single pole (switch arm **30***b*) may be set (thrown) to either of two positions.

Referring back to FIG. **2**, it will be seen that the relay base **12** actually contains two sets of relay elements **15***a*, **16**, **17***a*, **18***a*; and **15***b*, **16***b*, **17***b*, and **18***b*. These two sets of relay elements are illustrated as being identical, but as being reversed longitudinally with respect to each other; and as being in "opposition," i.e., facing each other.

For example, **15***a* and **15***b* are both straight elements; **16***a* and **16***b* are both switching elements; and **18***a* and **18***b* are both offset elements (realy elements **17***a* and **17***b* will be discussed later). Therefore, the above discussed switching operations may be performed by each of the two corresponding, but individual, switching arrangements (**16***b*, **15***a*, **18***b*; **16***a*, **15***b*, **18***a*). In this way, the disclosed relay may operate as two single-pole double-throw relay switching arrangements; or may operate as a double-pole double-throw switching arrangement - each switching arrangement handling its own individual electrical signal.

FIG. **2** illustrates that the contact surfaces, such as **27** and **34**, are convexly curved; but this curvature is not essential. The main requirement is that all contact surfaces must provide good electrical conductivity; this result being most readily obtained by suitably plating the contact surfaces — gold or silver plating being preferable in order to provide long lived contact surfaces. It has been preferable, as a matter of convenience, to plate the entire relay element; as will be discussed later.

It will be noted that in FIG. **1**, the external lead ends of relay elements **15**, **16**, **17**, and **18** are illustrated as being flared slightly outwardly; this flaring aiding in snapping the relay **10** into place on the printed circuit board, and also aiding in the holding of the relay **10** in place prior to the soldering operation that affixes the relay mechanically to the printed circuit board.

Relay Operation

It has thus far been explained how the disclosed relay may act as a switch of a desired type, by selecting a suitable number of relay elements, and by suitably positioning these relay elements. As indicated above, it is one of the desirable functions of a relay to be operated remotely, as by an electrical signal; and an explanation of how the disclosed relay achieves this remote control function will be understood from a further study of FIG. **2**.

It will be recalled from the previous discussion that a switching arrangement such as relay **10** of FIG. **2** has one or more normally closed contacts and one or more normally open contacts. For the state of the relay illustrated in FIG. **2**, the normally closed contacts are the straight elements **15***a* and **15***b*; and the normally open contacts are the offset elements **18***a* and **18***b* — so that input signals applied to switching elements **16***a* and **16***b* would normally appear at the normally closed straight elements **15***a* and **15***b*. This result is obtained by the curving and the biassing of the switch arms **30***a* and **30***b* so that they normally contact the straight elements **15***a* and **15***b*; but other normal states can be achieved by other curvature and biassing of the switch arms.

A slight digression becomes desirable at this time, in order to more fully understand the effects of magnetism. It has become customary to think that when a magnetic source is energized, "magnetic flux" flows out of one end of the magnetic source, flows through a magnetic circuit or loop, and then flows back into the other end of the magnetic source. In actuality, there is no actual flow; but this flowing flux concept permits a visualization of magnetic effects — and it will be used in the following explanation.

It is a characteristic of magnetic flux that it needs a completely closed path, or completely closed loop, in order to be most effective; and the loop should preferably have a low magnetic "reluctance" to obtain maximum magnetic flux. Such a low magnetic reluctance is provided by so-called magnetic materials (iron, etc.); air, on the other hand, providing a relatively high magnetic reluctance. It is also a characteristic of magnetic flux that it acts in such a way that it will, whenever possible, decrease the overall reluctance of the loop.

With the above discussion in mind, attention is again directed to FIG. **2**. The relay **10** must change its state in order to provide an output signal to the offset elements **18***a* and **18***b*; and this change of state is accomplished magnetically as follows. When energized, a magnetic source, (to be discussed later) causes magnetic flux to flow out of the magnetic source; and through two "pole pieces" **40** and **41** of FIG. **2**, as indicated by the arrows. These pole pieces **40** and **41** now serve as locations that produce localized magnetic fields.

It will be realized at this time, that the main reason for offsetting the offset elements **18***a* and **18***b* is to provide a location for the magnetic pole pieces **41** and **42**, so that the pole pieces are located close to the distal ends of the switch arms **30***a* end **30***b*. This extreme end location of the magnetic pole pieces provides optimal movement of the switch arms **30***a* and **30***b*.

Returning again to FIG. **2**, it will be recalled that the magnetic flux flows through the magnetic pole pieces **40** and **41**, through the adjacent air gaps, to the distal ends of the switch arms **30***a* and **30***b*; the air gaps forming a relatively high reluctance in the magnetic loop. In accordance with the above discussion about magnetism, the magnetic flux acts in such a manner as to reduce the overall reluctance of the loop; and, in the present case, it reduces the reluctance by attracting the movable distal ends of the switch arms **30***a* and **30***b* closer to the fixedly positioned magnetic pole pieces **40** and **41**. Thus, the distal ends of the switch arms are magnetically moved from the normally closed relay elements to the normally open relay elements; meanwhile switching the input electrical signals to different output terminals. The magnetic source may, of course, be energized for any desired length of time.

When the magnetic source is de-energized, this terminates the flow of magnetic flux; the magnetic attraction for the switch arms disappears; and the inherent resiliency and bias of the switch arms cause them to return to their normal illustrated state where they are again in contact with the normally closed relay elements **15**a and **15**b.

It becomes obvious that the switch arms **30**a and **30**b should be made of a low reluctance magnetic material in order to function magnetically as described above. It also becomes obvious that the switch arms **30**a and **30**b should also be electrically conducted in order to function electrically as described above.

Most of the comercially available soft irons satisfy both of these requirements; but some special alloys are particularly desirable for this purpose — nickel-iron and cobalt-vanadium-iron being typical of such special alloys. The switch arms **30**a and **30**b are therefore preferably made of a material of this type; and, as indicated above, are also preferably plated with gold or silver or "clad" with suitable layers to enhance their electrical characteristics at the area where they contact the contact surfaces. New alloys such as nyborium give premise of possessing mechanical, magnetic, and electrical properties that permit their use without plating or cladding.

The Magnetic Yoke

The above discussion has treated the two switching arrangement as though they were separate from each other; but they are actually interconnected for a very specific reason.

It will be advantageous at this time to follow the path of the magnetic flux; that is, to trace out the magnetic loop. Starting, for convenience, at pole piece **40**, the magnetic flux would flow in the direction of the arrow to the switch arm **30**b; would flow along switch arm **30**b to the switching element **16**b, would then flow along a "magnetic yoke" **42** to the other switching element **16**a; and would then flow along switch arms **30**a to magnetic pole piece **41**. It quickly becomes apparent that magnetic yoke **42** is a vital part of the series connected magnetic circuit, and should also be comprised of a magnetic material.

However, a close study of the electrical circuit of FIG. **2** shows the magnetic yoke **42** is also electrically connected directly across switching elements **16**a and **16**b; and may provide an undesired electrical interconnection, or a "short." Therefore, the magnetic yoke **42** must be, per se, either an electrical insulator or must be electrically insulated from one or both of the switching elements **16**a and **16**b.

It has been found preferably to use the latter approach; that is, to electrically insulate the magnetic yoke **42** from one or both of the switching elements. This result is most readily achieved by forming the magnetic yoke **42** of a magnetic material; but providing an electrically insulating film between the magnetic yoke **42** and the location where it is attached to the switching elements **16**a and/or **16**b. This electrically insulating film may take any of several forms. For example, it may be an air gap; alternatively it may comprise a thin sheet of electrically insulating material such as an adhesive, a plastic, or the like; or it may be an electrically insulating film, such as an oxide or the like, formed chemically on one or both surfaces of the adjacent materials that form the yoke/switching element interface.

Basically, magnetic yoke **42** takes the form of a U-shaped piece of magnetic material, wherein the upright portions have been slid longitudinally away from each other, while still remaining parallel. As indicated in FIG. **3**, the upright portions **43** of the magnetic yoke **42** have the above discussed electrically insulating film on their inner surfaces (or on all surfaces); and the film coated inner surfaces are adhered, clamped or otherwise affixed to the vertical surface of respective switching elements **16**a and **16**b. In this way, the magnetic yoke **42** completes the magnetic loop; but electrically separates the switching elements **16**a and **16**b.

The Simultaneous Switching

It will be recalled from the above described magnetic loop, that the two switching arms **30**a and **30**b are in a series type magnetic relationship; that is, the same magnetic flux flows through both switching elements **16**a and **16**b. This series relationship solves the following problem.

Obviously, no two switch arms have exactly the same amount of resiliency; no two magnetic pole pieces have exactly the same size and shape; no two pole piece/-switching arms will have exactly the same spacing; etc. Therefore, there is a slight tendency for the two switch arms to move at somewhat different rates; and to open or close their respective electric circuits at slightly different times. In some electronic circuits this maltiming is a serious disadvantage, because the electronics designer desires certain circuits to function similtaneously; and if these circuits do not do so because of the performance of a switching device such as a relay, the apparatus may malfunction or the designer must design in a safeguard.

The disclosed relay provides practically simultaneous switching, as may be understood from the following considerations. Assume that one of the switch arms, say **30**b for example, tends to move faster; and to thus complete its circuit somewhat earlier than the other switch arm **30**a. As the distal end of switch arm **30**b approaches its respective contact surface **34**, the decreased length of its air gap increases the amount of magnetic flux, and this increased magnetic flux acts on the other magnetic pole piece **41** to provide a stronger magnetic field that accelerates the movement of its associated switch arm **30**a. In this way, the disclosed series type magnetic arrangement tend to equalize the movement of the two switch arms; and to provide simultaneous opening and closing of their respective circuits.

Mechanical Considerations

In FIG. **4**, a typical relay, made in accordance with the teachings of theresent invention, is illustrated in an exploded manner in order to show the interrelationship between the various mechanical parts. In FIG. **4**, the relay cover **11** is shown to be a box-like configuration having walls **46**; the relay cover **11** being adapted to receive an electrical coil **47** that is enclosed in a relatively tough coating **48**.

The Coil

Coil **47** is of the type that comprises a winding of electric wire; the wire winding of coil **47** terminating at a coil tab **49**. Another such tab is on the other side of the coil **47**, and thus is not visible in FIG. **4**.

When electricity flows through coil tabs **49**, and thus through the wires forming the coil **47**, coil **47** becomes an electro-magnet, and magnetic flux appears at end pieces such as **50** and **51** which have the previously discussed magnetic pole pieces **40** and **41** positioned at their lower ends. The pole pieces **40** and **41** now activate the switch arms **30**a and **30**b as discussed previously in connection with FIG. **2**. Coil **47** preferably fits closely into the interior of relay cover **11**; being held there by friction, suitable clamps, adhesives, or the like, the end pieces **50** and **51** projecting downwardly out of relay cover **11** as indicated.

In FIG. **4**, the relay elements previously discussed in connection with FIG. **2** are now shown in a pictorial manner. In FIG. **4**, there is shown the previously discussed straight elements **15***a* and **15***b*, the offset elements **18***a* and **18***b*, and the bent L switch arms **16***a* and **16***b*.

It should be noted that in FIG. **4** the contact surfaces are illustrated as being flat rather than as being convex, and are further illustrated as having their outer lower ends extending vertically downward rather than flaring outwardly; the reasons for these will become apparent from a subsequent discussion.

The Coil Elements

FIG. **4** illustrates two relay elements **17***a* and **17***b* that have not been previously discussed, although they were shown in the top view of FIG. **2**. Relay elements **17***a* and **17***b* serve the function of contacting the coil tabs **49** illustrated as being positioned on coil **47** of FIG. **4**. Relay elements **17***a* and **17***b* will therefore be called the coil elements; and these coil elements **17***a* and **17***b* and the coil tabs **49** are suitable positioned to contact each other when the relay is assembled as will be discussed later.

Relay base **12** of FIG. **4** is illustrated as being box like in form, having walls **25** and a bottom **52**. Preferably, the walls **25** of the relay base **12** have a plurality of notches **53** that receive the previously discussed transitional portions of the various relay elements **15, 16, 17,** etc.; notches **53** acting to hold the relay elements in position during and after relay assembly, and until the relay is soldered in place on a printed circuit board.

In FIG. **4**, the various relay elements **15, 16 17,** etc. are illustrated as having interior portions that are downwardly directed; these in some cases (**15** and **18**) acting as a contact surface, and in some cases (**16**) acting as part of the switching element. In the relay element configuration of FIG. **4**, these downwardly directed element portions serve an additional purpose; namely, that of additionally holding the relay elements in place.

As indicated in FIG. **4**, relay base **12** has a support structure that may take the form of a plurality of individual prism like support pillars **54** that support the horizontal transition portions of the relay elements where they enter notches **53** of the relay base **12**, these support pillars **54** serving an additional function by permitting the downwardly directed portions of the relay elements to be "hooked over" the vertical edges of the support pillars **54** to further support and position the relay elements within the relay base.

The vertical portions of the support pillars also support the vertical contact surfaces of the relay elements **15** and **18**; and thus help provide proper pressure for making good electrical contact with the switch arms. In the case of the switching elements **16**, the vertical portions of the support posts **54** provide a support for the bending to which the switching elements **16** are subjected.

As an alternative form of the support structure, FIG. **4** also discloses a continuous support wall **55** that serves the same function as the individual support pillars **54**; but may, under some conditions, be easier to provide, especially if the relay base **12** is formed by a plastic molding process.

The Relay Element Array

One simple way of forming the various relay elements is shown in FIGS. **5** and **6**. Directing attention first to FIG. **5**, this shows a planar element array **60** produced as a result of a stamping or punching operation performed on a sheet of plated material such as the nickel ferrite mentioned above. As a result of the stamping operation, the resultant element array **60** comprises individual strips of material identified in FIG. **5** by the references characters **15***a*, **16***a*, **17***a*, and **18***a*; these individual strips being interconnected by a common carrier strip **61**. As may be realized, the individual strips of FIG. **5** will eventually form the various relay elements of FIGS. **1, 2, 3** and **4**.

Directing attention now to FIG. **6**, the relay element array **60** is shown to have been configured by suitable bending to a multi-plane configuration as indicated. In FIG. **6**, the carrier strip **61** has been bent horizontally to strengthen the array and has had a recntagular bend **62** formed in it to provide the desired spacing of the relay elements **16***a* and **17***b*.

This latter item may be best appreciated by referring back to FIG. **2**, which shows that the switch arms **30***a* and **30***b* need an appreciable length in order to function properly in that particular configuration. Unfortunately, the desired length for the switch arm is not conveniently available in a planar stamping configuration. Therefore, the distance between adjacent relay elements **16***a* and **17***a* is intentionally lengthened to provide the desired length for the resultant switch arm **30***a*. The rectangular bend **62** of FIG. **6** provides means for later obtaining the desired spacing between these relay elements.

Relay Assembly

The assembly of the disclosed relay is extremely simple and easy and therefore, economical as may be understood from FIG. **4**. Two identical relay elements arrays (as shown in FIG. **6**) are positioned in reversed opposition to each other and a magnetic yoke, **42** (shown in a somewhat different configuration) is then positioned as indicated in FIG. **4**. The resiliency of yoke **42** and the carrier strips (**61** of FIG. **6**) act to rigidify and integralize the composite dual element arrays for easier handling. The composite dual element arrays are then dropped into respective notches of the relay base **12** and are then hooked to respective portions of the support structure.

The next step is the insertion of the coil **47** into the relay cover **11**, and the cover/coil subassembly is then placed atop the base/element subassembly. At this time, the coil elements **17***a* and **17***b* make contact with the coil tabs **49**; the other relay elements being insulated from the coil wire by the coating **48**. Alternatively, the coil elements **17a** and **17***b* may be bent upwardly to contact suitably positioned coil tabs **49**.

The magnetic end pieces **50** and **51** of the coil **47** fit into their design locations; their magnetic pole pieces **40** and **41** coming to rest at or near the bottom of the relay base **12**.

The mating edges of the cover **11** and the base **12** may be held to each other with suitable adhesives, clamps, or the like; and, if desired, the relay elements may also be held in place by means of a suitable adhesive. If such an adhesive is used, it may be of the sealing type that produces a hermetically sealed relay. The carrier strips **61** are now cut away to form a "truncated" element array wherein the separated relay elements can perform their mechanical, electrical, and magnetic functions.

An alternative method of assembly is to first place the magnetic yoke **42** (having the above described electrically insulating film thereon) in position on the bottom **52** of the relay base **12** adjacent the support structure locations that will support the vertical part of the switching elements **16***a* and **16***b*. Two element arrays **60** are then positioned in opposition to each other, in the relay base **12**; the carrier strips **62** making the element arrays **60** easy to handle. In this way, the yoke, the switching element, and the support structure assure proper spacing and fit. The cover/coil subassembly is added as discussed above and the carrier strips **61** are cut away to form a truncated relay element assembly, the relay elements now being securely held in place by the notches and/or the adhesive.

It will be noted that the disclosed relay uses two identical, but reversed, element arrays to provide a double-pole double-throw switch mode. Obviously, different tyeps of element arrays may be used to achieve the same, or different switching arrangements.

Alternatively, a plurality of relay element arrays may be linked by a suitably configurated carrier strip; thus reducing the number of parts to be handled during the assembly of the relay.

The foregoing general description and exemplary body dimensions are typical of a configuration known in the integrated circuit terminology as a DIP (Dual In-Line Package); and while the circuit elements have been disclosed as being installed directly into a printed circuit board, these may alternatively be fitted into a socket that is, in turn, installed directly into a printed circuit board. The later arrangement provides facilities for easily replacing the relay, when this is desirable.

The installation and soldering of the elements of the relay or the socket may be accomplished manually or mechanically.

SUMMARY

The disclosed relay has many advantages over prior art relays. First of all, it is much smaller, lighter weight and more compact. Second, it is easy to manufacture and assemble. Third, it is economical to build. Fourth, it is adapted to a wide variety of switching modes. Fifth, it produces more simultaneous opening and closing of the switch contacts. Sixth, its terminals are formed into a very convenient configuration by means of simple stamping operations. Seventh, the terminals are in a rigidized and integralized condition during assembly. Eighth, the terminals of the assembled unit are easily separated from each other. And finally, the disclosed relay is ideally adapted for use with present day printed circuit boards.

What is claimed is:

1. A relay comprising in combination, a relay housing, an electrical winding within said housing energizable to provide magnetic flux and de-energizable to terminate said flux, means including a pair of magnetic pole pieces providing a path for the magnetic flux of said winding, a pair of movable contactors within said housing each having a stationary contact for circuit making and circuit breaking cooperation therewith, and means arranging said contactors in series relation in the path of said magnetic flux.

2. A relay according to claim **1** wherein said series arranging means comprises a magnetic flux conducting yoke magnetically interconnecting said contactors but preventing electrical energy flow therebetween.

3. A relay according to claim **2** wherein said yoke is so positioned relative to one of said contactors as to provide an air gap therebetween for preventing electrical energy flow while permitting magnetic flux flow in said contactors.

4. A relay according to claim **3** wherein each of said contactors and its respective stationary contact can be connected in an electrical circuit which is separate and distinct from the circuit of the other contactor and stationary contact therefor.

5. A relay according to claim **4** wherein each of said contactors includes a stationary terminal portion on which the respective contactor is mounted for arcuate movement toward and away from a separate one of said pole pieces in response to energization and de-energization of said winding.

6. A relay according to claim **5** wherein said yoke is mounted in spaced relation to at least one of said terminals to provide the air gap between said contactors.

7. A relay according to claim **5** wherein each of said contactors is formed integrally with its terminal portion.

* * * * *