April 12, 1966 S. H. KAUFFMAN 3,246,109

SQUIB PULSING HIGH CURRENT SWITCH

Filed Feb. 28, 1964 2 Sheets-Sheet 1

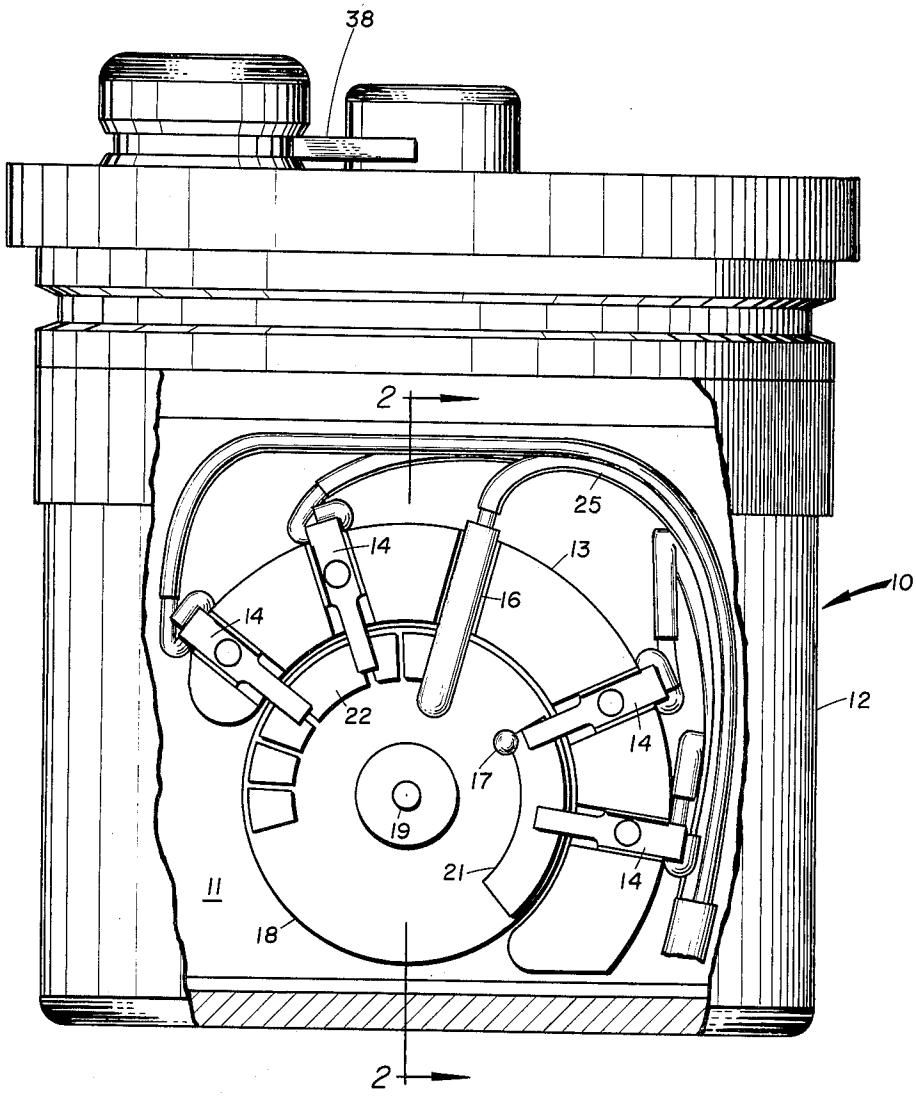

FIG. 1

Samuel H. Kauffman
INVENTOR.

BY M. Jacobs
ATTORNEY.

Robert H. Williams
AGENT.

April 12, 1966 S. H. KAUFFMAN 3,246,109

SQUIB PULSING HIGH CURRENT SWITCH

Filed Feb. 28, 1964 2 Sheets-Sheet 2

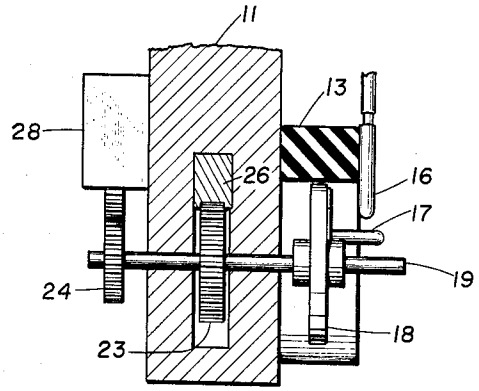

FIG. 2

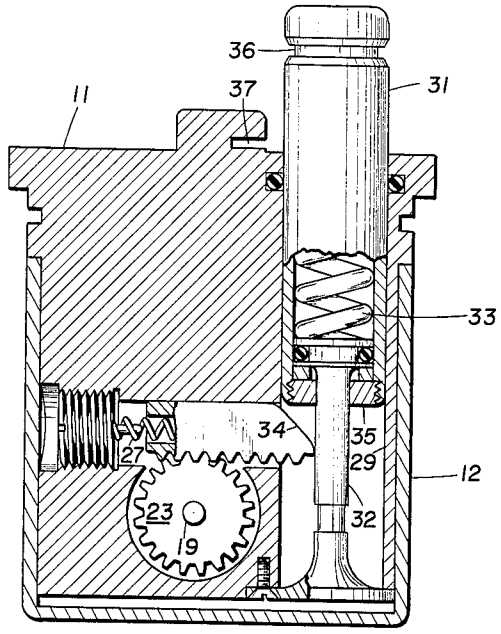

FIG. 3

Samuel H. Kauffman
INVENTOR.

BY
ATTORNEY.

AGENT.

United States Patent Office 3,246,109 Patented Apr. 12, 1966

3,246,109

SQUIB PULSING HIGH CURRENT SWITCH

Samuel H. Kauffman, Silver Spring, Md., assignor to the United States of America as represented by the Secretary of the Navy

Filed Feb. 28, 1964, Ser. No. 348,910
1 Claim. (Cl. 200—166)

This invention relates to the art of electric switches. More particularly, the invention concerns a switch intended to be used to discharge a capacitor in an explosive squib firing circuit in which a relatively high current for a short time is required. The invention is an improvement over the time delay switch described in U.S. Patent 2,998,944 to William Rimmer, issued September 5, 1961.

The present switch is intended for use as a rocket motor igniter switch although it is to be understood that it may be used in any high current firing circuit. Because of this important military application, the switch must meet rigorous test requirements. The prescribed performance characteristics are set out in Ordnance Standard 9816, paragraph 3.4.8.2 as follows:

Discharge across one (1) ohm resistance.—The measured voltage trace from an oscilloscope shall be not less than 90 percent of the voltage for a perfect switch for the initial two time constants after the initial rise of the trace except during the first 150 microseconds, when the measured voltage shall be not less than 67 percent of the perfect switch voltage. After the first 150 microseconds, the trace shall be smooth and continuous. The equation for the curve for a perfect switch signature is given as:

$$VDC = 60e - \frac{10^6 t}{200}$$

(Note that near $t=0$, the current in the 1 ohm test circuit is about 60 amps.)

The switch described in the aforementioned Rimmer patent, which has conventional plane and spherical contact surfaces, was found to be unable to meet this standard. Another contact scheme was tried, using a shorting bar and a pair of spring fingers, to provide a switch having a wiping action, but this too failed to meet the requirements of OS-9816. In both cases, the failure was apparently due to arcing at the contacts.

Accordingly, it is the object of this invention to provide a switch which exhibits contact signature performance above the minimum standards set out above.

It is known in the switch art that arcing and high contact resistance sometimes results from the fact that surface roughness makes it possible for first contact to be established by a whisker or protuberance from the contact surface. If the whisker or protuberance cannot carry the current in the circuit, it vaporizes and provides an ionized path for an arc to be established.

This arcing takes place even where, as in the present case, the voltages are not high enough to cause spontaneous air arcing. The vaporization phenomenon is discussed, for example, by Ragner Holm in his book entitled "Electric Contacts" at page 280. It is suggested there that such arcing could be overcome by providing a high polish on the contact surfaces, but the assertion is also made that it is not possible to achieve satisfactory results in practice. Applicant has found, however, that by making the contacts cylindrical (i.e. circularly cylindrical as distinguished from generally cylindrical) in

shape, it becomes possible to polish the surfaces easily to a high degree. Then, by arranging the two cylinders so that the planes containing their axes are at a substantial angle to each other, a substantially point contact arrangement is provided in which arcing does not occur.

The cross relationship of the contacts makes known the exact point at which contact will take place. Special attention can then be given to the inspection and polishing of the contacts at this point. While the precise reason for the good performance of the switch is not known, it is thought that it results from the combination of the features of high polish, the cylindrical shape of the contacts, and the cross relationship between them.

A further advantage of the present invention resides in the discovery that contact can be made repeatedly and at full load without burning the contacts. Thus the switch can be tested several times before use and reliability of performance in actual use is increased.

These and other objects and advantages will become more apparent from a consideration of the following detailed description when read with the accompanying drawings, wherein:

FIG. 1 is an elevational view, with parts broken away, of the switch incorporating the present invention;

FIG. 2 is a sectional view on line 2—2 of FIG. 1; and

FIG. 3 is a section through the switch taken on a plane parallel to the general plane of FIG. 1, viewed from below.

Referring now to FIG. 1, the switch of the present invention is generally indicated at **10**. The main switch elements are shown as mounted on a base **11** within the broken away portion of a housing cover **12**, the details of which are not important to the present discussion. Suffice to say that the support **11** and cover **12** are adapted to be mounted in the missile as described in the aforementioned Rimmer patent. Mounted on base **11** is a contact support element **13**, made of insulating material, which carries a plurality of auxiliary contacts **14** and the stationary contact **16** of the squib firing switch. The movable contact of the squib firing switch is indicated at **17** and is carried by a rotatable insulating disk **18** fixedly mounted on a shaft **19**. Movable contact **17** is in electrical contact with a conductive segment **21** on the surface of disk **18** and the circuit continues through auxiliary contacts **14**. It is to be understood that contacts **14** are spring fingers which act downwardly against the surface of disk **18**. Other conductive segments **22** may be provided as desired on disk **18** to perform other independent functions.

Electrical leads, generally indicated at **25**, extend from the various contacts to external circuitry, the leads extending from contacts **16** and **17** being connected of course into the aforementioned squib firing circuit.

Means are provided for rotating disk **18** to bring moving contact **17** into engagement with stationary contact **16**, which means are essentially the same as described in the Rimmer patent. As mentioned above, disk **18** is fixedly attached to a shaft **19**, which shaft is journalled for rotation in base **11** and carries two gears **23** and **24**. Gear **23** is engaged and rotated by a rack bar **26** which is biased to the right, as seen in FIG. 3, by means of a spring **27**. The rate of rotation of shaft **19** under the influence of spring **27** is controlled by an escapement mechanism **28**, which engages gear **24**. The details of escapement **28** are not shown, since they are not necessary to the understanding of the invention.

Prior to launching the missile, rack **26** is held in its retracted position. For this purpose, a transverse bore **29** is provided in base **11** in which a plunger **31** is guided for reciprocating motion. A flanged post **32**

mounted on base **11** coacts with plunger **31** to provide support for a spring **33** and to limit outward movement of plunger **31** by cooperation with an annular plug **35** in plunger **31**. Plunger **31** is adapted to cooperate with a ramp portion **34** on the end of rack bar **26**. When plunger **31** is pushed inwardly, ramp portion **34** is engaged by the end of the plunger to push rack bar **26** to the left as seen in FIG. 3 until the plunger clears the end of the rack bar. Plunger **31** is pushed in until groove **36** therein lines up with a slot **37** formed in base **11**. An arming pin **38** is then inserted in the groove and slot in order to hold plunger **31** in the inward position. When the missile is launched, pin **38** is withdrawn, plunger **31** moves to the extended position, and rack **26** is freed to rotate shaft **19** and bring contacts **16** and **17** together to close the squib firing circuit after a predetermined time delay.

Both switch contacts **16** and **17** are formed as pins with circular cross-section, such a shape being easily machined and polished to a high degree of smoothness. As stated above, such a polish is considered essential to the reliable operation of this switch. The contacts may be either solid or tubular, as long as the external surfaces are circularly cylindrical and polished. Further, as shown in the drawings, the contacts are arranged with the planes containing their axes at 90° to one another, although it is to be understood that the precise angle is not critical as long as it is large enough to insure substantially point contact between the contacts. A precious metal plating may be put on the contact surfaces as desired.

When constructed with the polished crossed cylindrical contacts as described above, the switch performed successfully when tested in accordance with OS–9816. Moreover, it was found that the test could be repeated several times without lowering the performance, thus indicating high reliability of performance in actual use.

It will be understood that the above description is intended to be illustrative only. Within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

What is claimed is:

A switch for pulsing high currents in a squib firing circuit, comprising:

housing means,

a stationary contact physically attached to said housing means, said stationary contact having low electrical resistance and a highly polished circularly cylindrical outside surface thereon,

a movable contact in said housing means having low electrical resistance and a highly polished circularly cylindrical outside surface thereon, said movable contact having the plane containing its longitudinal axis disposed at approximately a 90° angle with respect to the plane containing the axis of said stationary contact, electrical leads having a low resistance extending from said contacts and adapted to be connected into said squib firing circuit, said leads and contacts carrying current on the order of 60 amperes when said movable contact closes on said stationary contact and,

actuating means in said housing means having a predetermined time delay moving said movable contact surface into engagement with said stationary contact surface after said predetermined time delay.

References Cited by the Examiner

UNITED STATES PATENTS

1,599,507	9/1926	Abrahamson	200—33
2,653,199	9/1953	Brown et al.	200—166 X
2,755,346	7/1956	Fisher	200—166 X
3,140,376	7/1964	Tilse et al.	200—166

KATHLEEN H. CLAFFY, *Primary Examiner.*

H. O. JONES, *Assistant Examiner.*