Feb. 24, 1959 O. J. SAHOLT 2,875,292

PRESSURE-ACTUATED STEPPING SWITCH

Filed July 18, 1958 3 Sheets-Sheet 1

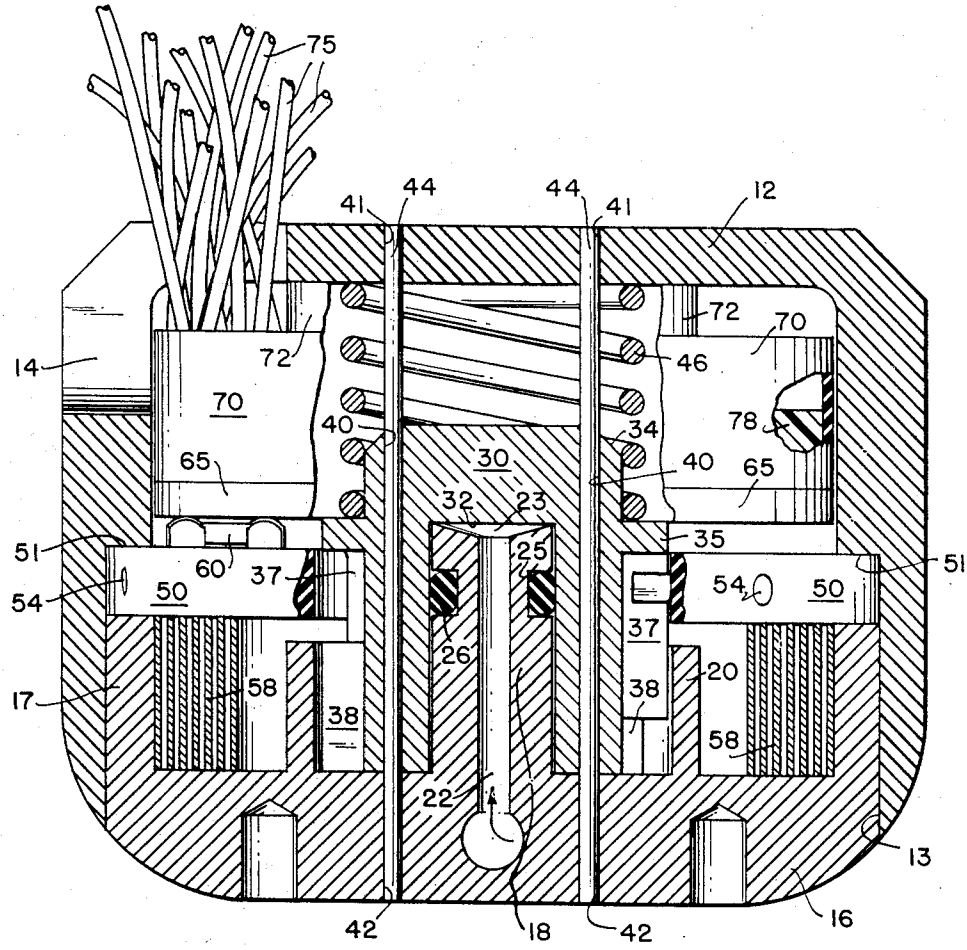



Fig. 1

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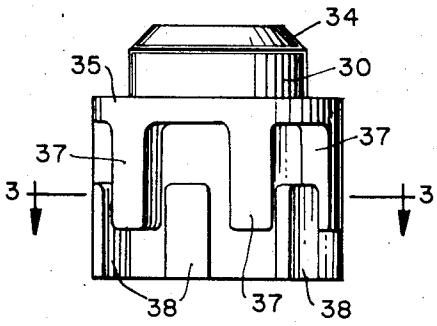



Fig. 2

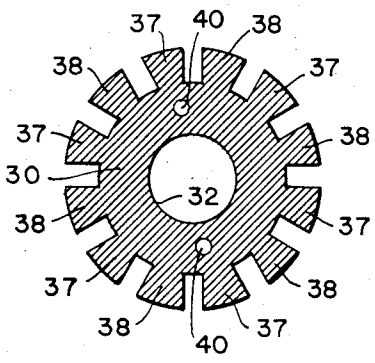



Fig. 3

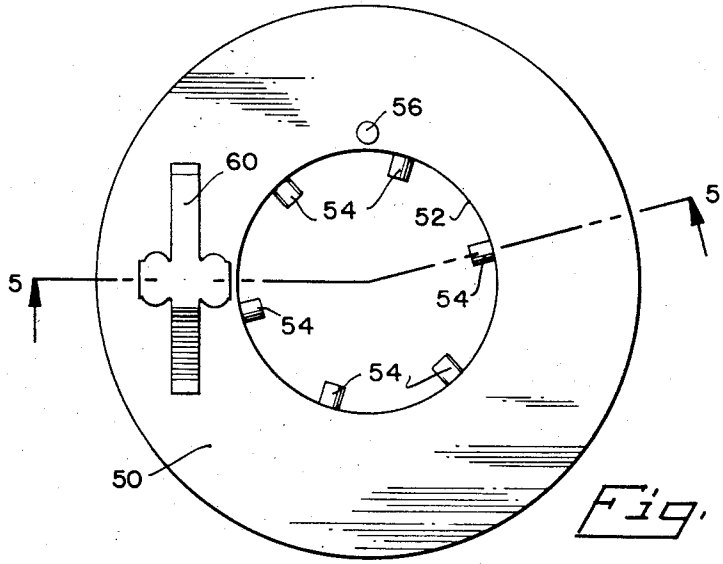



Fig. 4

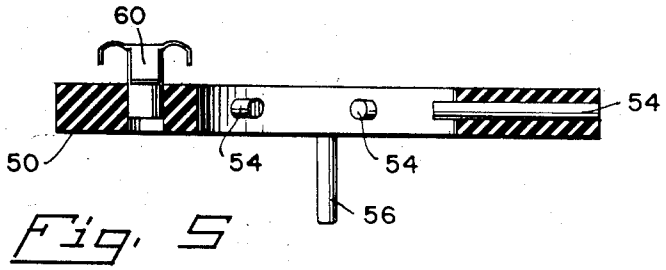



Fig. 5

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3 Sheets-Sheet 3

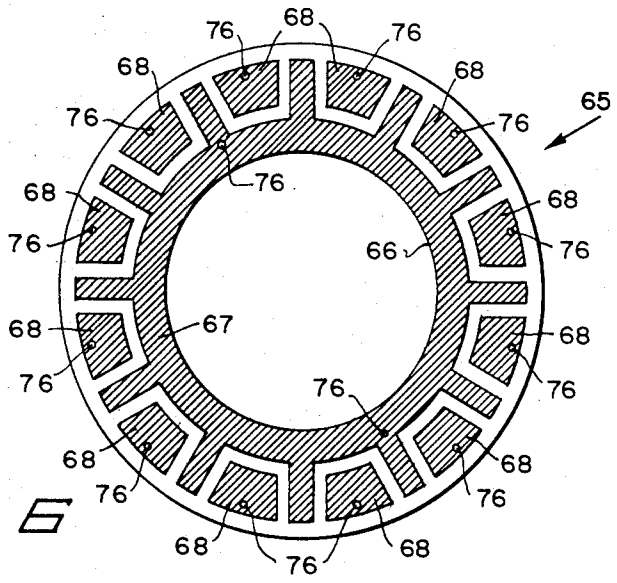



Fig. 6

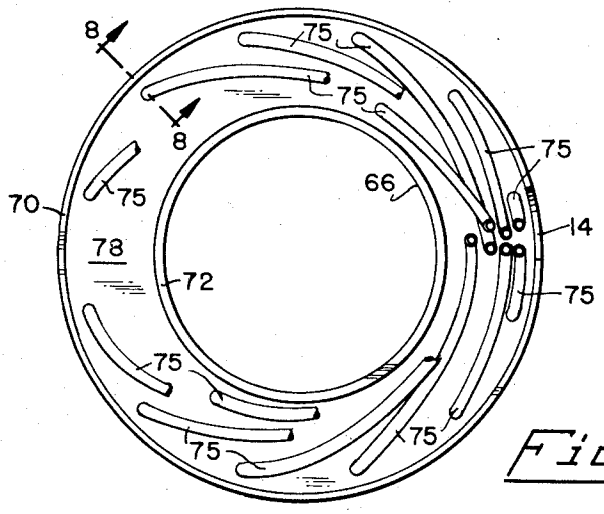



Fig. 7

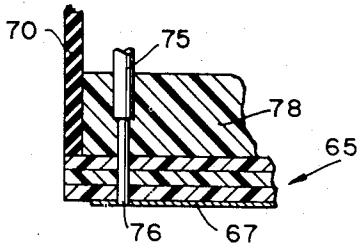



Fig. 8

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2,875,292

# PRESSURE-ACTUATED STEPPING SWITCH

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Application July 18, 1958, Serial No. 749,571

3 Claims. (Cl. 200—82)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to electrical switches and particularly to a gas pressure actuated stepping switch for closing electrical circuits in a specific sequence.

The switch of the present invention is a wafer-type switch mounted concentrically around a gas-operated piston such that a cam surface on the piston controls the advancement of the switch. It basically consists of a piston with a cam surface, a torsionally spring loaded contact disc and a fixed contact assembly. This switch has a particular use in closing igniter circuits of a multiple grain rocket motor in a specific sequence, preventing the ignition of any grain segment until the grain segment that precedes it has been expended. The gas pressure developed by each grain segment is used to operate the switch by moving the piston therein. Gas pressure moves the piston with the cam surface and thus permits the rotary spring-loaded contact to move half the distance between fixed contacts. When the gas pressure is reduced, as the grain is expended, the rotary contact moves to the next fixed contact closing the next circuit, thus firing the next grain.

It is an object of the present invention to provide a pressure actuated stepping switch for sequentially closing electrical circuits.

Another object of the present invention is to provide a gas operated stepping switch.

A further object of the invention is to provide a new stepping switch having a gas operated piston with a cam surface thereon for controlling the advancement of the switch.

Other objects and many of the attendant advantages of this invention will become readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a side cross-sectional view of the gas pressure operated stepping switch;

Fig. 2 is a side view of the piston cylinder showing the cam surface;

Fig. 3 is a cross-sectional view of the piston cylinder taken along the line 3—3 of Fig. 2;

Fig. 4 shows a plan view of the contact disc;

Fig. 5 is a cross-sectional side view of the contact disc taken along the lines 5—5 of Fig. 4;

Fig. 6 is a plan view of the switch contact plate showing the terminals of the switch surface;

Fig. 7 shows the opposite side of the switch contact plate assembly illustrated in Fig. 6;

Fig. 8 is a cutaway section, taken along line 8—8 of Fig. 7, showing electrical lead wire connection to the contact surface of the switch contact plate.

Referring now to the drawings like numerals refer to like parts in each of the figures.

The switch assembly 10, illustrated in Fig. 1, comprises



a housing 12 entirely open at end 13 and having a passage 14 at the other end through which electrical lead wires pass. A base 16 completely encloses the entire open end 13 of housing 12. The base has an upwardly extending flange 17 about the periphery thereof which is of the size to fit within and completely close open end 13 of the housing; and a shaft 18 that extends upwardly from the center of the base. Between the peripheral flange 17 and central shaft 18 is another flange 20 which extends upwardly from the base slightly less than the length of peripheral flange 18. Central shaft 18 has a passage 22 therethrough for the passage of gas to operate the switch; the top end of shaft 18 is beveled inwardly toward passage 22 forming a small cup-shaped chamber 23. A circumferential groove 25 extends about shaft 18 at a small distance below the top thereof; an O-ring 26 fits within groove 25.

In Figures 1, 2 and 3 is illustrated a cylindrical piston 30 having a hollow portion 32 which fits over shaft 18; piston 30 is operable to ride up and down on shaft 18. Hollow portion 32 of the piston is of substantially the same size as shaft 18 with just enough clearance to allow up and down movement on the shaft. The upper end of piston 30 has a chamfer 34 about its periphery, and a flange 35 near the top of the piston which extends about the circumference thereof. Beneath flange 35, there is a cam surface on the outer cylindrical surface of the piston. This cam surface consists of a plurality of cam teeth 37 and 38 which extend from the cylindrical surface of the piston to the outer diameter of flange 35. Cam teeth 37 and 38 are spaced alternately and equidistant about the cylindrical surface of the piston. Cam teeth 37 extend from flange 35 to slightly more than half way to the bottom of the piston, and cam teeth 38 extend from the bottom of the piston to slightly more than half way to flange 35; thus cam teeth 37 and 38 overlap slightly up and down about the circumference of the piston, the space between the cam teeth forming a somewhat zig zag path about the circumference of the piston cylinder, as can be seen from Fig. 2. Two small passages 40 extend through the walls of the piston cylinder from top to bottom; similar and related passages 41 pass through the top of housing 12, and passages 42 pass through base 16. Pins 44 fit within passages 40, 41 and 42 for guiding piston 30 as it rides up or down and preventing the piston from rotating about shaft 18. A bias spring 46, which fits about the top end of the piston against flange 35 and extends to the top of the housing, tends to force the piston downward on the shaft.

A contact disc 50 (Figures 1, 4 and 5), having an outer diameter which is nearly the same as the outer diameter of flange 17 on base 16, is movably supported for rotation within housing 12 between the top of flange 17 and step 51 along the inside wall of the housing. Contact disc 50 has a central opening 52 which is slightly larger than the outer diameter of flange 35 on the piston, and has a plurality of pins 54 fixedly spaced equidistant about the circumference of central opening 52 and extending radially from the outer periphery of disc 50 into opening 52 for a distance almost equal to the depth of cam teeth 37 and 38. The contact disc 50 is preferably made of a non-conductive material whereas pins 54 are preferably made of metal. A pin 56 extends through the contact disc and is connected to one end of a clock spring 58 housed in base 16 between flanges 17 and 20. The other end of clock spring 58 is fastened to the base, and when it is wound-up will tend to cause the contact disc to rotate. Contact disc 50, movably mounted in the housing, fits about piston 30 so that it is always just below flange 35 on the piston, and pins 54 bear against cam teeth 37 or 38 due to the torsional force of the clock spring. This contact disc carries a depressable spring type slide contact 60 mounted on its surface opposite to the surface fac-

ing the clock spring. Slide contact **60** contacts the surface of the switch contact plate **65** for closing and opening electrical circuits in sequence.

Switch contact plate **65** is best illustrated in Fig. 6, and consists of a disc of insulative material having a central opening **66** of greater diameter than piston flange **35** and having an electrically conductive pattern thereon which make up the common terminal **67** and a plurality of sequence terminals **68**. The switch surfaces, terminals **67** and **68**, may be constructed by printed circuit techniques rather than by the conventional type construction of wafer-type switches, providing a smoother operating switch which is less expensive to manufacture and allowing a more compact assembly. Contact disc **50** with its slide contact **60** together with switch contact plate **65** form and operate like a wafer-type switch.

In Figures 1 and 7 is illustrated the contact plate assembly. A circumferential flange **70** of insulative material, having an outer diameter the same as that of switch contact plate **65**, is mounted on the contact plate on the opposite side to terminals **67** and **68**. A spacer flange **72** of insulating material having an inner diameter the same as central opening **66** and slightly higher than flange **70**, is also mounted on the side of the contact plate opposite to terminals **67** and **68**. Holes are drilled through switch contact plate **65** and terminals and ends of electrical leads **75** are passed therethrough from the opposite side, as shown in Figures 7 and 8. The lead ends **76** are soldered to the terminals, then the terminal surfaces are ground and polished, after a potting compound **78** is poured between flanges **70** and **72** to hold wires **75** firmly in place, so that terminals **67** and **68** have a smooth surface. The entire contact assembly fits snugly within the upper portion of housing **12** and electrical lead wires **75** pass out through opening **14** therein. The upper end of spacer flange **72** rests against the inner top surface of housing **12** correctly positioning the contact plate assembly within the housing so that slide contact **60** will properly slide over terminals **67** and **68** on the contact plate making good electrical contact. Piston spring **46** and the upper end of piston **30** are positioned and free to move in the space within circumferential spacer flange **72**.

The stepping switch operates as follows:

Gas pressure, from an ignited gas producing grain or other source, is used to actuate piston **30** by forcing it upwards until contact disc pins **54** no longer bear against piston cam teeth **37** and contact disc **50** is rotated by torsionally loaded clock spring **58** for a half position opening electrical contacts and bringing pins **54** to bear against cam teeth **38**. The electrical contacts remain open as long as the gas pressure is maintained to keep piston **30** forced upward. O-ring **26** on the shaft tends to prevent gas from leaking between the piston and shaft into the inside of the housing. When the gas pressure drops sufficiently, spring **46** drives the piston back down to its original position (as shown in Fig. 1) where pins **54** will no longer bear against cam teeth **38**, thus allowing the contact disc to rotate another half position, which closes the switch contacts in a position adjacent to the starting position, to where pins **54** bear against cam teeth **37** preventing further rotation of the contact disc until the piston is actuated again. The sequence repeats each time gas pressure actuates the piston until a complete rotation of the contact disc is completed.

Instead of using a clock spring for torsionally loading the contact disc the cam teeth may be designed so as to drive the contact disc a half position on the gas pressure stroke and then drive it the remaining half position on the return stroke.

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 gas-pressure actuated stepping switch comprising a housing member completely open at one end, a base member which encloses the open end of said housing member, a central shaft which extends upwards from said base into said housing member, a hollow cylindrical piston on said shaft and having a cam surface on the outer cylindrical surface thereof, said piston being operable to ride up and down upon said shaft, a bias spring for normally biasing said piston downward on said shaft, a passage in said shaft and base extending from an external source of gas pressure to the upper end of said shaft, said piston operable to be actuated by being forced upward under gas pressure, a torsionally spring loaded contact disc having a central aperture therein through which said piston extends, said disc having means thereon for riding on said piston cam surface, a fixed contact assembly within said housing having switch terminals thereon and being normally contacted by said contact disc, said cam surface being operable to allow said torsionally loaded spring contact disc to rotate a half position opening contact between a pair of switch terminals when said piston is raised by gas pressure and again to rotate another half position when gas pressure drops allowing said piston to be returned to its original position thereby closing switch terminals on the contact assembly in a position adjacent to the starting position, the sequence repeating each time the piston is pressurized until a complete rotation of the contact disc is made.

2. A gas-pressure actuated stepping switch comprising a housing member open at one end, a base member for completely closing the open end of said housing, a central shaft which extends upwards from said base member into said housing and a hollow piston which is operable to ride up and down upon said shaft, means for normally biasing said piston downward on said shaft, a cam means on said piston, a passage extending from the top of said central shaft to an external source of gas pressure, said piston operable to be actuated by being forced upward under gas pressure, a contact disc in said housing, said contact disc having means thereon for riding on said piston cam means, a fixed contact assembly in said housing having a plurality of switch terminals thereon normally contacted by said contact disc, said contact disc normally completing an electrical circuit between two of said switch terminals, said cam means being operable to rotate said contact disc a half position and open the electrical contact between the two of said switch terminals when said piston is raised by gas pressure and again to rotate the contact disc another half position when gas pressure drops allowing said piston to return to its original position thereby closing electrical contacts between switch terminals on the contact assembly in a position adjacent to the starting position, the sequence of opening and closing electrical contact between adjacent switch terminals repeating each time the piston is pressure actuated until a complete rotation of the contact disc is made.

3. A gas-pressure actuated stepping switch comprising a housing member completely open at one end and having a small aperture at the opposite end through which electrical lead wires pass, a base member which completely encloses the open end of said housing member, a shaft which extends approximately half-way upward from the center of said base member into said housing member, a hollow cylindrical piston on said shaft and having cam means thereon, said piston being operable to ride up and down upon said shaft, a bias spring positioned between the top of said piston and the inside top of said housing for normally biasing said piston downward on said shaft, means preventing rotation of said piston about said shaft, a passage in said shaft extending from a source of gas pressure external of said housing member through said base member to the upper end of said shaft, said piston operable to be actuated by being forced upward

under gas pressure, a contact disc in said housing carrying a slide contact thereon and having a central aperture therein through which said piston extends, said disc having means thereon for riding on said cam means, means normally tending to rotate said contact disc, a fixed contact assembly in said housing having switch terminals thereon and being normally contacted by said slide contact, said cam means permitting said contact disc to rotate and move the slide contact a half position opening electrical contact between switch terminals on said fixed contact assembly when said piston is raised by gas pressure and again to rotate moving the slide contact another half position when gas pressure drops allowing said



piston to be returned to its original position thereby closing electrical contact between switch terminals on the contact assembly in a position adjacent to the starting position, the sequence of opening and closing electrical contact between adjacent switch terminals repeating each time the piston is pressurized until a complete rotation of the contact disc is made.

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