July 7, 1970 H. J. MACKWAY 3,519,766

PUSHBUTTON MECHANISM

Filed Feb. 23, 1968 4 Sheets-Sheet 1

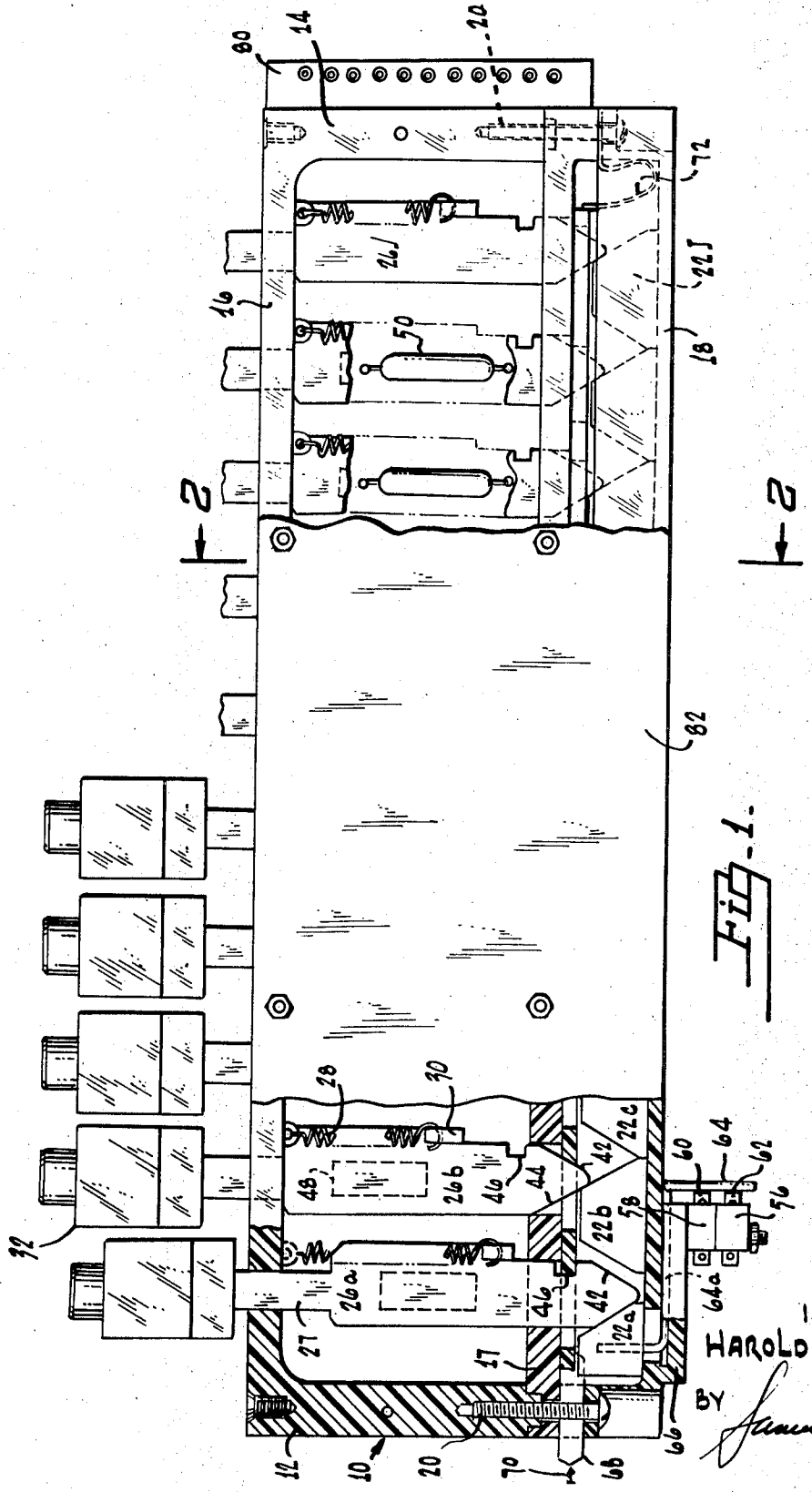


Fig. 1.

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PUSHBUTTON MECHANISM

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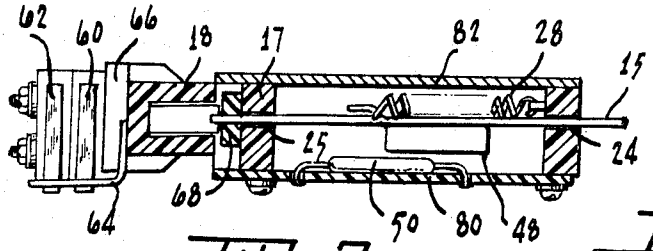


Fig. 2

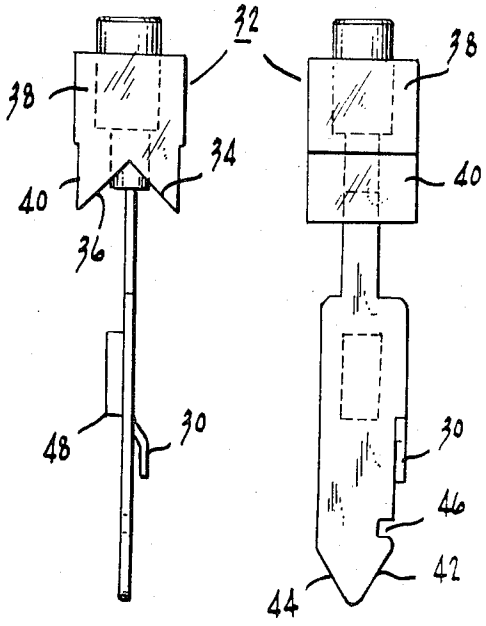


Fig. 3 Fig. 4

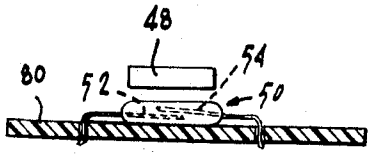


Fig. 6

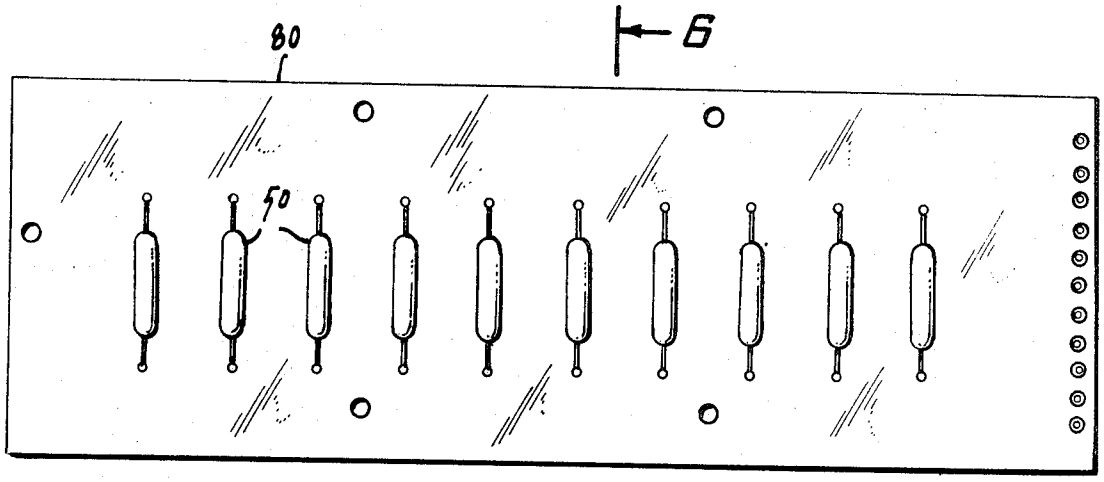


Fig. 5

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PUSHBUTTON MECHANISM

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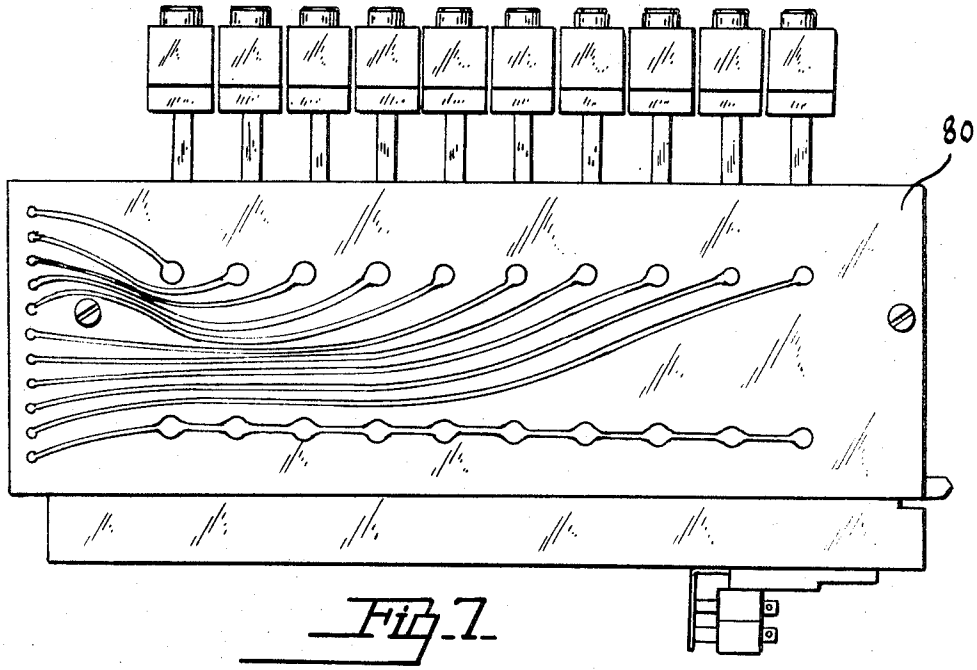


Fig. 7

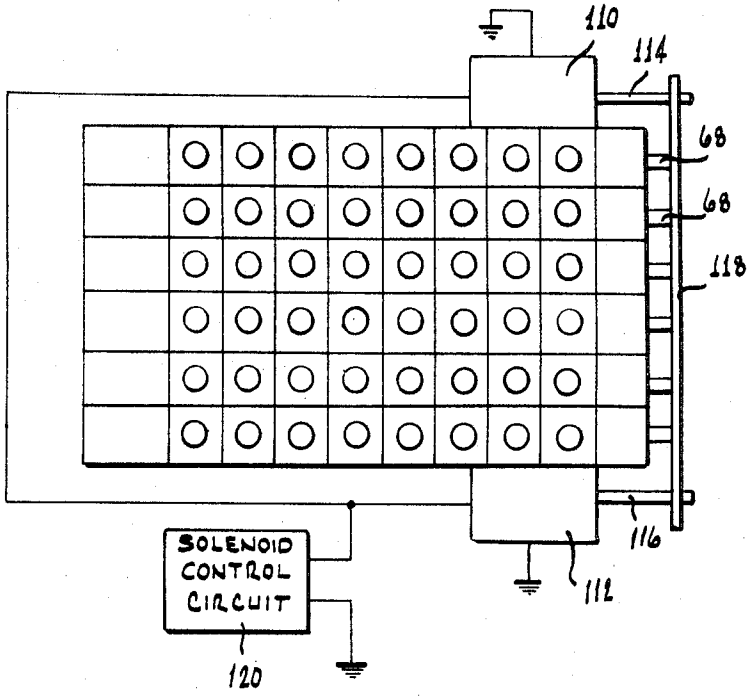


Fig. 8

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PUSHBUTTON MECHANISM

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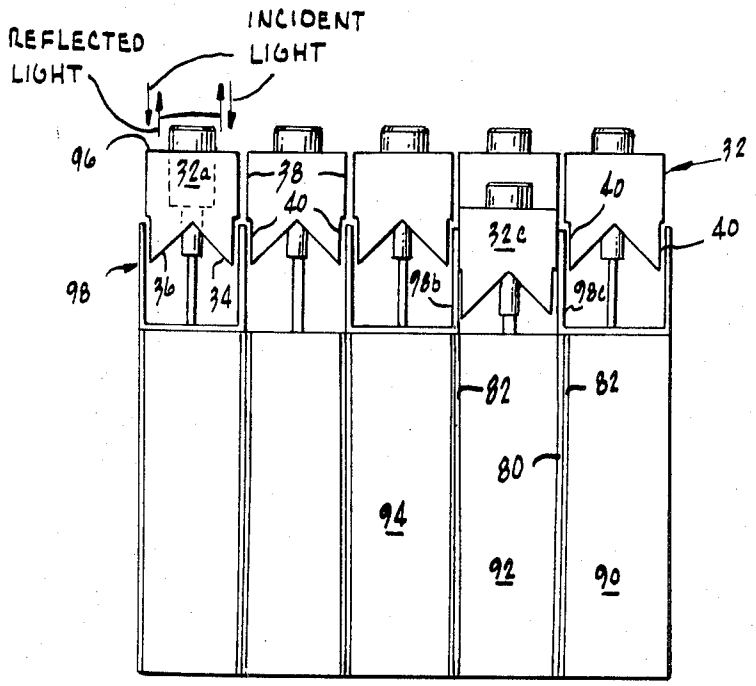


Fig. 9

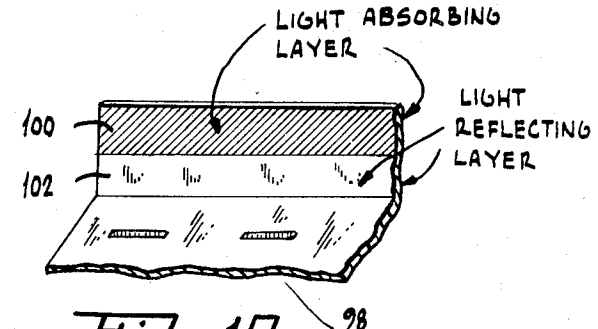


Fig. 10

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United States Patent Office 3,519,766
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3,519,766

PUSHBUTTON MECHANISM

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Filed Feb. 23, 1968, Ser. No. 707,800
Int. Cl. H01h 9/26
U.S. Cl. 200—5 8 Claims

ABSTRACT OF THE DISCLOSURE

Pushbutton switches of the type in which, in each bank, the depression of one button releases a previously depressed button. A printed circuit board leading to the electrical contacts of one bank of switches acts also as a side wall for that bank of switches, and an electric and magnetic field shield member serves as its other side wall. Additional features of these switches include simple and inexpensive one-piece plungers, simple means for automatically illuminating the depressed buttons, simple means for atuomatically illuminating the depressed buttons, means for automatically electrically indicating whether a pushbutton in a bank is depressed, and means for resetting, in unison, a plurality of banks of switches.

BACKGROUND OF THE INVENTION

Pushbutton switches are well-known and are commonly used for controlling the operation of electrical circuits. Typical of such switches are those illustrated, for example, in U.S. Pats. Nos. 2,414,307, 2,192,621 and 3,281,544, and many other patents in Class 200–5 and related classes. However, in one particular application, that of a matrix of such switches arranged in the form of a keyboard and employed for the purpose of entering binary information into a data processing machine, the known switches have been found not to be entirely satisfactory.

For example, one commercially available switch is guaranteed for 100,000 operations, whereas in the particular requirement mentioned above, at least a million operations should be performed during the life of the switch. A second disadvantage of the known switches resides in their complexity—a factor which accounts for their high initial cost and their potential high cost for maintenance. Finally, in the known switches, features such as switch button illumination, switch reset capability and others, either are completely unavailable or are of excessive cost.

The object of this invention is to provide a greatly improved switch of good operating characteristics, of extremely long life and relatively low cost.

SUMMARY OF THE INVENTION

In the pushbutton type switch bank of the present invention, each plunger element is formed of a single sheet of metal and is formed with a first cam surface at one edge thereof which, when the plunger is depressed, engages a latch and causes it to release any other plunger which previously may have been depressed and a second cam surface at the opposite edge thereof for engaging one of a group of side-by-side elements which prevent the depression of any other plunger. The two cam surfaces of said plunger, in a preferred form of the invention, together define the pointed end of said plunger.

The side-by-side elements mentioned above are normally biased to a home position when none of the plungers is depressed. According to a feature of the invention, means coupled to an end of one of the elements actuates a switch which is common to all plungers, when any one of the elements is moved in response to the depression of a plunger.

Another feature of the invention is the use of a printed

circuit board to mount the switches actuated by the plungers, to carry the printed wiring for said switches, and to serve as a side wall of the housing for a bank of the switches. A second side wall serves as an electric and magnetic field shield and prevents the operation of any switch bank from adversely affecting the operation of any other switch bank.

A fourth feature of the invention is the use of transparent pushbuttons movably mounted in guide channels and formed with internal prism surfaces. The guide channels are formed with coatings optically coupled through the side walls of the pushbuttons of these prism surfaces so that in one position of the pushbutton, the face of the pushbutton is dark and in another position of the pushbutton, its face appears to be lit up.

A final feature of the switch bank of the invention is its ability automatically to be reset. Reset means are coupled to the latches of all switches and in response to an electrical signal simultaneously release all depressed pushbuttons.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a plan view, with one side wall removed, of a switch bank according to the invention;

FIG. 2 is a section taken along line **2**—**2** of FIG. 1;

FIGS. 3–4 are plan and edge views of the plunger assembly of the switch of FIG. 1;

FIG. 5 shows one side wall of the switch of FIG. 1;

FIG. 6 is a section taken along line **6**—**6** of FIG. 5;

FIG. 7 is a plan view of the switch of FIG. 1 which shows the back side of the printed circuit board of FIG. 5;

FIG. 8 is a top view of a keyboard consisting of 6 banks of switches arranged side-by-side and showing the means for resetting all banks in unison;

FIG. 9 is an end view of 5 banks of switches side-by-side; and

FIG. 10 is a perspective, partially broken-away view of a portion of FIG. 9.

DETAILED DESCRIPTION

The switch bank shown in FIGS. 1 and 2 includes a housing **10** formed of a plastic material such as a polycarbonate. (One suitable commercially available plastic is "Lexan" made by General Electric.) This housing includes end walls **12** and **14** and a top wall **16**, these three walls being formed of a single piece of material. The second part **17** of the housing **10** serves as a guide for the pushbutton plungers. It is formed with ten slots through which the ten plungers **26** fit. A third part **18** of the housing serves as a guide for the polycarbonate plastic wedge-shaped elements, **22***a*, **22***b* . . . **22***j*. The polycarbonate plastic parts **17** and **18** are secured to the end walls **12** and **14** by two metal screws **20**.

Located within the housing are ten plungers **26***a*, **26***b* . . . **26***j*. The shaft **27** of each plunger passes through a slot **24** in the upper wall **16** and the opposite end of each plunger passes through a slot **25** in the part **17** at the lower part of the housing. These two slots therefore permit the plunger to move only along a straight line path.

Each plunger is normally maintained in its retracted position by means of a coil spring, one of which is shown at **28**. The coil spring is secured at one end to the upper wall **16** of the housing and at its other end to a tab **30** on the body of the plunger. The plunger is made of a nonmagnetic metal such as brass and is stamped out in a single operation. This stamping process both produces a plunger of the shape shown with the tab **30** bent in the manner shown.

A transparent pushbutton of molded acrylic plastic, such as Plexiglas, one of which is shown at **32**, is located at the end of each plunger. The details of this pushbutton

are shown more clearly in FIG. 3. The lower surface is cut in inverted V-shape to provide two prism surfaces **34** and **36**. For the sake of convenience, each prism is at an angle of 45° and the angle between the two surfaces **34** and **36** is 90°.

FIG. 3 shows that the upper part **38** of each pushbutton is somewhat thicker than the lower part **40** of the pushbutton. The reason for this will be discussed shortly.

The plunger body is pointed at its end. The two surfaces **42** and **44** act as cam surfaces when the plunger is depressed. As will be discussed in more detail shortly, cam surface **42** pushes a latch mechanism **68** (FIG. 1) in one direction to effect the release of any other pushbutton which may then be in a depressed condition, and the surface **44** engages a wedge and pushes it in the opposite direction. In brief, the purpose of doing this is to prevent a second pushbutton from becoming latched and also to actuate the switches **56** and **58**. The slot **46** is for the purpose of engaging the latch mechanism so that when the plunger is depressed, it will remain depressed and not be pulled back by a spring (**28**, FIG. 1).

There is secured to the side of the plunger, a ceramic permanent magnet **48**. Its purpose is to control the operation of a reed-type switch **50**, such as shown in FIG. 6. The contacts of the switch are normally biased to the open position by the natural tension of the switch elements **52** and **54**. When a pushbutton is in its released position, as shown in FIG. 2, the pole of the permanent magnet **48** is located adjacent to the contact region and the contacts remain open. However, when a pushbutton is depressed so that the center of the magnet is aligned with the contact area, as shown in FIG. 6, the switch contacts **52–54** close. The theory is well understood and need not be discussed here and the switches **50** are commercially available.

Returning to FIG. 1, there is secured to the channel element **18**, two microswitches **56** and **58**. The arms (actually leaf springs) **60** and **62** for these microswitches are engageable by a bent element **64** formed of spring steel wire, which is secured at one end to the end wedge **22***a*. The center region **64***a* of the spring element **64** rides in a channel in the plastic supporting bracket **66** of the microswitches.

The polycarbonate plastic latch mechanism for the plungers is element **68**. It is slidable in the direction of arrows **70** but is normally maintained in the position shown in FIG. 1 by means of the leaf spring **72** at the extreme right end of the channel **18**, as seen in FIG. 1.

In the operation of the switch bank of FIG. 1, assume first that all plungers are retracted. The leaf springs **60**, **62** move the wedge **22***a* to the right via the bent element **64** and the microswitches **60**, **62** are open.

Assume now that the plunger **26***a* is in its depressed state, as shown, and that all of the other plungers are in their upper or retracted position. When the plunger **26***a* is depressed, the wedge-shaped element **22***a* is moved to the left and this moves with it, the bent element **64**. The latter actuates the microswitches **56** and **58** and they indicate to a computer that a plunger in the bank shown is depressed. It is important, for reasons not necessary to discuss here, that the computer have this information.

Assume now that it is desired to depress plunger **26***b*. As the plunger moves down, the cam surface **42** at the end of the plunger rides against the latch mechanism **68** and moves this mechanism to the right. Concurrently, the cam surface **44** engages the wedge **22***b* and moves it to the left. After the plunger is depressed a certain amount, the latch mechanism **68** moves sufficiently so that it disengages from the slot **46** of the depressed plunger **26***a*, releasing plunger **26***a*. The spring (not shown) of plunger **26***a* now withdraws this plunger to its retracted or upper position.

The plunger **26***b* continues to move down and shortly its notch **46** aligns with the latch **68** and the spring **72** thereupon snaps the latch into position to hold the plunger **26***b* in its depressed position. At the same time, the wedge-shaped element **22***b* has moved to the left until it engages the lower part of the wedge-shaped element **22***a*. Thus, the wedge-shaped element **22***a* is returned to the position shown and the microswitches **56** and **58** return to their actuated position. Note that when a plunger is released, the switches **56** and **58** also momentarily are released before the plunger then being depressed is latched.

Finally, in the extreme down position of the plunger **56***b*, all of the wedges are so positioned that insufficient space remains to permit a second plunger to be fully depressed while the plunger **26***b* is being maintained in the depressed position. If the plunger **26***b* is being maintained fully down with one finger, no other one of the plungers can be pushed to its fully depressed position as, before it gets there, one of its cam surfaces **42** or **44** will engage one of the wedges **22**. Those plungers **26***c*–**26***j* to the right of plunger **26***b* will engage a wedge-shaped element with their cam surface **44**. If, on the other hand, it were attempted to depress plunger **26***a* while plunger **26***b* was maintained fully depressed, its cam surface **42** would engage wedge-shaped element **22***b* which would prevent plunger **26***a* from being fully depressed.

The side walls **80** and **82** of the switch bank of FIG. 2 also have important functions in addition to the usual one of environmental protection. The side wall **80**, for example, serves as a printed circuit board. The reed-type switch elements **50** are fixed to the inner surface of this circuit board **80** and printed circuit wiring, as shown in FIG. 7, is located on the outer surface of the circuit board **80**. The generally circular areas shown in FIG. 7 are the points at which the leads for the reed switches **50** are located as shown somewhat more clearly in FIG. 2. After the printed circuits are laid down, they are insulated by a transparent material in a manner well understood in the art.

The side wall **82** is formed of a magnetic material such as iron and its purpose is to provide electrical and magnetic isolation between successive bangs of pushbutton switches. Such successive banks are shown in end view in FIG. 9. Note that the shield **82** for switch bank **90**, for example, is located immediately adjacent the printed circuit board **80** for switch bank **92**. Thus, any electrical or magnetic fields present in switch bank **92** are shielded from switch bank **90**. In a similar manner, the shield **82** for switch bank **92** isolates it from the switch bank **94** and so on.

The design of the pushbuttons is such that they are self-illuminating without the use of any external power. As is shown in FIG. 9, incident light passes through the upper face **96** of each button **32** and is then reflected from the prism surfaces **34** and **36** to the walls of the U-shaped housing **98**. As is seen more clearly in FIG. 10, the upper part **100** of each wall of the housing is coated with a light-absorbing layer such as dull black paint, whereas, the lower part **102** of each side wall is covered with a light-reflecting layer. As one example, the coating may be a masking tape such as "Scotchcal" in a yellow-orange or similar fluorescent, very-bright shade. These light-absorbing and light-reflecting layers are located in the same position both on the inner and the outer surfaces of the walls of each U-shaped housing for reasons which will become clear shortly.

In the operation of the arrangement shown in FIG. 9, when a pushbutton such as **32***a* is in the upper position, incident light passes through the pushbutton and is reflected from the prism surfaces **34** and **36** onto the light-absorbing layer **100**. This light is very poorly reflected from layer **100** so that the button looks very dark to the eye. On the other hand, when a button such as **32***c* is depressed, the incident light strikes the lower region **102** of the outside surfaces of the two adjacent U-shaped channels **98***b* and **98***c*. This light is reflected back from the prism surfaces of button **32***c* and through the upper

surface of the button **32***c* to the eye. To the viewer therefore, the depressed switch looks bright and appears to emit colored light, the color depending upon the material of which the layer **102** is made.

The fact that the U-shaped housings **98** are coated with light-absorbing and light-emitting layers on their inner and outer surfaces permits a saving in costs. One such housing is needed for only every other switch bank so that if there is an add number n of side-by-side banks only $(n+1)/2$ housings **98** are needed.

When a pushbutton is depressed, its surfaces **38** actually engage either the outer or the inner surfaces of a U-shaped housing **98**. However, the recessed portions **40** of the switch do not make such contact. Thus, the recessing prevents abrasion of either surface **40** and this is important as such abrasion would soon cause these surfaces to become translucent rather than transparent and the self-illuminating properties of the button to become lost.

It is sometimes desirable, upon command from the computer, to reset all banks of a switch matrix in unison. The resetting of all switches, in accordance with the invention, is accomplished by using a pair of solenoids **110** and **112** positioned in the manner shown in FIG. 8. These solenoids are mechanically coupled by linkages **114** and **116** to a bar **118** which is engaged with the extending ends of all of the latches **68**. (In FIG. 1, this end of latch **68** is visible at the lower left.) When both solenoids are energized by the solenoid control circuit **120**, the bar **118** is retracted and this causes all of the latch mechanisms to move in a direction to release the plungers of all switch banks.

While for purposes of illustration, FIG. 8 shows a pushbutton with 6 switch banks, each with 8 switches, it is to be appreciated that, in practice, the pushbutton may be much larger than this. Similarly, while the switch bank of FIG. 1 is shown to have one magnet and one switch per plunger, in practice, there may be more magnets and switches per plunger. For example, there may be magnets glued to each surface of the plunger and a switch adjacent each magnet so that the depression of a plunger simultaneously will actuate several switches. As a matter of fact, models have been constructed where as many as five switches have been actuated by a single plunger.

As stated in the introduction, the best commercially available switch of the general type discussed herein is guaranteed for only 100,000 operations. Extensive tests have been performed of switch banks made according to the present invention and all such banks have gone better than one million operations without failure. A number of such banks already have exceeded two million operations and some, it is believed, will go well in excess of three million operations. With respect to costs, it is possible to manufacture a switch bank of the present invention for less than one-half the price of competitive designs. The reason is the very simple nature of the various parts. As already mentioned, the metal plunger is punched from a single piece of metal in a single operation. The plastic parts of the housing are molded in three pieces; one piece for element **12**, **14**, **16**, one piece for element **17** and one piece for channel **18**. The latch is molded as a fourth piece. The side walls serve multiple purposes, one including that of a printed circuit board and the other including that of a magnetic and electrical field shield. In addition to all of this, each switch bank has such additional important features as self-illumination of pushbuttons, automatic reset capability, and means for indicating whether or not a pushbutton is depressed.

What is claimed is:

1. In a pushbutton switch bank of the type including a latch and a plurality of plungers, and in which the depression of one plunger actuates the latch to cause it to release any other plunger engaged thereby, and also including a plurality of elements responsive to the depression of one plunger for preventing the depression of any other plunger, the improvement in each plunger comprising:

solely a single generally flat member formed from a single sheet of material and formed with a first cam surface at one edge thereof, which when the plunger is depressed, engages said latch and causes it to release any other plunger which previously may have been depressed, and a second cam surface at the opposite edge thereof for engaging one of said elements when said plunger is depressed, and formed also with a slot along one of said edges for engaging said latch.

2. In a switch bank as set forth in claim **1**, said two cam surfaces on said improved plunger comprising two edges of said plunger which together define the pointed end of said plunger.

3. In a pushbutton switch bank as set forth in claim **1** in which said plungers are located in a housing, further including switch means fixed to said housing, and a switch engaging means coupled to an end one of said plurality of elements for actuating said switch means in response to the depression of any one of said plungers.

4. In a pushbutton switch bank of the type including a latch and a plurality of plungers, and in which the depression of one plunger actuates the latch to cause it to release any other plunger engaged thereby, and also including a plurality of elements responsive to the depression of one plunger for preventing the depression of any other plunger, an improved plunger comprising:

a member formed from a single sheet of material and formed with a first cam surface for engaging and moving said latch in one direction for causing it to release any previously engaged plunger, and a second cam surface for engaging and moving one of said elements and for moving others, if any, adjacent to said one element, in the direction opposite from the direction of movement of said latch, said two cam surfaces together defining the pointed end of said plunger.

5. A pushbutton type switch bank comprising, in combination:

a channel;

a plurality of elements, movable relative to one another, each formed with at least one cam surface adapted to be engaged by the end of a plunger, said elements for preventing more than one plunger from being depressed at a time, each element having a length which is a fraction of that of said channel, said elements being arranged one after another, in end-to-end abutting relation, along the length of said control;

biasing means at one end of said channel for normally biasing said elements for maintaining all elements in a home position when none of said plungers is depressed;

a switch; and

means coupled to the end one of said elements which moves in response to the displacement of any one of said elements from its home position, for actuating said switch.

6. In a pushbutton type switch bank as set forth in claim **5**, said last-named means including said biasing means.

7. In a pushbutton switch bank as set forth in claim **1**, said plungers being located in a housing, each said plunger being formed with a tab along one edge thereof for anchoring a spring, and further including for each plunger a spring secured between said tab and a point on said housing such that each spring tends to oppose the depression of its plunger.

8. A pushbutton type switch matrix comprising the combination of:

a plurality of switch banks arranged side-by-side so

that the pushbuttons form a keyboard array, each switch bank comprising:

a latch;

a plurality of plungers, each plunger actuated by a pushbutton, each plunger for actuating said latch and causing it to retain said plunger in a depressed position in response to the depression of said plunger and

release means for said latch extending from said bank for causing the latch to release any plunger it may be retaining, when said release means is actuated; and

a common release mechanism for all of said latches comprising means mechanically coupled to all of said release means for concurrently actuating the release means for all latches.

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ROBERT K. SCHAEFER, Primary Examiner

J. R. SCOTT, Assistant Examiner

U.S. Cl. X.R.

200—153, 169