United States Patent [19]

Schumacher et al.

[11] **3,781,502**

[45] **Dec. 25, 1973**

[54] **MERCURY SWITCH WITH HEAT SINK CONTACT**

[75] Inventors: **Walter C. Schumacher,** Warwick; **Ralph L. Graves,** East Greenwich, both of R.I.

[73] Assignee: **General Electric Company,** Providence, R.I.

[22] Filed: **Apr. 28, 1972**

[21] Appl. No.: **248,407**

[52] **U.S. Cl.** ..... **200/226,** 200/166 K, 200/221

[51] **Int. Cl.** **H01h 29/20**

[58] **Field of Search** ..... 200/226, 227, 228, 200/221, 220, 222, 166 K

[56] **References Cited**

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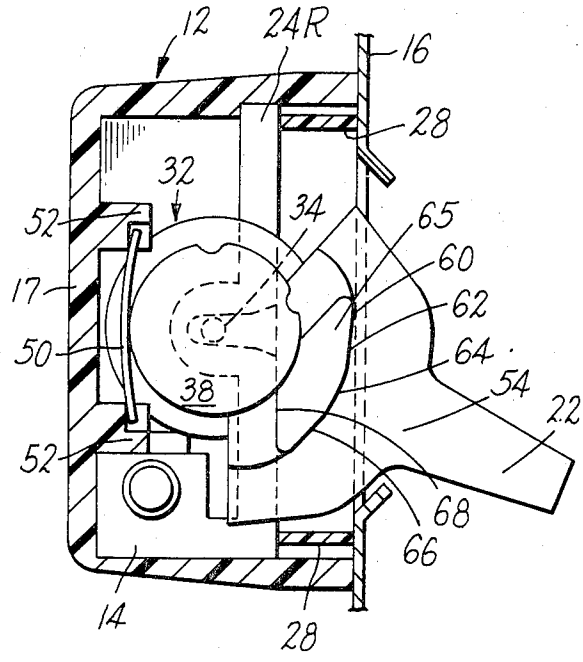
Primary Examiner—Herman J. Hohauser

Attorney—Paul E. Rochford et al.

[57] **ABSTRACT**

A mercury switch is provided which gives a mercury button a higher switching capacity in terms of the level of electric power which can be switched. The switch is provided with novel contacts which have spring action to enhance both electrical contact and transfer of heat from the button and from the switch. Greater compactness of switch structure is achieved in spite of the higher power switching capability built into the switch thus reducing crowding of wire connections within the wall box in which the switch is mounted.

16 Claims, 17 Drawing Figures



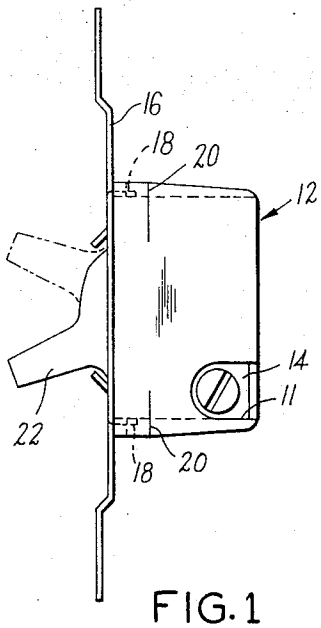


FIG. 1

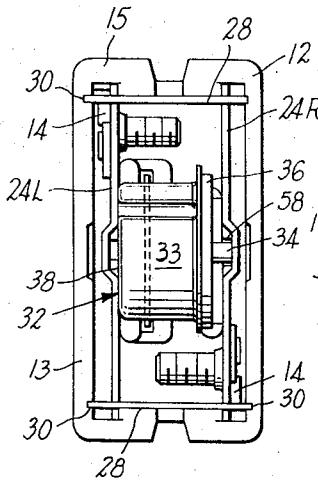


FIG. 2

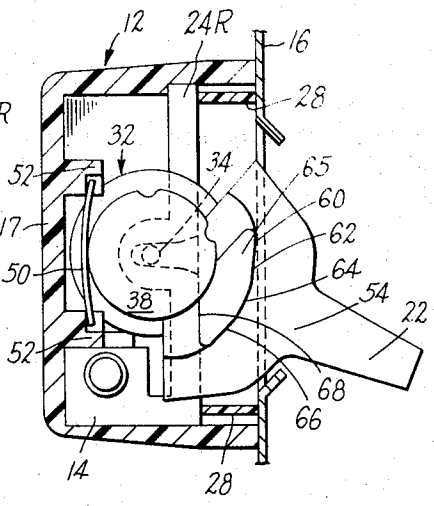


FIG. 3

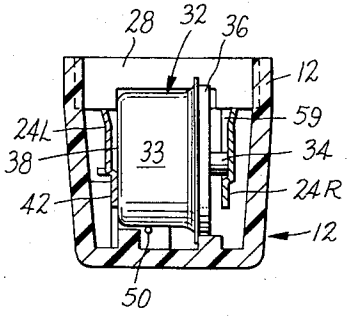


FIG. 4

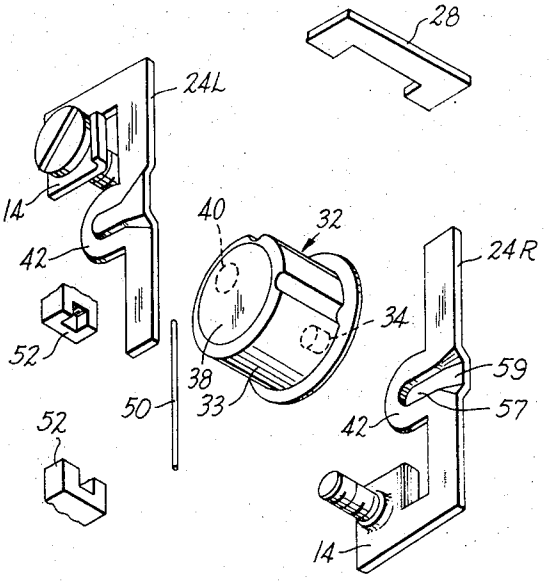


FIG. 6

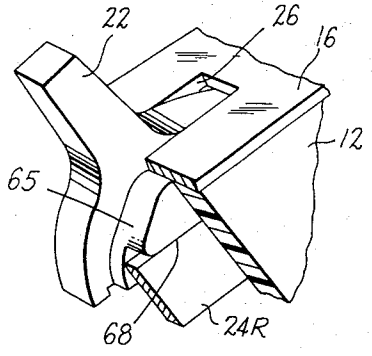


FIG. 5

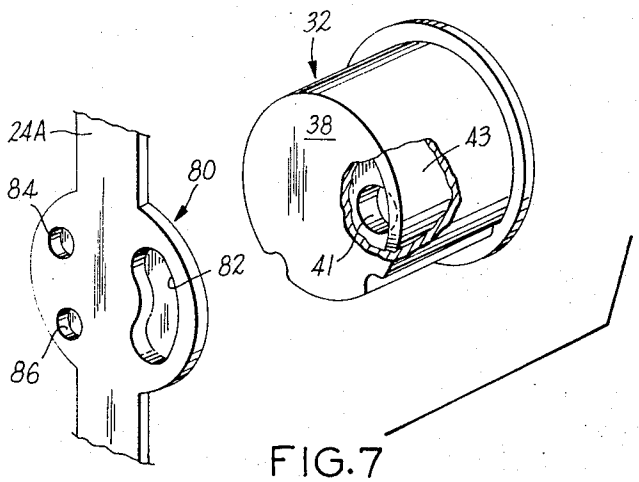


FIG. 7

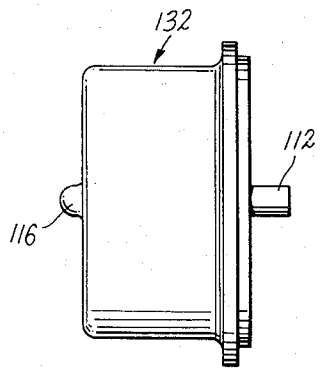


FIG. 9

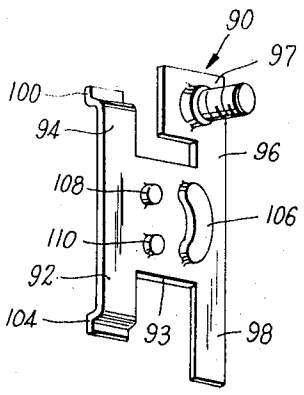


FIG. 8

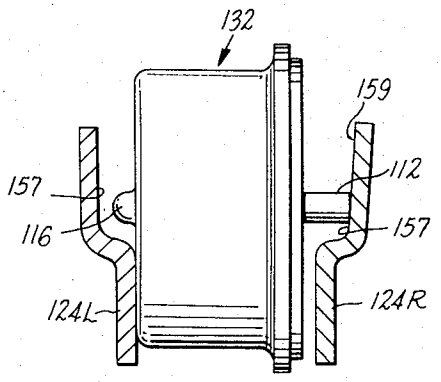


FIG. 10

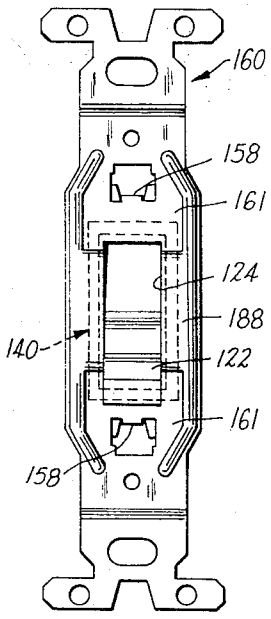


FIG. 11

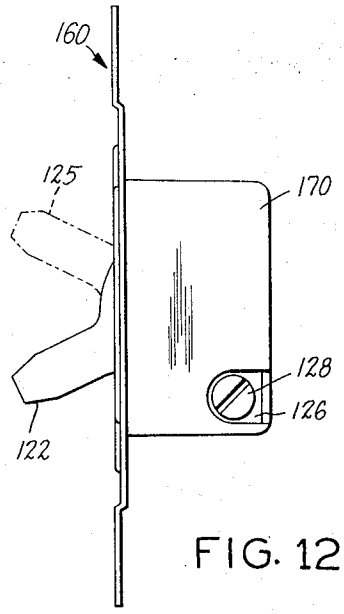


FIG. 12

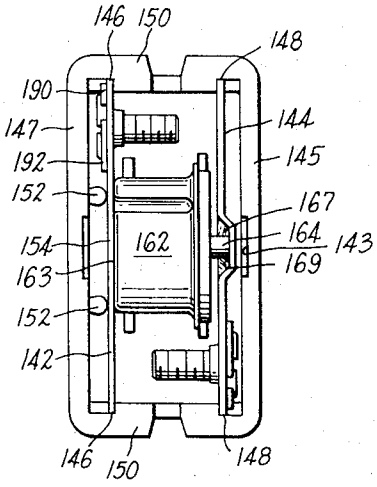


FIG. 13

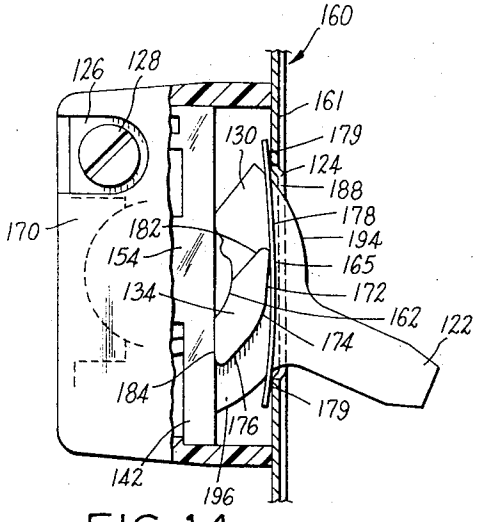


FIG. 14

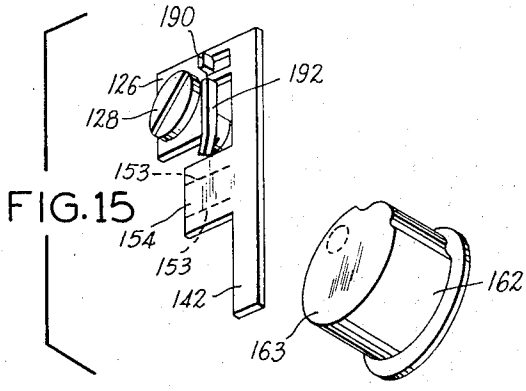


FIG. 15

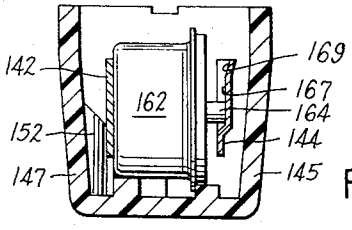


FIG. 16

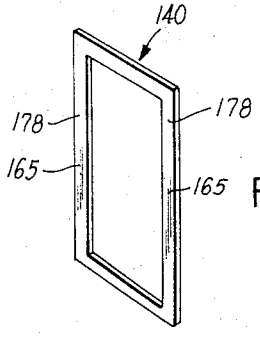


FIG. 17

MERCURY SWITCH WITH HEAT SINK CONTACT

CROSS REFERENCE TO RELATED APPLICATION

This application relates to application Ser. No. 248456 filed Apr. 28, 1972, Attorney's Docket 58WD-1105 of Walter C. Schumacher, owned by the same assignee as this application.

BACKGROUND OF THE INVENTION

Many types of mercury switches are known in the art including small switches employed in switching signal levels of current and large mercury relays having magnetically operated plungers used in switching electric power supply to large industrial equipment.

The switches most closely related to the present invention employ a mercury button as the circuit control element. The switches have an insulating casing attached to a metal mounting strap for mounting the switch within a wall box. The insulating casing also has external screw terminals and internal contacts, with a mercury button held between the contacts, and a pivot mechanism controlled by an externally extending trigger.

The mercury buttons have liquid mercury sealed within an hermetically sealed envelope made up a cylindrical metal shell having one closed end, and a three element closure element welded to and sealing the other end. The closure element is made up of an axially extending electrode or contact extending through and bonded to an annular glass insulator, and a metal rim bonded to the outer perimeter of the annular glass insulator.

An internal liner bonded to the glass insulator can divide the mercury into two pools when the button is placed in operating position. When the button is rotated to its open position the mercury is separated by the liner into two pools one contacting the metal shell, which serves as one electrode, and the other contacting the electrode extending through the glass insulator. When rotated to its closed position the mercury extends through a hole through the liner and forms a single continuous pool which completes the circuit between the electrode and metal shell.

Control over the separation or joining of the mercury pools is typically exercised by an operating means such as one having a trigger extending from the insulating casing of the switch which means can be employed to pivot the mercury button about its cylindrical axis between the switch open and switch closed positions.

Mercury buttons and mercury switches have been known in the art for a number of years extending back to patents such as U.S. Pat. 3,101,093 and several others which were granted in the 1930's. Improvements have been made in mercury buttons and in the switches in which mercury buttons are employed since their early introduction in commerce to improve product performance in response to the changing functions which these and other switches must perform. Some improvements in mercurey buttons and mercury switches are concerned with the control of higher levels of electric power as for example the power normally supplied for use within residences or commercial buildings. It is well known that the level of use of electric power within homes, factories, schools, banks, etc. is continuously increasing as the level of lighting and the use of apparatus run by electric power is increasing.

Accordingly, there has been a need over a period of years to increase the power switching capabilities of switches employed in buildings from the lower values which were satisfactory when mercury buttons wer first developed in the 1930's to the present time when the higher loads of air-conditioners, heaters, office machines, and other conveniences are employed within buildings. The improvement in the electric power switching capacity of mercury switches and of mercury buttons within mercury switches has been a particularly difficult technological problem to solve. In part this is due to restrictions on the size of the switch, and accordingly on the size of the button within the switch, which restrictions are imposed by the standardization of electric supply and distribution devices used within buildings.

Devices such as switches installed within buildings to be used by occupants in control of lighting and other electrical apparatus are preferably of a size which permits them to be included together with electric wires and connectors within the conventional metal wall boxes. These metal wall boxes are themselves quite small and of a standard size so that the wiring devices of any manufacturer will fit into the wall box of any other manufacturer based on the standards established and used in the industry. The actual opening within a conventional metal wall box is a rectanguloid about 1.75 inches wide by 2.75 inches high by 1.5 to 2.5 inches deep. Were it not for this restriction, it might be feasible to increase the switching capacity of mercury switches by enlarging the switches and the amount of mercury contained therein to a larger size which can accommodate the higher power.

Larger mercury switches such as relay switches and the like can be used in industrial applications where size is of no importance. However, such larger switches used for control of higher levels of electric power are very costly and are not economically useable within the walls of residences or buildings which are subject to conventional building codes.

It is known in the art that there are commercially available mercury tilt switches of recent manufacture which have a stepped switching capacity,which capacity increases in steps both with the size of the switch structure and also the amount of mercury contained within the tilt switch structure. Such a switch is conventionally formed with an open ended generally cylindrical outer shell of steel and an insulating enclosure for the open end having an electrode extending through the insulating enclosure. Such a conventional switch which has a switching capacity for 1,600 watt load will be approximately 2 and 9/64th inches in length and 0.600 inches in diameter. By contrast, a U.S. Pat. 3,451,965 assigned to the same assignee as this application teaches a cylindrical button having an axial length of only one half of an inch and having an outer diamter of three quarters of an inch to be capable of handling a 1800 watt lamp load and accordingly to have a switching capability of the much larger conventional mercury tilt switch.

A central problem in the improvement of mercury switches is that of increasing their capacity for the switching of electric power without at the same time increasing their size to a point where they no longer fit within the conventional wall boxes of standard buildings. While some increase in size is possible, it is undesirable because less room is then available for the wires

and wire connectors which must extend from the wall box during installation of the switch and which must be folded back into the box when the switch is mounted into operating position in the box.

In the past ten years, several patents have issued to the assignee of this invention directed to improvements in the fabrication or construction of mercury switches and mercury buttons designed to improve the capability and reliability of operation of these products within the restrictions imposed by building codes and electrical codes. Such U.S. Pats. include: 2,916,589; 2,929,902; 2,956,656; 3,032,633; 3,109,079; 3,089,937; 3,229,354; 3,265,844; 3,327,084; 3,415,965.

It was known from experience gained in conducting tests on the mercury button disclosed and claimed in the U.S. Pat. No. 3,415,965 assigned to the same assignee as the subject application that the mercury button having the features described and claimed in the patent could switch currents of 15 amperes at voltages of 277 volts through extended periods of time with little more than 3 grams of mercury. This higher power operation represented significant improvements over buttons which had the capacity for switching alternating current power at ratings of 10 amperes at 277 volts where the amount of mercury contained was slightly less than 4 grams. Expressed in terms of watts per gram, the improvement in switch performance is from about 700 watts per gram to over 1,300 watts per gram.

Another requirement which a mercury button and mercury switch must meet in qualifying for commercial use as a wall switch in residences or in other buildings is that of being produced at a reasonable cost but also with a high level of reliability of performance. With particular reference to the factors affecting costs, one of these factors is the produceability on a large scale with a relatively low number of reject of defective units. Efforts to produce the mercury button substantially of the construction disclosed in U.S. Pat. No. 3,415,965 in large quantities by manufacturing processes having reasonable costs, and to use these buttons in mercury switches such as the switch dislosed and taught in U.S. Pat. 3,265,844 of the same assignee, proved to be difficult and to lead to higher costs and lower performance capabilities than are acceptable in switches produced for use in conventional wall boxes.

In particular it was found that excessively large numbers of such buttons when tested in wall switches such as that of the 3,265,844 patent led to excessive rise in temperature of the button and switch and eventually led to failure of the button due to an arc or prolonged flow of arcing current through the switch. It should be emphasized that while it remains possible to form mercury buttons having the structure taught in the 3,415,965 patent which buttons have the capability described in the patent, that the cost of producing buttons having this capability was found to be excessive when the factor of defective buttons or buttons of substandard performance capability is taken into account in computing cost.

While numerous buttons of the 3,415,965 patent, when tested in the switch of the 3,265,844 patent, gave unique results in demonstrating the capability to switch 15 ampere currents of 277 volts on a sustained basis there were still fewer of such button which could pass additional Underwriters Laboratory tests for a switch rating of 15 amperes and 277 volts. For a switch to have this rating it must be capable of performing **100** on-off switching cycles with a voltage of 277 volts and a current of 72 amperes. After this sequence of **100** on-off cycles the switch is subjected to a current flow of 15 amperes at 277 volts for 60 minutes and a measurement is made at each binding post of the rise in temperature above ambient temperature. If the temperature rise is excessive in the sense of being above an established test value then the switch is considered to have failed the test although it can still have and display the capability for switcing 15 amperes at 277 volts.

SUMMARY OF THE INVENTION

It is accordingly one object of the present invention to provide a mercury switch of improved power switching capability.

Another object is to provide a high performance mercury switch of smaller overall size.

Still another object is to provide a switch capable of a large number of switching cycles.

A further object is to provide a switch capable of reducing the level of arcing which occurs in a mercury button used therein.

Still a further object is to provide a mercury switch which affords a higher power switching capability at lower cost.

One way in which the invention may be carried out is by providing an insulating housing having bottom, end, and side walls, and by providing two contact strips mounted within the housing proximate its side walls. The contacts have disposed between them in spring biased relation a generally cylindrical mercury button, the axis of the cylinder being aligned generally normal to the side walls of the housing. The mercury button has an electrical contact axially extending from an annular insulating closure in one of its end faces into pressure contact with a generally conforming recess in the proximate portion of a first of the contact strips. The button also has a substantial flat area of its opposite end face and this flat area is biased into pressure contact with a conformingly flat area of the second of the contact strips. The portion of the second strip extending between the flat area and the screw terminal provides a path for the flow of heat energy at a high rate.

Other objects and advantages of the invention will be in part apparent and in part pointed out in the description which follows.

The manner in which these and other objects of the invention may be achieved will be made clearer in the description which follows by reference to the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exterior side elevation of one form of switch housing showing part in phantom and illustrating a manner of affixing a mounting strap to a housing.

FIG. **2** is a front elevation a switch as illustrated in FIG. **1** with the mounting strap and trigger removed showing the relation of one form of a mercury button to contact strips.

FIG. **3** is an enlarged vertical section in part in phantom of a switch as shown in FIG. **1** illustrating the internal positioning of several elements of the switch.

FIG. **4** is a horrizontal section of a switch as illustrated of FIG. **2** with the strap and trigger removed.

FIG. **5** is a perspective view of a portion of a switch as in FIG. **3** with parts cut away to show the relation-

ship of internal portions of the trigger to the contact strips.

FIG. 6 is an exploded perspective view of certain internal elements of the switch.

FIG. 7 is an exploded perspective view showing the relation of the internal structure of the mercury button to the heat receiving portion of another form of contact strip usable in the switch of the present invention.

FIG. 8 is a perspective view of a modified contact element having a shortened heat path.

FIG. 9 is a profile view of a mercury button for mounting between contact strips.

FIG. 10 is a similar view of a button illustrating its relation to contact strips shown in section.

FIG. 11 is a front elevation of a modified form of switch.

FIG. 12 is a side elevation of the modified switch of FIG. 11.

FIG. 13 is an enlarged front elevation of the modified switch with strap and trigger omitted as in FIG. 2.

FIG. 14 is an enlarged side elevation with the casing in part broken away to illustrate the relation of some parts

FIG. 15 is an exploded perspective view of a modified form of heat sink contact shown in relation to a button.

FIG. 16 is a horizontal section similar to that of FIG. 4 showing some switch elements assembled within the insulating casing.

FIG. 17 is a perspective view of a spring element employed in the modified switch.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1 an external view of a switch is given in its normal operating position when mounted in a wall. The switch is shown in actual size and a compactness, achieved as is explained below, is evident by comparison to switch housings of other mercury switches particularly prior art switches of lower or equivalent power rating. The switch includes an insulating housing **12**, a mounting strap **16**, and a trigger **22**.

One screw terminal **14** is evident on the side of the switch shown and another is also located catercornered to that shown on the opposite side of the switch. An economical means for mounting the strap **16** to the switch housing **12** is by the conventional bosses **18** folded over conforming recesses **20** in the end walls of the housing.

Trigger **22** is shown in the at-rest OFF position and is shown in phantom in the at-rest ON position. Through use of a mercury button such as that taught in U.S. Pat. No. 3,415,965 the switch is rendered invertible and in such case the up position of the trigger will be the ON position in either orientation and similarly the down position will be the OFF position.

Turning now to FIG. 2, the strap **16** and trigger **22** of FIG. 1 are omitted and the placement of some of the other elements within a switch is shown.

The insulating housing **12** is seen to have side walls **13** and end walls **15** defining a chamber within the housing. Two contact strips **24L** and **24R** are mounted in the chamber with their long dimension extending along the longer side walls **13** of the housing, and are spaced from side walls **13** sufficiently to permit the strips **24R** and **24L** to be flexed outwardly in a direction generally normal to their long axis. The strips **24R** and **24L** are mounted in insulated relation in said chamber in conventional recesses and slots formed integrally with the side, bottom, and end walls of the housing.

The screw terminals **14** are located at side openings **11** in the housing walls to provide tool access to the screws thereof to permit electric supply wires to be securely fastened to the terminals.

Fiber inserts **28** seen in FIGS. 2 and 3 are mounted in slots **30** in side walls **13** and serve to hold the contact strips **24R** and **24L** in place in the housing. The inserts **28** are retained in place by the mounting strap **16** and this retaining ensures against contact of either contact strip with the mounting strap **16.** Alternatively the holding down of contact strips **24R** and **24L** may be accomplished by hold down bosses built onto the trigger as explained more fully below and in such case the inserts **28** may be omitted.

A mercury button **32** as sused in this switch has a generally cylindrical metal shell **33** with a closed end **38,** giving it a general cup shape seen best perhaps in the perspective view of FIG. **6.**

A closure for the open end of the cup shaped shell **33** of button **32** includes an electrode **34** protruding axially from an annular glass insulator held within a metal rim **36** as more fully described in the U.S. Pats. 3,327,084 and 3,415,965 of the same assignee as this invention.

The outer end of electrode **34** may be seen from FIGS. 2 and 4 to extend beyond the outermost reach of the rim **36** of the button closure. Accordingly, when the button is inserted in place between the contact strips **24L** and **24R** the srip **24R** is in direct electrical contact with the closed end **38** of button **32** but is maintained at an air gap insulating distance from the rim **36** of button **32.**

The contact of the closed end **38** of the cup shaped shell **33** of the button **32** with the contact strip **24L** may be seen to be quite different from the contact of the stem like electrode **34** with strip **24R**. This contact of the flat surface of closed end **38** with the flat portion of strip **24L**, and the maintenance of effective heat transfer contact between the surfaces, has been found surprisingly to be vitally important to the capability of the switch to operate at higher levels of power and particularly to interrupt current flow at higher levels of voltage and amperage.

What is deemed unique is the finding that a mercury button which has lower power switching capability when employed in the switch of patent 3,265,844 has a substantially higher switching capacity when employed in the switch of this invention. What is more the higher switch rating, i.e., the capability for switching higher wattages, is accomplished within a switch having appreciably smaller overall volume for its switch housing than the switch of the 3,265,844 patent. In large part, the improvements in switch operation are due to improvements made in the transfer of heat generated within the button.

Regarding transfer of heat pursuant to the present invention improved heat transfer may be provided in part by the provision of an improved electrically conductive heat sink directly against one surface of the button. By itself, provision of this electrically conductive heat sink is important because it places a metal element of high heat conductivity directly against a surface of the shell where heat is produced as a result of operation of the

switch. This relation of heat sink to shell surface effectively reduces concentrations of heat at localized hot spots of the shell where it has been found that such hot spots are likely to be formed.

It has been found possible through use of heat sinks persuant to this invention to remove heat from such hot spots at such a rate that the spot does not become excessively hot. By excessively hot is meant a heating which results in decreased operating efficiency or damage to the button, including eventual failure of the button through its destruction or otherwise. Further it has been observed that there is greater probability of arcing and continuation of arcing to destruction of the button where heat is not removed from locally overheated spots of the button shell than where such spots are in contact with heat sinks providing for more effective transfer and dissipation of heat from such hot spots and in this way reduction in the temperature of button metal exposed to internal arcing as a result of button operation.

This removal of heat and resultant improvement in operation has been found to be possible for buttons of a construction which had been shown through tests to become excessively heated in switches which did not utilize such heat sinks.

An important guide in the provision of a heat sink for the button is based on the discovery that there are certain portions of the metal shell which ae more likely to be intensely heated than others, and that preservation of the button from the destructive effects of such heating, as by arcing, can be accomplished by providing more effective removal of heat from these spots.

With reference to the button of FIG. **6** for example, it has been found that one portion of the steel shell most likely to be overheated locally is a portion directly opposite the through hole **41** of the ceramic liner **43** of the button.

The through hole **41** is the hole through the ceramic liner **43** of the button into which the two bodies of mercury flow in making contact when the switch is closed and from which they flow when the switch is opened and the single mercury pool is separated into two separate pools, one on either side of the ceramic liner.

For a button constructed similarly to that described in U.S. Pat. 3,415,965 (but omitting any nipple from closed end **38**) the through hole is located opposite approximately the position **40** shown in dotted outline on the closed end **38** of the button **32.**

While the structure of the contact as shown in FIGS. **2, 4,** and **6** is fully adequate to provide removal of heat for operation at appreciable levels of amperages and voltages, it is preferred that the heat sink portion such as **42** of strip **24L** be enlarged, and particularly be large enough to cover the area,such as area **40** of closed end **38,** which is swept by the portion of the shell opposite a through hole of the contained ceramic liner as the button is rotated from its ON to its OFF position.

It will be understood that the present invention contemplates a heat sink disposed in direct contact with that portion of the steel shell of a mercury button such as portion **40** of FIG. **6** which is aligned with the through hole within the button. Further the heat sink is formed to provide such direct contact in all positions in which a portion such as **40** of FIG. **6** may be disposed as the button is pivoted to perform actual switching action.

It will further be understood that this relationship of the disposition of the heat sink in close thermal contact with the indicated portion of the steel shell will yield the improved switching performance of the button without limitation to a particular button construction of to a particular through hole placement. Also improved heat transfer may be attained by providing a heat shunt, or shortened heat path, from the wire terminal to the indicated portion of the heat sink without limitation to a particular form of mercury button employed or location of through hole in the ceramic liner of the button.

A mercury button such as that illustrated in FIGS. **2, 4,** and **6** is seen to have a closed end **38** which is the flat bottom face or surface of the cup shaped metal shell **33** of button **32.** It is also evident that in these figures not all of this surface of closed end **38** is in direct contact with the heat sink portion **42** of contract strip **24L.** While it is desirable as is explained above that the strip have appreciable mass proximate the button for heat sink purposes, it is not necessary that the entire flat surface of the closed end **38** of the button be contacted. Rather what can be done to provide effective heat dissipation by selectively contacting those areas of the surface of closed end **38** most likely to be overheated.

In order to obtain more effective heat transfer it is desirable that the metal through which the heat is to be transferred have a high heat transfer coefficient. A **70–30** brass as normally used as the brass of a contact strip, for example, has a higher heat transfer coefficient than the steel normally employed in the button. Use of brass in the contact strip is desirable for transfer of heat. Use of copper-iron, or other copper alloys including brasses such as **85–15** brass with higher electrical conductivity is contemplated in carrying out the present invention.

Further it is desirable to have a relatively high contact pressure between the button and the contact strip heat sink. However, as the pressure between the strip and button is increased, and also as the area of contact is increased, there is a tendency to increase the friction between the button and contact strip to a level at which the smooth low effort motion of the trigger is reduced.

This increased friction can be in part reduced by use of very flat surfaces and also by use of lubricants on such surfaces. High load, high temperature greases with high thermal stability and melting points above about 500°F are useful for this purpose.

Alternatively where the contact pressure and friction between button and heat sink surfaces result in reduction is smooth motion of the trigger, what can be done to reduce friction is to reduce the area of contact of the heat sink against the button without reducing of the heat sink mass and without extending the length of the heat flow path to the binding post.

An important factor here is that, pursuant to one aspect of this invention, maintenance of contact at a higher pressure can be accomplished on those portions of the button face left in contact with the heat sink where the contact is between heat sink and those portions of the button face most likely to receive the higher heating as a result of switching operation of the button.

In other words, the total pressure between the contact strip and button surface can actually be reduced while at the same time increasing the pressure

between the portions of the heat sink and button which are in contact. This contact pressure can be increased by forming the heat sink to permit pressure to be applied selectively at those portions of the closed end 38 of button 32 where higher heating is most likely to occur.

For example with reference to reducing the contact area without reducing the effectiveness of heat transfer, portions of the heat sink surface confronting the button may be depressed so as to be spaced from the button surface. When the actual area of a contact strip making contact with a closed end such as 38 of mercury button 32 is reduced in this way, the metal of the sink out of contact with the buttons still performs the heat absorbing and heat transmission and dissipation function. This is so because heat received by heat sink portions in contact with the button may be quickly transmitted to the adjoining portions spaced from and out of direct thermal contact with the mercury button particularly where the heat sink itself is formed of a material having a higher coefficient of heat transfer.

Where areas of the heat sink are formed so as to be depressed out of contact with the button, care must be exercised to avoid having the button or heat sink shift within the switch so that the heat receiving areas of the button and heat absorbing contact areas of the sink are not in registry. Also, it is important that neither the button nor the heat sink be tilted where the tilting results in the flat contact portions of the heat sink being out of good thermal contact with corresponding portions of the button. In order to optomize the effectiveness of the heat transfer contact at least three spaced contact zones are formed on the heat sink. This form of heat sink surface is illustrated in FIG. 7.

Referring to FIG. 7 a round enlarged heat sink portion 80 of a contact strip is seen to be formed in a central portion of a contact strip 24A. This portion 80 may have, for example, essentially the same effective diameter as that of a button closed end 39 surface to be contacted. Only three areas are formed on the heat sink portion 80 for contact with the flat surface. These are the crescent shaped larger raised flat area 82 and the two additional smaller flat areas 84 and 86 which, in this case, are shown to be circular in shape.

One consequence of providing the three raised flat area for contact with the flat surface of closed end 38 of button 32 is that inasmuch as three points determine a plane assistance in automatic paralleling of the flat areas of the button to the flat of the heat sink is achieved. This is in part the result of the suspending of the button under spring pressure from one point along its axis on one side and from three points on the opposite side between spring biased contact strips such as 24A on one sie and another strip, not shown, on the opposite side of button 32.

Another advantage of this mode of mounting a button in the switch structure of this invention is the increased contact pressure between the button and the heat sink in those areas where the contact is most needed.

In this regard, and with reference to the form of heat sink shown in FIG. 7, the crescent shaped raised area 82 corresponds to the area of the heat sink which is contacted by the portion of closed end 38 of button 32 aligned with the through hole extending through the ceramic liner of the button. Accordingly, no matter what position the switcy trigger is in, anywhere between a full ON and full OFF position, the portion of the closed end 38 aligned with through hole 42 of button 32 will be in close pressure contact with the same part of crescent shaped raised area 82 of the heat sink.

It is not essential that the heat sink surface be parallel to the internal side surface of the switch housing so long as there is a close contact of the flat surface of the closed end 38 of button 32 with the corresponding heat receiving flat surface of a heat sink.

To improve positioning of the heat sink in the switch housing and particularly to give the heat sink good spring support in the housing the contact strip may be given an H form by including an H pattern of support arms extending out from an enlarged central heat sink portion. Such a contact strip 90 having the H configuration of arms is shown in FIG. 8.

As is evident from FIG. 8 two of the arms 92 and 94 occupy positions extending out to each side of the central heat sink. Of the two remaining arms, a first arm 96 may serve as heat shunt and may for this purpose be connected directly to the binding post 97 of the switch. The remaining support arm 98 completes the H configuration of support arms of the contact strip 90. Support arm 94 is provided with a brace 100 and support arm 92 with a brace 104, each of which is stepped back out of the plane of the strip 90 to brace the central sink 93 for spring deflection toward the wall of the switch housing. Contact strip 90 and its various arms and braces may be supported from appropriate pedestals, slots, or bosses formed integrally with an insulating housing not shown. For the form of contact strip 90 shown, however, there would be no support of the housing directly behind the central heat sink portion 93 but this central portion is formed to be supported by its arms 92, 94, 96, and 98 and will be able to deflect slightly in a direction generally normal to the plane of central heat sink portion 93.

With regard to the spring pressure developed between the contact strips and a mercury button it will be appreciated that it is not necessary that both strips be capable of spring deflection. Adequate pressure for both heat transfer and electrical conductivity purposes may be derived from the spring bias of a single contact strip imparting a sufficient spring pressure to the button to make it bear against both contact strips with the needed pressure.

It will also be clear that other spring biasing means may be used to develop the needed pressure. However, the use of the contact strips for this purpose has the advantage of low cost coupled with simplicity of construction and reliability of operation.

With further reference to FIG. 8 three raised flat areas including crescent shaped flat area 106 and two smaller and generally round flat areas 108 and 110, serve essentially the same purposes as the raised flat areas 82, 84, and 86 of heat sink 80 of FIG. 7. The areas in FIG. 8 are seen from the side of heat sink 90 contacted by a closed end 38 of a mercury button whereas heat sink 80 is seen from its opposite side.

The heat sink 80 of FIG. 7 and heat sink 93 of FIG. 8 are not usable as shown in making contact with the opposite electrode of a mercury button such as 32 of FIG. 7. This electrode has the form of a stem such as 112 of FIG. 9 and it is preferable that a contact strip which makes contact with such an electrode have a groove in its face to guide the electrode into place during switch assembly and to hold the electrode in place

in an assembled switch. A form of groove **59** which may serve this purpose is illustrated in contact strip **24R** of FIGS. **4** and **5**. The button electrode **34** rides down the chute **59** formed in the contact strip **24R** and remains in pivot channel **57** where it can pivot under the urging of a trigger such as **54** best seen in its relation to a button and strip **24R** in FIG. **3**.

Where the strips such as **24R** and **24L** are employed there is an additional economy of switch construction inasmuch as these two parts are interchangeable as either contact strip **24L** or strip **24R** may be used on either side of a mercury button such as **32** of FIG. **6**. Such an interchangeable strip is provided with both an enlarged heat sink portion **42** and with the chute **59** and channel **57** for guiding the axially extending electrode **34** to its proper position relative to the housing and contact strips. The heat sink portion **42** of such an interchangeable strip is principally useful in relation to the flat surface of the closed end **38** of a mercury button and the chute and channel portion formed within the heat sink portion are mainly useful in relation to the electrode such as **34** protruding from the closure element of a button such as **32**.

However, the closed end of a button need not be as flat as the buttons **32** shown in FIGS. **2, 4, 6,** and **7** but may be provided on its steel shell surface with a nipple such as that disclosed in U.S. Pat. 3,415,965 and shown in FIG. **9** of the present application as a nipple **116** of button **132**.

What has been found feasible in one mode of practice of the present invention is the formation of a button with a nipple **116** which is only half or other appropriate fractional part as high as the electrode **112** extending from the button closure in the opposite direction as shown in FIGS. **9** and **10**. Pursuant to this mode of construction, a channel **157** of the contact strip is made of a depth and length to prevent any contact of the outer surface of the nipple **116** with the contact strip surface in the depth of the channel **157**. However, the depth of the channel **157** below the chute **159** is also of such depth that the electrode **112** of FIGS. **9** and **10** displaces the strip **124R** outward under spring pressure. This outward displacement establishes and maintains an insulating air gap separation between the rim **136** of the button **132** and the contact strip **124R**. Thus although each channel **157** is of equal depth the different length of the nipple **116** and electrode **112** extending into the channels results in the heat sink flat of the strip **124L** contacting the flat of the button while the heat sink flat of strip **124R** is held spaced from the flange of the closure rim **136** by an insulating air gap sufficient to maintain an electrical potential of 1,500 volts therebetween as is conventionally required for such switch structures.

The nipple **116** of button **132** can serve the purpose of preventing lateral motion of the button as for example during rotation of the button accompanying the switching action.

For smooth rotary action neither the nipple **116** nor the protruding electrode **112** should "strike bottom" in the channel **157** formed in an enlarged heat sink portion of a contact strip. Rather for best trigger action the button should be maintained in a constrained floating position with the nipple **116** and electrode **112** held above the bottom of the channel **157** but constrained from side to side movement by the sidewalls of channel **157** acting on the nipple **116** and electrode **112** as needed.

To give the switch a smooth action and to provide a cushioned stop at the end of the stroke a spring may be provided between a button and some portion of the insulating casing as the back wall or bottom of the insulated housing.

Turning back again to FIGS. **2** through **6**, it will be seen that a trunion portion **65** of toggle **54** has two relatively flat bearing surfaces **62** and **66** which can register with the underside of the mounting strap **16** to impart to the finger of the user of the switch the sensation of two "at rest" positions. These positions are analagous to the at-rest positions of an overcenter switch. In actuality, however, there is no spring pressure on the toggle sufficient by itself to advance the trigger to its at-rest position ahead of the motion resulting from the action of the finger of the operator of the trigger portion **22** of the toggle **54**. Rather the action of a spring **50** on button **32** and toggle **54** is that of assisting the user to lodge the trigger **22** in one of its two at-rest positions. The overall smoothness of the switch action is such that the trigger may actually be left in essentially any intermediate position between the two at-rest positions to which the operator may choose to move it.

With reference again to FIG. **3** a wire spring **50** is supported between two bosses **52** formed integrally with and extending out from the back wall **17** of the switch housing. The wire spring ends are received in conforming notches in the forward end of the bosses **52** and the spring is held in place by the pressure of button **32** pressing inwardly against it. Button **32** is in turn held in place laterally between the contact strips, only one of which **24R** is seen in FIG. **3**, as explained more fully above.

The button **32** is also confined to its operating position by an inward push of toggle **54**. Toggle **54** accordingly bears outwardly at its trunion surfaces **62, 64,** and **66** against the underside of mounting strap **16** and presses button **32** inwardly against wire spring **50**.

Very limited in and out motion of the button **32** takes place. What motion does take place occurs mainly when the trigger passes through about the mid-point between its at-rest positions, i.e., when trunion bearing surface **64** engages the underside of strap **16**, and when the trigger arrives at the end of its stroke at the full ON or full OFF positions.

The spring action which accompanies action of the toggle **54** is now described. Referring again to FIGS. **2** through **6** it will be evident that rotation of the button **32** by movement of the trigger **22** to various positions does not interrupt close thermal and electrical contact of the flat surface of closed end **38** of button **32** with the flat portion of contact strip **24L**. As viewed in FIG. **2** it may also be seen that slight in and out motion of button **32** relative to casing **12** and against the wire spring **50** (a seen in FIG. **3**) does not dislodge or separate the flat surface of closed end **38** of button **32** from its close thermal contact with the confronting flat surface of heat sink portion **42** of contact strip **24L**.

The continued contact of the closed end **38** of button **32** with heat sink **42** is important of course in assuring that no over heating of the button surface occurs during any of the button motions which must be made in operating the button. Even a momentary separation of button surface from the heat sink can cause localized over heating and even breakdown of the button where

the higher amperage and voltage level are being controlled by the mercury switch. This overheating can occur because the energy generated by an arc in the button is very high and the localized overheating can cause the arc to be continued thus leading to further overheating and breakdown of the button. An important relationship made possible by this new switch structure is a continued contact of that portion of the flat surface of closed end **38** of button **32** and particularly at that portion where localized overheating has been found to be most likely to take place.

As the toggle handle **22** is moved from an OFF position as shown in FIG. **3** toward an ON position the flat bearing surface **62** of the trunion **65** is separated from the underside of the mounting strap **16** and the crest **64** comes into contact with the undersurface strap. Because the crest is further from the center of rotation of the button (generally at the electrode **34**) the toggle **54** and accordingly the button **32** are displaced slightly into the housing as the crest **64** comes into contact with the underside of strap **16.** As this occurs wire pring **50** is put under further spring bias as it is bent further toward the back wall **17** of the housing **12.**

After the trigger **22** has passed the mid-point of its travel to the ON position the pressure on the spring **50** is relieved slightly as a second relatively flat portion **66** of the trigger trunion **65** is brought into contact with the underside of the strap **16.** This arrival of flat portion **66** into contact with the underside of strap **16** is the motion which gives the sensation to the finger of the switch operator of the arrival of the switch handle at a second at-rest position familiar in overcenter trigger actions.

As the trigger moves through the course recited above or through the reverse course from ON to OFF the button moves in and out slightly with the electrode **34** travelling a slight distance along channel **57** in thermal and electrical contact therewith.

At the end of the normal course of travel the trigger is given a soft stop due to a similar set of motions of toggle **54,** button **34** and spring **50.** Again this soft stop does not result in or involve a thermal disengagement of the flat surface of closed end **38** of button **32** from the flat surface of heat sink portion **42** of the contact strip **24L.**

In this soft stop motion the trigger overtravels slightly past the normal at-rest position, i.e., the position in which the flat bearing surface **62** or **66** of the trunion **65** is flush with the underside of the strap **16.**

Considering for purposes of illustration flat bearing surface **62,** the soft stop effect is achieved when the outer end **60** of flat bearing surface **62** engages the strap **16** and urges the toggle **54** and button **32** further into the housing **12.** The motion of button **32** further into the housing is resisted by the increased biasing of the spring **50.** Accordingly, this overtravel of the trigger **22** results in increased spring bias and increased tendency of the trigger **22** to be returned to the at-rest postion. The trigger does not strike a stop but rather the end of the stroke is cushioned and rendered silent by the translation of the rotary motion of the trigger and button into an increased bending of biasing of the spring **50** in a direction away from the strap against which the outer end **60** of the bearing surface **62** acts. The position in which the trigger **22** and trunion **65** is illustrated in FIG. **3** is the overtravel position in which the spring return of the trigger **22** to its at-rest position is induced. The outer end **60** of flat bearing surface **62** and a similar outer end **68** of of flat surface **66** are effective in inducing soft stop as the trigger travels past the full ON position, or past the full OFF position.

Accordingly there is an actual spring return of the trigger toward one of the at-rest positions from an overtravel as distinct from the action induced by the deflection of the spring **50** as crest **64** passes against strap **16.**

Referring next to FIG. **5** an alternative means for holding the contact strips in place in the switch housing is shown in greater detail.

The trigger **22** is shown in a normal position extending from trigger opening **26** in mounting strap **16.**

As is evident the trigger is in a position which may for convenience of reference be referred to as an OFF position. The trigger can be pivoted to the vacant portion of trigger opening **26** which corresponds to an ON position.

In the OFF position shown it will be seen that trunion **65** has a bottom trunion stop surface **68** which is poised immediately above or is in contact with contact strip **24R.**

Normally contact strip **24R** is held in position in insulating body **12** by a wire affixed to a screw terminal such as **14** of FIG. **3.** The terminal strip cannot normally rise in housing toward a mounting strap such as **16** when the screw of a screw terminal is backed out or where a wire is attached. But it will be evident from FIG. **5** that because trunion **65** underlies strap **16** and overlies contact strip **24R** the contact strip not only cannot rise into contact with strap **16** even in the absence fiber inserts **28,** but in addition will be driven or depressed down into the switch body by normal operation of the switch toggle **65.**

Turning now to FIG. **11** through **17** an alternative form of switch is described.

Referring first to FIGS. **11** and **12** a mounting strap **160** of the switch is shown assembled to a switch housing **170** by bosses **158** formed integrally with strap **160** and extending through opening **153,** to grip conforming slots, not shown, in the housing wall.

A trigger **122** emerges through a trigger opening **124** and is pivoted between an OFF position shown in solid lines and an ON position shown in dashed outline **125.**

A conventional screw terminal **126** and screw **128** permit power supply wires not shown to be joined to the switch.

In FIG. **13** a front elevation reveals internal details of the switch as the toggle mounting strap **160** and spring **140** are omitted. Contact strips **142** and **144** are disposed internally along the longer side walls **145** and **147** of the insulating housing **170** and communicate with the housing exterior at the terminals such as **126.** Strip **142** is held at is end in positioning slots **146** in end walls **150,** and strip **144** is held in similar positioning slots **148.**

Contact strip **144** is spaced along its length, and particularly at chute **167** and pivot channel **169,** away from side wall **145.** In fact a set back such as **143** in side wall **145** may be provided to ensure against contact of the strip **144** with the side wall **145.**

By contrast two ribs **152** are formed integrally on the inner surface of side wall **147.** These ribs stand out from side wall **147** and lie flush in contact with contact strip **142** when strip **142** is in place in the switch housing. The ribs accordingly prevent any outward deflection of strip **142** and particularly any outward pivoting

of outward deflection of the enlarged heat sink portion **154** of strip **142.** The relationship of ribs **152** to heat sink **154** of strip **142** may be seen in FIG. **15** where the portion of the heat sink **154** contacted by the ribs is shown by dashed lines **153** lying approximately along the lines of contact between ribs and heat sink.

Mercury button **162** is positioned in housing **170** between contact strips **142** and **144** so that the closed and **162** of button **162** is in flush planar contact with heat sink portion **154** of contact strip **142.** Also electrode **164** is in pressure contact in pivot channel **167** with contact strip **144** so that the electrode **164** can pivot in channel **167** and maintain electrical and thermal contact with contact strip **144.**

The distance between contact strips **142** and **144** is preferably slightly less than the thickness dimension of button **162** from flat closed end **163** to the end of electrode **164.** Accordingly, button **162** is maintained between contact strips **142** and **144** under spring bias and more specifically under a spring bias generated by a slight outward bowing of the contact strips, particularly strip **144** which is unrestricted in its outward movement. Good thermal and electrical contact is maintained between the contact strips and button due to this spring pressure.

Referring next to FIG. **14** an elevational view in part in section of a switch having elements as shown in FIG. **13** is illustrated. The insulating housing **170** has a strap **160** mounted to it. The strap **160** has a trigger opening **124** and a trigger portion **122** of a toggle extending through the opening **124** from the switch interior. The toggle **130** has a trunion **134** showing, and a second showing, not showning, on the opposite side of toggle **130.** The trunion bears at its upper surface **172, 174,** and **176** against the longer sides **178** of a generally rectangular leaf spring **140.** The two flat bearing surfaces **172** and **176** are the trunion surfaces in contact with spring **178** when the trigger is at its at-rest ON position or at its at-rest OFF position.

Two flat under surfaces **182** and **184** of trunion **134** stand spaced respectively a small distance from the upper edge **186** of strap **142** when the trigger is in its ON and OFF positions.

Normally the upper surfaces **172, 174,** or **176** of trunion **134** are in contact with leaf spring **178.** As the trigger moves to the end of its stroke, as for example to the position shown in FIG. **14,** the surface of trunion **134** bearing against leaf spring **178** will apply increasing pressure on the spring until the spring is bowed up toward strap **160** as shown. Spring **178** bears at its ends **179** against the under side of strap **160** and particularly at a land portion **161** of strap **160.** However, the midsection **165** of spring **178** is located beneath a bridge **188** on each side of trigger opening **124** and does not strike the underside of the strap until the spring **178** is bowed out of its normal configuration in applying pressure on trunion **134.**

Normally the spring **178** bears on the bearing surfaces **172, 174,** and **176** of trunion **134** with sufficient pressure to provide a frictional engagement between toggle trunion **134** and spring **178** such that the trigger **122** will remain in any positon to which it is set by the user.

When flat bearing surface **172** is in contact with spring **178** the flat under surface **184** of trunion **134** is not normally in contact with the upper edge **186** of contact strip **142.** However, as contact pressure of trunion **134** against spring **178** increases and causes an upward bowing of spring **178** toward bridge **188,** a further descent of flat under surface **184** toward and into contact with edge **186** of contact strip **142** occurs.

This contact of trunion **134** with contact strip **142** and with **144** prevents the strips **142** and **144** from rising to a point where any contact can be made with strap **160.**

Referring back now to FIG. **5** the relation of the contact strips to the toggle is further explained.

An unusual compactness of the mercury switch of this invention is achieved partly because an appreciable portion of the toggle body moves down between the contact strips in the normal switch operation. In other words it has been found possible to bring the contact strips up closer to the mounting strap, or conversely to bring the trigger down further into the switch body by spacing the contact strips by a width greater than than the width of the trigger opening of the strap and by forming the body of the toggle so that substantially the entire trigger opening is occupied by the toggle body at any position to which the trigger may be moved.

This shaping of the toggle to fill the trigger opening is a safety feature of the switch in that it prevents injury to children who might otherwise push a wire or nail into the trigger opening of the switch and receive injury when the metal article touches a live contact within the switch. One would be led to expect that a mercury switch which is provided with toggle of such full dimensions would require an enlarged switch housing.

However, by spacing the contact strips and by providing a narrow central portion of the toggle body to conform to the width of the trigger opening which it must occupy, a compact switch construction is achieved in which portions of the trigger opening guards **194** and **196** are able to move down into the switch between the contact strips.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A mercury switch of improved switching capacity which comprises

an insulating housing

a mercury button mounted for pivoting motion in continuous contact with and between two electrical contacts within said housing, said pivoting motion producing a switching action with respect to electrical current flowing between electrical conductors extending from said contacts to the housing exterior and

a heat sink in thermal contact with said mercury button,

said switch being of a size smaller than a standard wall box.

2. The switch of claim **1** in which the switch includes means for conducting heat from said heat sink to the exterior of said housing.

3. The mercury switch of claim **2** in which the heat conducting means is an electrical conductor of said switch.

4. The mercury switch of claim **1** in which the heat sink is an electrical conductor of said switch.

5. A mercury switch which comprises,

an insulating housing,

a mercury button within said housing mounted in pivoting relation between two contact strips,

said button comprising a cylindrical metal shell having a closed end and having an electrode insulat-

edly mounted through a closure for the other end,
a heat sink in thermal contact with the portion of said metal shell which receives the greatest heat during switch operation.

6. The switch of claim **5** in which said heat sink provides both electrical and thermal contact between said metal shell of said button and one of said contact strips.

7. The switch of claim **5** in which the heat sink is disposed in the area contacted by the portion of the mercury button shell opposite the through hole of said button.

8. The switch of claim **5** in which the heat sink is integral with a contact strip of said switch.

9. The switch of claim **5** in which the heat sink is an enlarged section of the contact strip of said switch.

10. A mercury switch which comprises
an insulating housing having two contact strips in insulated relation to each other in said housing
a mercury button mounted between said two electrical contact strips to pass and interrupt flow of electric power between said strips in said housing in response to the pivoting of said button,
said button comprising a cylindrical shell having a flat closed end and having an electrode insulatedly mounted through a closure for the other end,
electrical contacts for said button extending into contact with said flat closed end and electrode
a heat sink disposed against the metal shell of said button.

11. The switch of claim **10** in which one of said contact strips has a flat metal contact in planar contact with the flat surface of the closed end of said button.

12. The switch of claim **10** in which the heat sink is integral with the contact strip of said switch.

13. The switch of claim **10** in which the two contact strips have identical form.

14. A compact mercury switch comprising
an insulating housing
a mercury button disposed in pivotaing relation in said housing
a mounting bracket affixed to said housing and having a trigger opening therein,
contact strips spaced within said housing by a distance greater than the width of said trigger opening,
a toggle having a body embracing said mercury button, a trigger extending through said opening, and opening guards abutting said trigger and aligned with the opening to limit entry of foreign matter through said opening,
a trunion on each side of said toggle extending laterally from the body thereof a distance greater than the width of said trigger opening
said guards having depending end portions extending below said trunion,
and said end portions being disposed to extend below the upper level of said contact strips on pivoting of said toggle.

15. The switch of claim **14** in which the contact strips communicate with the housing exterior.

16. The switch of claim **14** in which the mercury button is held in pivoting relation between said contact strips under spring bias thereof.

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