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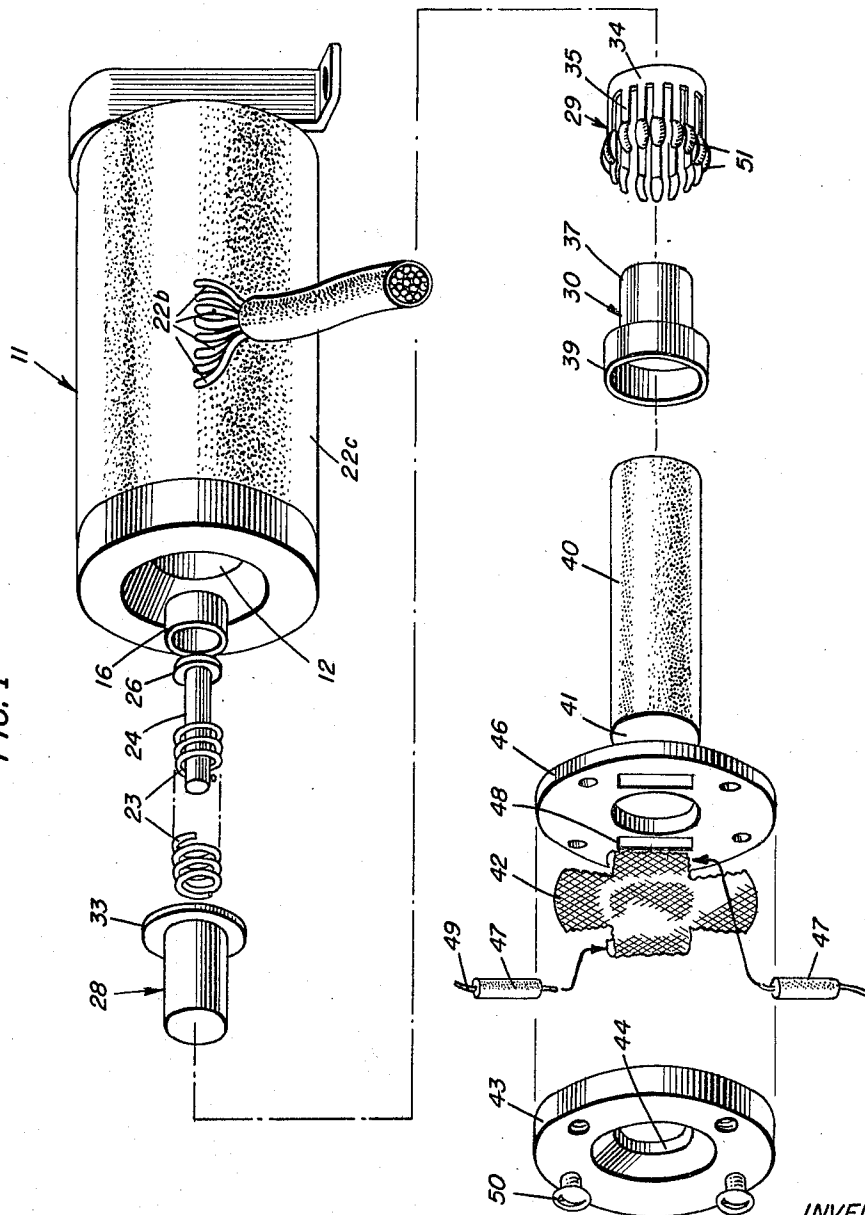
L. WILSON ET AL  
SUBLIMATION TIMING SWITCH

3,286,064

Filed March 31, 1965

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FIG. 1



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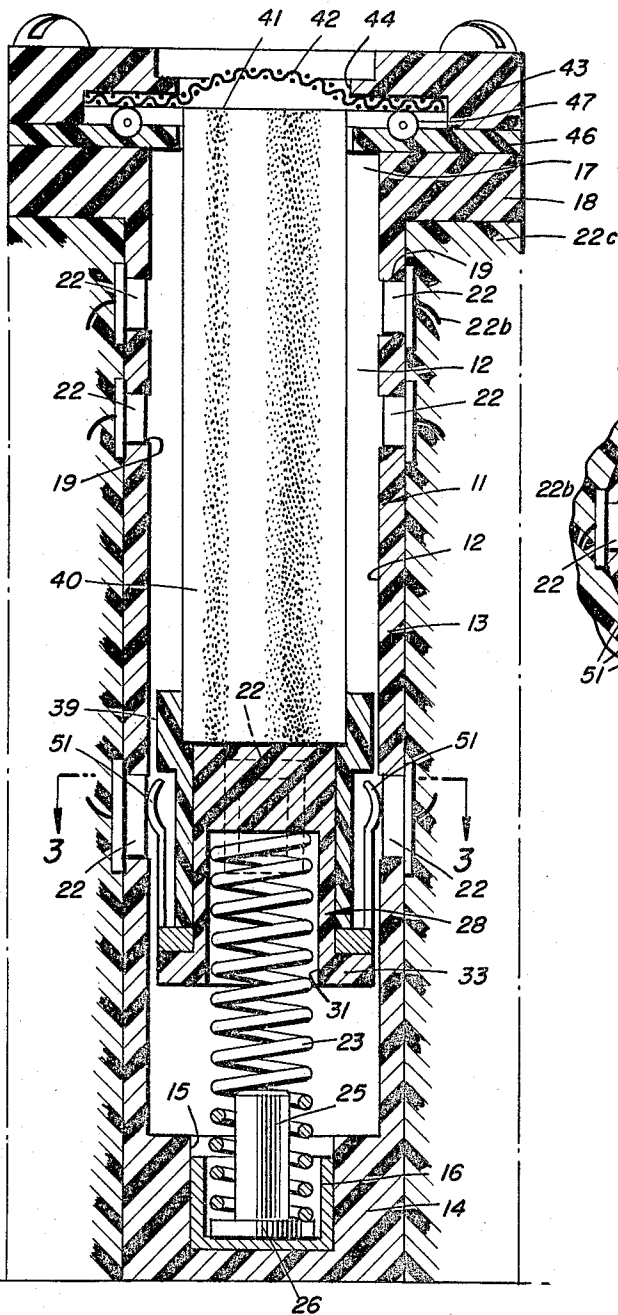
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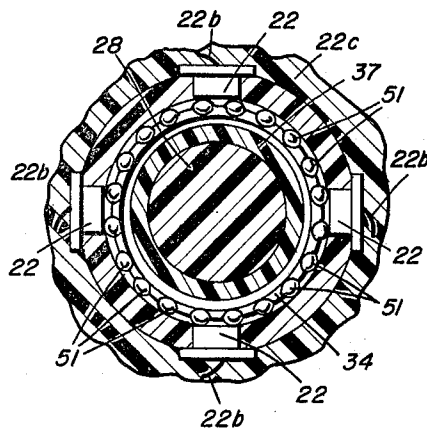
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FIG. 2



**FIG. 3**



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FIG. 4

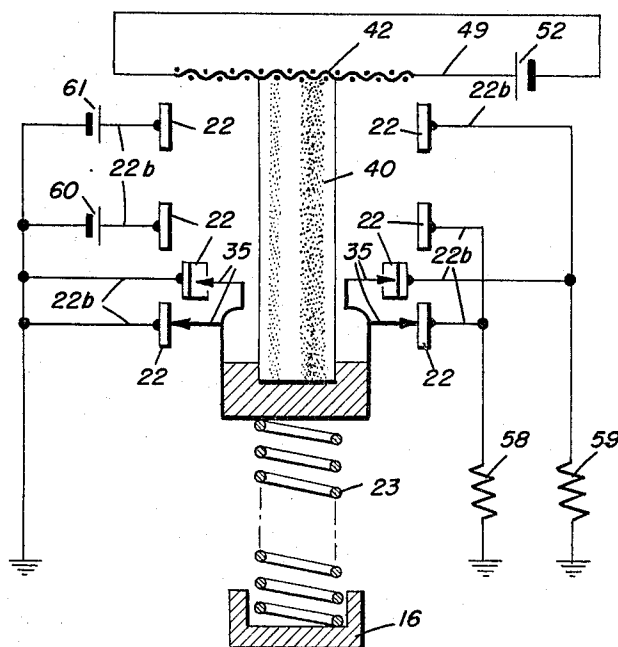
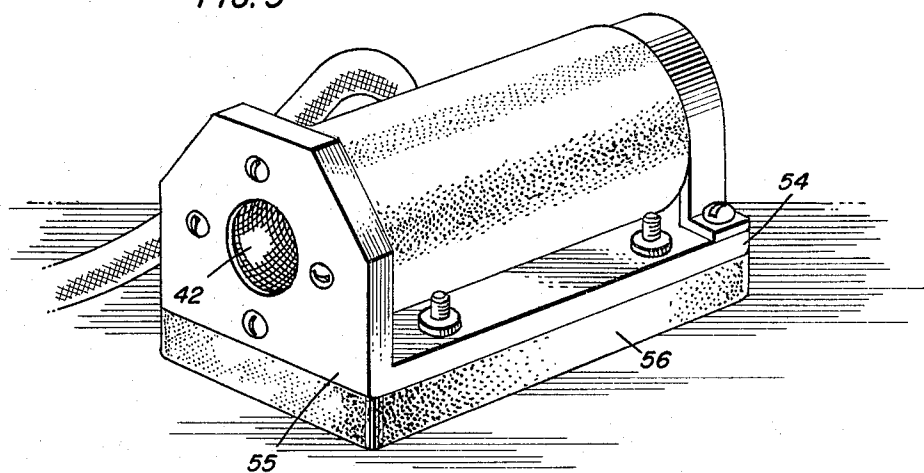


FIG. 5



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3,286,064

## SUBLIMATION TIMING SWITCH

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Filed Mar. 31, 1965, Ser. No. 444,469

6 Claims. (Cl. 200—142)

The present invention relates generally to a timing device and more particularly to a sublimation timing switch exhibiting predetermined time delays for sequentially actuating various electrical circuits in a spacecraft after being launched.

An object of the present invention is to provide for a large number of sequentially switching operations in a satellite.

Another object of the present invention is to provide for reliable multi-pole operations of a switch in a satellite.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is an exploded perspective view of an embodiment of the present invention;

FIG. 2 is an axial sectional view of the assembled switch;

FIG. 3 is a cross-section on line 3—3 of FIG. 2;

FIG. 4 is a schematic diagram of a circuit showing the operation of the switch of the present invention; and

FIG. 5 is a side perspective view of a different embodiment of the present invention.

Referring now to the drawings, the elongated tubular plastic housing 11 of the switch mechanism supports movable elements within an interior axial cavity or chamber 12 defined by enclosing wall 13. A bottom wall 14 of the housing closes the axial chamber 12 and has a recess or pit 15 for receiving a metallic cup-shaped seat 16 therein. The enclosing wall 13 of the housing at the open or top end 17 of the axial chamber 12 has an outwardly extending surrounding flange 18. The enclosing wall of the housing has a series of peripherally and longitudinally spaced slots 19 extending from exterior surface 20 to the interior surface 21 of the enclosing wall into the chamber of the housing. The slots or bores 19 of the enclosing wall receive solid metal plugs as electrical terminals 22 as shown in FIGS. 2 and 3. The terminals 22 with prior attached lead wires 22b are held in place and electrically insulated from each other by a moldable epoxy resin 22c. The longitudinally separated terminals 22 are arranged in peripherally aligned sets which are indicated in FIG. 2 as position 1, position 2 and position 3. Depending upon the particular use of the switch, any number of positions of the electrical terminals can be incorporated in the enclosing wall.

Within the axial chamber of the elongated housing, a coil spring 23 encompasses a stem 24 of a spring guide pin 25 and bears on a base 26 of the spring guide pin 25 placed within the seat 16 of the bottom wall. With this arrangement, the spring in operation does not hand away from an axial direction and the lower end of the spring does not scarify the bottom wall of the housing. The upper end of the spring presses against a plunger movable within the chamber. The plunger includes a thimble-shaped insulating member 28, a ring-shaped segmented contact member or shorting bar 29 and a sleeve-shaped member 30. The thimble-shaped member 28 has an axial recess 31 for receiving the upper end of the coil spring and has an outwardly directed flange 33. The

ring-shaped segmented contact member 29 has a circular metallic band 34 with a series of longitudinally extending segmented electrical finger contacts 35 fastened to the circumferential edge of the band. The band 34 encompasses the outer surface of the thimble member 28 and rests on the upper surface of the outwardly directed flange 33 of the thimble member. The sleeve-shaped member 30 has a downwardly extending skirt 37 for receiving the thimble-shaped member 28. The lower edge of the skirt 37 retains the band 34 of the shorting ring bar 29 on the flange 33 of the thimble member 28. The sleeve member 30 has an upstanding circular rim 39 for holding a cylindrical-shaped charge 40 of compressed sublimable material. The upper end 41 of the charge 40 presses against a heated wire mesh 42 by the tensile action of the coil spring retained under compression between the thimble-shaped member 28 and the bottom wall 14.

An annular holder 43 with a central opening 44 and an undercut circular recess 45 adjacent to the opening retains the heated wire mesh 42 across the open end of the axial chamber of the housing against the upper end 41 of the charge 40. The mesh 42 allows upon sublimation of the material for subliming vapors to escape and material to pass therethrough. An annular spacer extending inwardly beneath the undercut recess of the annular holder rests on the exterior flange 18 of the enclosing wall of the housing. In order to achieve more uniform heating of the wire mesh, projecting ears of the wire mesh are wrapped around resistors 47 received within the recess 45 of the holder and indentations 48 made within the spacer. Lead wires 49 to the resistors extend through the holder for connection to an external battery, not shown. The holder and spacer are retained in tight relationship by fasteners 50 inserted through the holder and spacer and secured to the flange 18 of the housing.

Referring to FIGS. 2 and 3, the finger contacts 35 extend longitudinally over the skirt 37 of the sleeve-shaped member 30 and have curved ends 51 for pressing against the interior surface of the enclosing wall and terminals 22. The finger contacts 35 will press against the terminals 22 inserted into the slots of the housing wall depending upon the position of the plunger within the chamber of the housing. The terminals 22 and fingers 35 have such a size relationship that at least two adjacent fingers will make contact with a terminal so that during operation the switch will have greater reliability.

The charge of sublimable material 40 comprises either camphor, naphthalene, biphenyl, benzioc acid or any combination thereof. These materials are compressed under high pressure into the charge or cartridge which then can be either lathed or milled with considerable ease and precision. Each of the above-mentioned materials have a different rate of sublimation. At normal atmospheric pressure the rate of sublimation is extremely slow but become more rapid in the vacuum of space. In addition, the application of heat to a sublimable material will increase its rate of sublimation.

When heat is applied to the device of the present invention, it is designated as an active switch. An embodiment of the holder 43 of FIGS. 1 and 2 shows a heated wire mesh 42 secured between the holder 43 and spacer 46 with the upper end of the charge pressing against the mesh. In order to effect a more rapid rate of sublimation, the mesh is connected to a small silver zinc battery, not shown. The battery supplies enough current to heat the metallic mesh. Consequently, the material sublimates due to the lack of pressure in space and the addition of heat applied to the upper end of the charge.

Another embodiment of an active switch is shown in

FIG. 5 in which the housing of the switch is carried by an angle-shaped metallic support 54. The flange 55 of the support has an opening covered with a wire mesh similar to mesh 42. With this arrangement the heat of the rocket or missile casing is transferred to the base of the metallic support 54 and subsequently to the wire mesh to heat the sublimable material. Since the missile casing exhibits considerable amounts of heat immediately after launching of a missile, the metallic support 54 is insulated from the casing with a sheet 56 of glass fiber encapsulated epoxy resin to delay the operation of the switch to a later desired time of missile flight.

In place of a wire mesh, a perforated sheet of carbon of known resistivity could be used. In this case, the carbon sheet would absorb heat from the environment and apply it to the top end of the charge of material.

If the switch is to be subjected only to the vacuum of space, then the purpose of the wire mesh is to retain the charge of sublimable material in place. The switch is then known as a passive one. The rate of sublimation of a passive switch could be delayed on the order of years by requiring the subliming vapor to pass through a series of cavities each with a small orifice before reaching the vacuum of space.

If the switch is to operate at higher temperatures, the synthetic plastic or nylon material of the housing 11, thimble 28, sleeve 30 and holder 43 can be made of ceramic or other compositions.

Referring now to FIG. 4, the operation of the switch in a satellite is illustrated. When the material of the charge sublimates from a solid to a gas, the spring 23 moves the plunger 27 holding the finger contacts 35 from an initial position pressed against terminals 22 in position 1. Upon continued sublimation, the finger contacts 35 make connection sequentially with the terminals 22 at positions 2 and 3.

The schematic of FIG. 4 shows the finger contacts 35 at position 1 grounding through band 34, squibs 58 and 59 during the launching phase of a missile or satellite. After a predetermined interval of time depending upon the rate of sublimation of the charge, the finger contacts 35 at position 2 connect the battery 60 attached to one of the terminals at position 2 to a squib 58 attached to another of the terminals at position 2. Likewise, the operation is the same at position 3 to connect a battery 61 to squib 59. In actual use more than one terminal is connected to the same electrical circuit so that reliability of the switch is insured.

The device of the present invention can be used to initiate separation of a payload from a rocket or to separate multiple payloads from each other. The device has been used as a back-up switch for initiating separation in event the rocket's programmer failed to provide the payload separation signal. Other uses of the switch are possible such as turning on high voltage for a particular satellite experiment.

The switch of the present invention shows use of a multi-pole operation by the number of terminals and segmented finger contacts. The number of sequentially switching operations is determined by the number of aligned position of the terminals. Another variation for increasing the number of switching operations is to make the band 34 of contact member 27 with insulated elements to isolate certain fingers so that a circuit is only connected between any two adjacent terminals.

The intervals of time during which the switch mechanism operates is determined by the rate of sublimation of the material used, the length of the sublimable charge, the temperature and pressure of the environment and a combination of any of these.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A timing switch in a missile or satellite comprising insulating housing means having closed end means and open end means and having a plurality of longitudinally separated series of peripherally spaced terminal means between said closed and open end means; carrying means being positioned within said housing means between said closed and open end means, said carrying means for sliding sequentially and longitudinally from one of said separated series to another of said separated series of peripherally spaced terminal means and having electrical shorting means for connecting said peripherally spaced terminal means of one of said longitudinally separated series of said spaced terminal means; sublimable means being positioned between said open end means and said carrying means within said housing means and abutting against said carrying means; resilient means being positioned within said housing means between said closed end means and said carrying means for loading said carrying means and said sublimable means; holding means attached to said housing means at said open end means for retaining said sublimable means against said carrying means and maintaining said resilient means within said housing means bearing against said closed end means of said housing means and said carrying means whereby upon sublimation of sublimable means due to the vacuum of space, said resilient means expand longitudinally and move said carrying means enabling said electrical shorting means to make contact sequentially with said longitudinally separated terminal means.
2. A timing switch of claim 1 in which said holding means comprises heating means in the form of a wire mesh for retaining said sublimable means and for accepting an electrical current for heating to said sublimable means to increase the rate of sublimation of said sublimable means.
3. A timing switch for a satellite for initiating electrical circuits sequentially according to predetermined time delay intervals after launching of a satellite into space comprising insulating housing means with an enclosing wall having exterior and interior surfaces defining an interior axial chamber with closed and open ends, said enclosing wall having a plurality of longitudinally separated series of peripherally spaced terminal means extending from said exterior surface of said wall through said wall to said interior of said wall to said interior chamber; sliding means being positioned within said chamber of said housing means, between said closed and open ends, said sliding means having electrical shorting means with a plurality of segmented fingers for pressing against said interior surface of said enclosing wall and said terminal means; sublimable means being positioned between said open end and said sliding means within said chamber axially abutting against said sliding means; resilient means being positioned within said chamber between said closed end and said sliding means for loading said sliding means and said sublimable means; holding means attached to said housing means at said open end for retaining said sublimable means against said sliding means and maintaining said resilient means within said chamber bearing against said closed end of said housing means and said sliding means whereby upon sublimation of sublimable means due to the lack of pressure after launching a satellite into space, said resilient means move said sliding means enabling said segmented fingers of

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said shorting means to make contact sequentially with said separated terminal means.

4. A timing switch for a satellite for initiating electrical circuits sequentially according to predetermined time delay intervals after launching a satellite into space comprising

insulating housing means with an enclosing wall having exterior and interior surfaces defining an interior axial chamber with closed and open ends, said enclosing wall having a plurality of longitudinally separated series of peripherally spaced terminals extending from said exterior surface of said wall through said wall to said interior surface of said wall to said interior chamber;

sliding means being positioned within said chamber of said housing means between said closed and open ends, said sliding means having electrical contact means including a plurality of segmented annular fingers for pressing against said interior surface of said enclosing wall and said spaced terminals; a charge of sublimable material being positioned between said open end and said sliding means within said chamber axially abutting against said sliding means;

resilient means being positioned within said chamber between said closed end and said sliding means for loading said sliding means and said charge; guiding means within said chamber abutting against said closed end of said housing means and having projecting means extending axially through said resilient means for limiting said resilient means to a longitudinally axial movement;

holding means having screening means attached to said housing means at said open end for retaining said charge, said sliding means and said resilient means in an initial position under compression within said chamber and said screening means having openings for allowing the escape of subliming vapors upon sublimation of said charge due to the lack of pressure in space, whereby upon sublimation of said charge said resilient means move said segmented fingers for contacting sequentially said longitudinally separated series of terminals.

5. A timing switch of claim 4 in which said screening means in form of a wire mesh for accepting an electrical current for heating said charge to increase the rate of sublimation of said material.

6. A timing device for a satellite for initiating electrical circuits sequentially according to predetermined time de-

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lay intervals after launching a satellite into space comprising

insulating housing means with an enclosing wall defining an axial chamber having an open end, a closed end, said enclosing wall having a plurality of longitudinally separated series of peripherally spaced terminals extending through said wall to said chamber, said terminals adapted for connection to a series of electrical circuits;

sliding means being positioned within said chamber of said housing means, said sliding means carrying a metallic ring having a plurality of segmented annular fingers for pressing against said enclosing wall and said spaced terminals, said annular fingers having more than one finger for making contact with one of said terminals;

a charge of sublimable material being positioned within said chamber axially abutting against said sliding means;

resilient means being positioned within said chamber between said closed end and said sliding means for loading said sliding means and said charge;

holding means having screening means attached at said open end of said housing means for retaining said charge and said sliding means under compression of said resilient means and for maintaining said metallic ring in alignment with one of said series of said longitudinally separated terminals, said screening means having openings for allowing the escape of subliming vapors of said charge, whereby upon sublimation of said material due to the lack of pressure on said material, said charge decreases in length allowing said ring to contact said other series of longitudinally separated terminals for initiating any electrical circuits attached to said terminals sequentially depending upon the rate of sublimation of said material.

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