United States Patent [19]

Blaha

[11] **3,921,117**

[45] **Nov. 18, 1975**

[54] **SOLID STATE ELECTRICAL SWITCH**

[75] Inventor: **Robert F. Blaha,** Dedham, Mass.

[73] Assignee: **Texas Instruments Incorporated,** Dallas, Tex.

[22] Filed: **Nov. 29, 1974**

[21] Appl. No.: **528,066**

[52] **U.S. Cl.**..... **338/13;** 317/9 R; 318/471; 318/221 E; 318/221 H; 338/49; 338/220

[51] **Int. Cl.**[2]..... **H01C 7/00**

[58] **Field of Search**..... 338/13, 22 SC, 22 R, 25, 338/49, 220–221; 174/52 R; 318/471, 221 E, 221 H; 317/9 R

[56] **References Cited**

UNITED STATES PATENTS

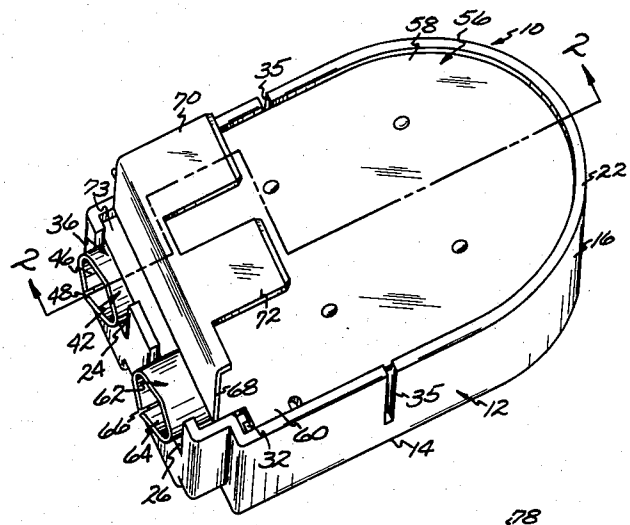
3,586,939	6/1971	Buiting et al.	318/221 E
3,737,752	6/1973	Strachan	338/220
3,842,188	10/1974	Petersen	338/220
3,878,501	4/1975	Moorhead et al.	338/22 R

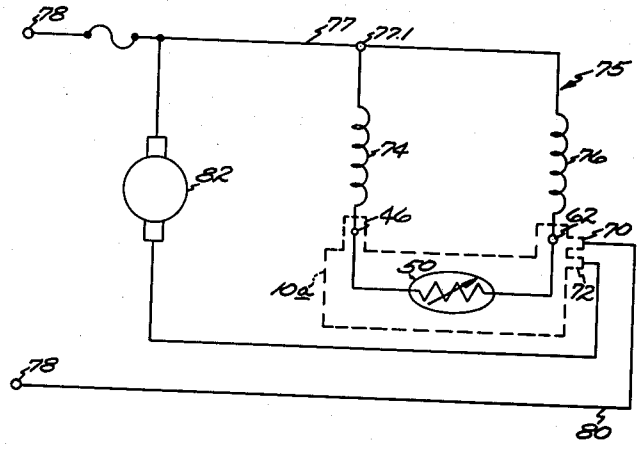
Primary Examiner—C. L. Albritton
Attorney, Agent, or Firm—John A. Haug; James P. McAndrews; Russell E. Baumann

[57] **ABSTRACT**

A solid state electrical switch of versatile and economical structure for use in starting a split-phase electrical motor incorporates a single cup-shaped dielectric casing open at one end. A first terminal disposed within the casing has integral spring portions bearing against the casing bottom and has a connector portion extending through the casing wall to receive connection from the starting winding of such a motor. A ceramic-type resistor element of positive temperature coefficient of resistivity which displays a sharp increase in resistivity when it is heated to a selected temperature by directing electrical current through the resistor is disposed in engagement with the first terminal within the casing. A second terminal which has a heat-dissipating plate portion closing the open casing end and engaging the resistor element has a connector portion of the terminal extending through the casing wall for receiving connection from the main winding of such a motor, has quick connect tabs on the plate portion for line connection thereto and for fan motor connection when desired, and also has tabs extending through the casing and staked apart beneath the casing for securing the switch components securely together with the terminals resiliently pressed in firm electrical contact with opposite sides of the resistor element.

11 Claims, 5 Drawing Figures





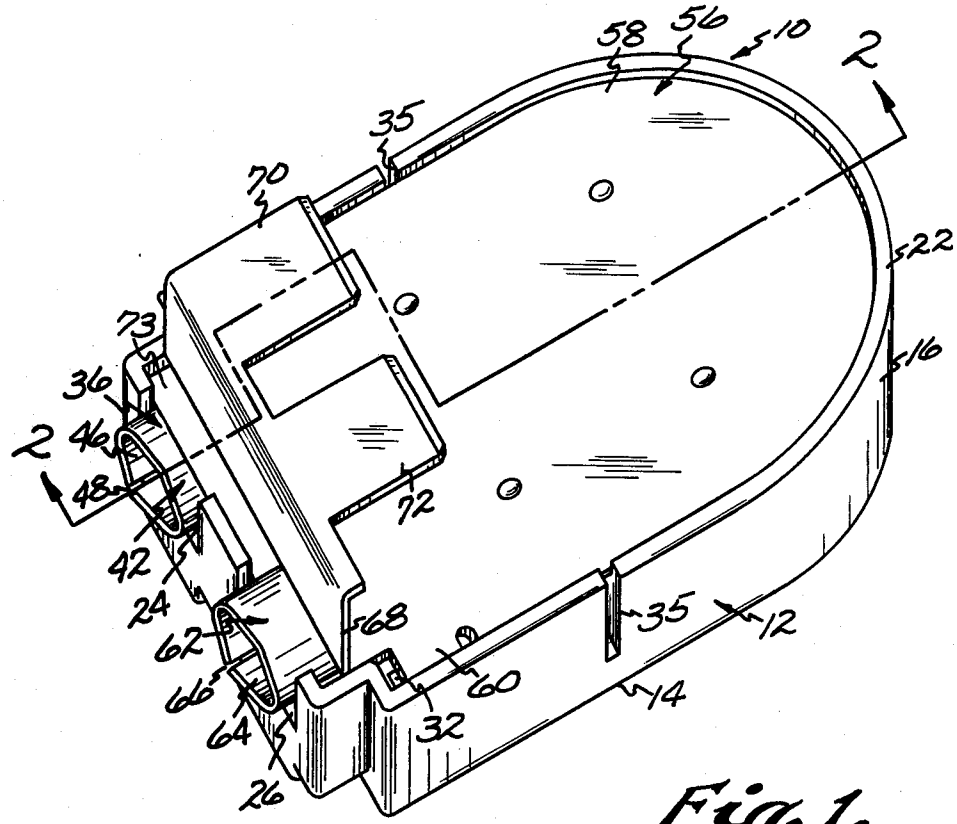

58
56
10
2
35
70
22
73
16
36
2
46
48
72
42
24
68
35
12
62
60
66
14
64
32
26

Fig. 1.

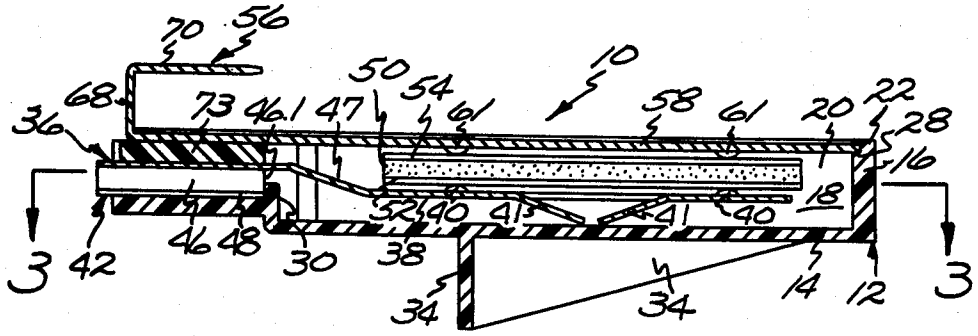

70
56
10
50
54
68
73
46
47
61
58
61
20
22
28
36
16
18
52
40
41
41
40
3
42
46
48
30
38
14
12
3
34
34

Fig. 2.

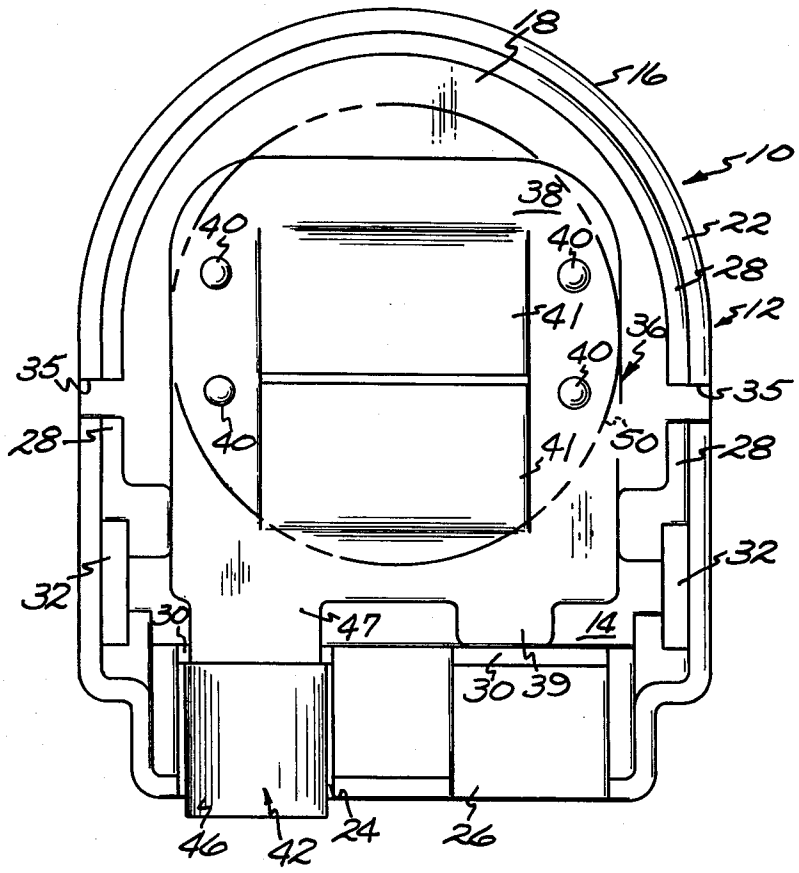

18
16
10
38
40
40
22
28
41
12
36
40
35
35
40
41
50
28
28
32
32
30
47
14
30
39
46
42
24
26

Fig. 3.

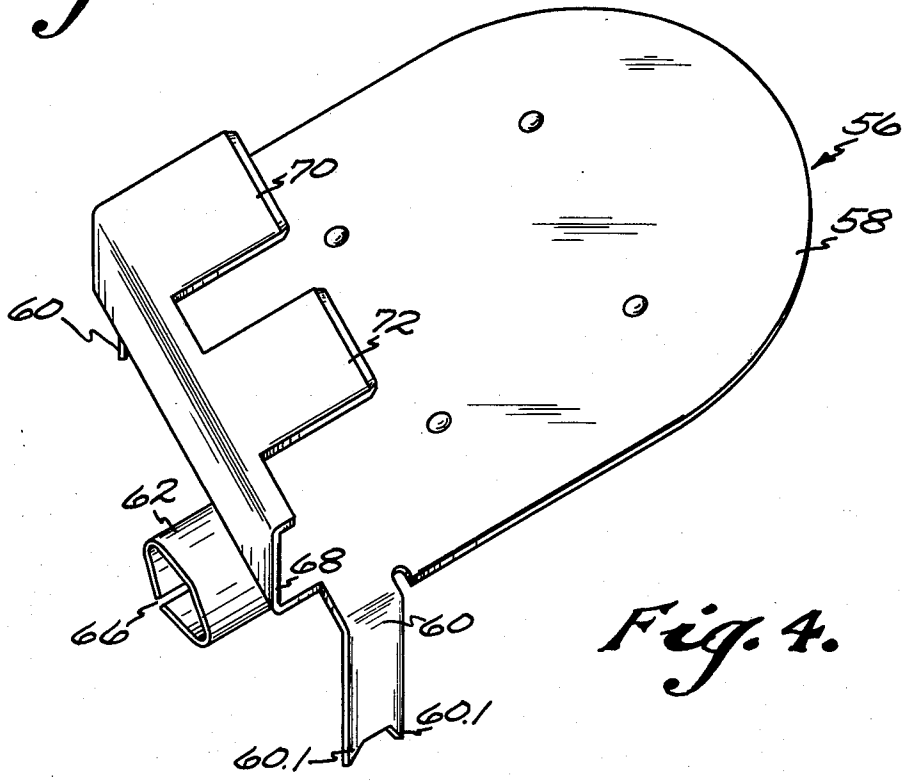

56
70
58
60
72
62
68
66
60
60.1
60.1

Fig. 4.

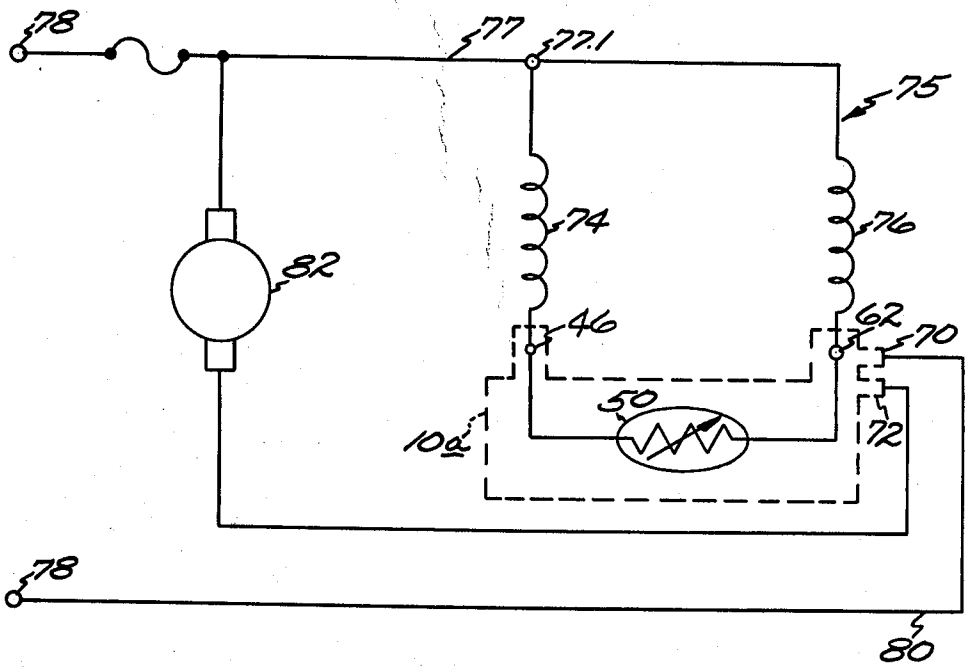


Fig. 5.

SOLID STATE ELECTRICAL SWITCH

In split-phase electrical motors, an auxiliary or starting winding is connected directly across the power supply in parallel with the main motor winding to provide the motor with a desired starting torque. Such a starting winding is normally wound with fewer turns and with smaller wire than the main motor winding and the current density in the starting winding is quite high so that the rate of temperature rise in the starting winding is also quite high. In order to prevent overheating of the starting winding and to increase motor efficiency, it is important to remove the starting winding from the motor circuit promptly after motor starting has been effected. In the past, this has been accomplished by the use of various means including centrifugal and solid state switches as well as electrical relays of various types. However, particularly where such split-phase motors have been incorporated in hermetically sealed units, as in various refrigeration compressor applications where the main, start and common motor winding leads are brought out of the sealed unit through pin elements mounted in a wall of the sealed unit, the means employed for cutting the starting winding out of the motor circuit have tended to be of complex and expensive structure and have been somewhat difficult to connect to the noted pin elements.

It is an object of this invention to provide a novel and improved solid state switch which is particularly adapted for use in starting of split-phase and capacitor start electrical motors; to provide such solid state switches which are of very compact and economical construction; to provide such switches which are particularly adapted for convenient and trouble-free connection to the main and start motor winding leads of hermetically sealed compressor motors; and to provide such switches which are of versatile application.

Other objects, advantages and details of the solid state switch of this invention appear in the following detailed description of preferred embodiments of the invention, the detailed description referring to the drawings in which:

FIG. **1** is a perspective view of the solid state electrical switch of this invention;

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

FIG. **3** is a section view along line **3—3** of FIG. **2**;

FIG. **4** is a perspective view of a component of the switch of FIG. **1**; and

FIG. **5** is a schematic view illustrating application of the switch of this invention.

Referring to the drawings, **10** in FIGS. **1–3** indicates the novel and improved solid state switch of this invention which is shown to include a generally cup-shaped casing **12** having a bottom **14** and a sidewall **16** forming a casing chamber **18** which is open at one end **20** and which has a rim **22** extending around the open casing end. As shown, the casing rim preferably has a slotted portion indicated by the slots **24** and **26** and, as is shown particularly in FIG. **2**, the casing sidewall preferably has a groove extending substantially around the sidewall forming a shoulder **28** within the casing chamber. Preferably also the casing has an additional wall **30** upstanding from the casing bottom in spaced adjacent relation to the slotted portion of the casing rim. The casing also has a plurality of apertures **32**, best shown in FIG. **3**, which preferably extend through the casing sidewall from the sidewall shoulder **28** and which open

exteriorly of the casing adjacent the casing bottom. The casing **12** is formed of an electrically insulating or dielectric material and is preferably formed of a relatively rigid material such as a thermoplastic polyester or the like. Preferably also the casing has reinforcing means **34** integrally formed therein as shown in FIG. **2**, these reinforcing means including ribs **34.1** and a plate part **34.2** which extends across the exterior of the casing bottom a selected distance from the one end of the casing having the slotted portion of the casing rim **22** and which faces toward said one casing end for a purpose to be described below. If desired, slots **35** are formed in the casing sidewall to facilitate dissipation of heat from the switch.

In accordance with this invention, a first electrically conductive metal terminal **36**, preferably formed of stiffly resilient material such as plated phosphor bronze, beryllium copper or steel or the like is disposed within the casing **12**. As shown, the first terminal preferably has a plate portion **38** provided with a plurality of raised projections **40** thereon and has integral spring legs **41** extending downwardly from the plate portion **38** to resiliently bear against the casing bottom **14**. If desired, the first terminal also has a spacer portion **39** engaging the wall **30** of the casing **12** for positioning the first terminal within the casing. The first terminal also has a connector portion **42** extending through the casing sidewall. Preferably, for example, the connector portion **42** is integral with the plate portion of the terminal and has the form of a metal sleeve **46** of selected length connected to the plate portion **38** by an intermediate connector part **47** and split as indicated at **48**, one end **46.1** of the sleeve being engaged with the additional wall **30** of the casing for locating the terminal laterally within the casing with the sleeve extending through the slot **24** in the casing sidewall.

In accordance with this invention, a resistor element **50** is also disposed within the casing chamber **18**. Preferably the resistor element **50** is formed of a ceramic material such as a lanthanum-doped barium titanate having a positive temperature coefficient of resistivity. Preferably the selected resistor material is adapted to be self-heated by directing electrical current through the resistor material and is adapted to display a sharp and very large increase in electrical resistance when heated to a selected temperature for reducing current flow through the material to a very low level and for thereby limiting the heating of said resistor material to approximately that selected temperature level. As shown, the resistor **50** is preferably in disc form and has contact surfaces **52** and **54** formed thereon by metallizing or the like in any conventional manner for facilitating electrical contact to the resistor element. The contact surface **52** of the resistor element is disposed on the projections **40** on the first terminal **36** in electrical engagement with that terminal.

In accordance with this invention, the solid state switch **10** further includes a second electrically conductive metal terminal **56**. The second terminal **56** has a plate portion **58** which rests on the casing shoulder **28** as is shown in FIG. **2** for closing the open end **20** of the casing and has a plurality of tabs **60** which are preferably integral with the plate portion **58** and which extend into respective apertures **32** in the casing. As shown, the plate portion **58** of the second terminal preferably has a plurality of projections **61** formed thereon for electrically engaging the contact surface **54** of the resistor element **50**. The second terminal also has a connec-

tor portion **62**, preferably in the form of a metal sleeve **64** split at **66** and welded or otherwise connected to the terminal plate portion **58** and extending through the casing rim slot **26**, the connector sleeve **64** also having one end **64.1** engaged by the additional wall **30** of the casing for assisting in locating the second terminal relative to the casing. As shown particularly in FIG. **1**, the second terminal **56** preferably has an upturned flange portion **68** having one or more tab terminals such as the tabs **70** and **72** extending from the flange spaced above the plate portion of the terminal **56**. In a preferred construction, an insulator strip **74** is entrapped between the sleeve connector **46** of terminal **36** and a part of terminal **56** and between the rim **22** and additional wall **30** of the casing for assuring that the sleeve connector **46** is electrically insulated from the terminal **56**.

As shown particularly in FIG. **4**, the extending tabs **60** of the second terminal **56** preferably have a pair of extensions **60.1** at the tab ends which are flared away from each other after the tabs have been inserted through the apertures **32** in the dielectric casing. In this way, the flared tab extensions form enlarged ends on the tabs which bear against the casing exteriorly of the casing for holding the two terminals **36** and **56** as well as the resistor element **50** securely together with the casing **12** while resiliently pressing the two terminals into firm electrical engagement with respective opposite contact surfaces of the resistor and while resiliently pressing the spring portions **41** of the terminal against the casing bottom.

In this arrangement, the solid state switch is of very inexpensive construction utilizing a minimal number of component parts but is easily and accurately assembled to provide a switch which is very versatile in application. The switch terminals are readily adapted to receive either leads or pin connections in the receptacle-like sleeve connector portions of the terminals and the second terminal includes the tab terminals **70** and **72** for facilitating quick electrical connection of the switch to a line lead and, if desired, to a fan motor lead. For example, as is illustrated schematically in FIG. **5**, wherein the switch **10** is indicated by broken line **10***a*, the sleeve connector **46** of the switch **10** is conveniently adapted to be electrically connected to one end of the start winding **74** of a split-phase electrical motor **75** while the sleeve connector **64** of the switch is adapted for convenient electrical connection to one end of the main winding **76** of the motor, the opposite ends of the motor windings being connected to a line lead **77** from the power supply (indicated by the terminals **78**). The tab terminal **70** of the switch **10** is then conveniently connected to the line lead **80**. In this way, the resistor element **50** of the switch is conveniently connected in series with the start winding **74** in parallel with the main winding **76** across the power supply so that, when the motor **75** is started, the start winding is initially energized to start the motor but so that, as the resistor element **50** is heated by the start winding current directed therethrough, the resistor reaches a selected temperature at which the resistance of the element sharply increases for effectively removing the start winding from the motor circuit and for thereafter limiting heating of the resistor element to approximately said selected temperature. The small additional heat thereafter generated by the resistor is effectively dissipated from the switch **10** through the plate portion **58** of the second terminal **56**, through the terminal sleeves **42** and **62**, and through the casing slots **35** when provided. The heat-dissipating nature of the plate portion **58** also permits the switch **10** to cool to normal temperature more quickly after the motor is deenergized for permitting faster restarting of the motor when required. Where the motor **75** is provided in a hermetically sealed unit for refrigeration compressor applications or the like, and where the motor leads are brought out of the sealed unit through closely spaced pins sealed in the unit casing, the connector sleeve portions **46** and **64** of the switch conveniently fit over the closely spaced pins for pluggable mounting of the switch and the tab terminal is readily connected to the line lead **80**, the compact construction of the switch **10** conveniently disposing the resistor element **50** in series with the start winding **74** in parallel with the main motor winding **76**. Further, where an additional pin element **77.1** (see FIG. **5**) is extended through the casing of a sealed motor unit for connecting the common lead **77** to the motor winding as is conventional, such a pluggable mounting of the switch **10** on two of the motor lead pins disposes the plate part **34.2** of the casing reinforcing means over such an additional pin for shielding the connection of the lead **77** to that pin and for tending to retain such a lead connection on the additional pin. If a fan is to be used with the motor **75**, a lead from the fan motor **82** is also conveniently attached to the tab terminal **72** on the switch **10**. It will also be understood that although the switch **10** is shown for use in starting of a split-phase motor, the switch **10** is also adapted for use in starting of other types of motors such as capacitor start motors as well as in other applications, the switch providing a very economical switch construction for a wide variety of uses.

It should also be understood that although particular embodiments of the invention have been described by way of illustration, this invention includes all modifications and equivalents of the disclosed embodiments falling within the scope of the appended claims.

I claim:

1. A solid state electrical device comprising a cup-shaped casing of dielectric material having a bottom and a sidewall forming a casing chamber having an open end, a first electrically conductive metal terminal means disposed in the casing having a resilient spring portion bearing against said casing bottom and having a connector portion extending through said casing sidewall, a ceramic resistor element of positive temperature coefficient of resistivity disposed within said casing resting on and in electrical engagement with said first terminal means, and a second electrically conductive metal terminal means having a heat-dissipating plate portion closing said open casing end and electrically engaging said resistor element, said second terminal means having at least one tab portion extending through said casing toward said casing bottom and having an enlarged end on said tab portion engaging said casing exteriorly of said casing chamber holding said first and second terminal means pressed resiliently in electrical engagement with said resistor element and securing said terminal means and resistor element with respect to said casing with said first terminal means pressed resiliently against said casing bottom.

2. A solid state electrical switch comprising a cup-shaped casing of dielectric material having a bottom and a sidewall forming a casing chamber having an open end and a rim around said open end, said casing having a slotted portion at said rim and having a plurality of apertures opening at said casing bottom, a first

electrically conductive metal terminal disposed in the casing having a resilient spring portion bearing against said casing bottom and having a connector portion extending exteriorly of said casing chamber through said slotted portion of said rim, a resistor disc of a ceramic material of positive temperature coefficient of resistivity adapted to be electrically self-heated by directing electrical current therethrough and to display a sharp increase in resistivity when self-heated to a selected temperature for limiting said heating, said resistor disc having contact surfaces on opposite disc sides thereof and being disposed in said casing chamber on and with one of said contact surfaces in electrical engagement with said first terminal, and a second electrically conductive metal terminal having a heat-dissipating plate portion closing said open casing end and electrically engaging the other of said contact surfaces on said resistor disc, having a connector portion extending exteriorly of said casing chamber through said slotted portion of said rim, and having a plurality of tabs extending through said respective casing apertures, said tabs being enlarged at their distal ends to engage said casing exteriorly thereof holding said first and second terminals pressed resiliently in electrical engagement with said resistor disc and securing said terminals and disc to said casing with said first terminal pressed resiliently against said casing bottom.

3. A switch as set forth in claim **2** wherein said second terminal has at least one tab portion upstanding from said plate portion thereof forming an additional connector portion of said second terminal.

4. A switch as set forth in claim **2** wherein said casing sidewall has a groove extending around a substantial part of said sidewall adjacent said rim forming a shoulder within said casing chamber and said plate portion of said second terminal is held in engagement with said shoulder for closing said open casing end.

5. A switch as set forth in claim **4** wherein said casing apertures extend through said casing sidewall from said shoulder to said casing bottom.

6. A switch as set forth in claim **2** wherein said connector portions of said first and second terminals comprise slit metal sleeves extending from said terminals to receive leads within said sleeves.

7. A switch as set forth in claim **6** wherein said casing has an additional wall portion upstanding from said casing bottom adjacent said slotted portion of said casing rim engaging one end of each of said connector sleeves of said first and second terminals for further securing said terminals in selected portions relative to said casing.

8. A switch as set forth in claim **7** having an insulator member held between said connector sleeve of said first terminal and said second terminal and between said sidewall and additional wall of said casing.

9. A switch as set forth in claim **2** wherein said first terminal has a plate portion engaging a surface of said resistor disc and has a plurality of integral spring portions extending from said first terminal plate portion resiliently engaging said casing bottom.

10. A solid state electrical switch comprising a cup-shaped casing of dielectric material having a bottom and a sidewall forming a casing chamber having an open end and a rim around said open end, said casing having a slotted portion at said rim, having an additional wall upstanding from said casing bottom adjacent said slotted rim portion, having a groove in said sidewall adjacent said rim forming a shoulder within said casing chamber extending around a substantial part of said sidewall, and having a plurality of apertures extending through said sidewall from said shoulder to said casing bottom, a first electrically conductive metal terminal having a plate portion, having a plurality of integral spring portions extending from said plate portion resiliently engaging said casing bottom, and having a split sleeve connector portion extending through said slotted portion of said rim and engaged by said additional casing wall for positioning said first terminal within said casing chamber, a resistor disc of ceramic material of positive temperature coefficient of resistivity adapted to be electrically self-heated by directing electrical current therethrough and to display a sharp increase in resistivity when self-heated to a selected temperature for limiting said heating, said resistor disc having contact surfaces on opposite sides thereof and being disposed in said casing chamber with one of said contact surfaces resting on and in electrical engagement with said first terminal plate portion, and a second electrically conductive metal terminal having a heat-dissipating plate portion resting on said casing shoulder closing said open casing end and electrically engaging the other of said resistor disc contact surfaces, having a split sleeve connector portion extending through said slotted portion of said rim and engaged by said additional casing wall, and having a plurality of tabs extending through said casing apertures, said tabs being enlarged at their extended ends engaging said casing exteriorly thereof holding said first and second terminals pressed resiliently in electrical engagement with said resistor disc and securing said terminals and disc to said casing with said first terminal pressed resiliently against said casing bottom.

11. A switch as set forth in claim **10** wherein said first terminal has a portion engaging said casing sidewall for positioning said first terminal within said casing.

* * * * *