Aug. 14, 1951 L. J. SCHILLING 2,564,081

MERCURY SWITCH

Filed May 23, 1946

Fig. 1.

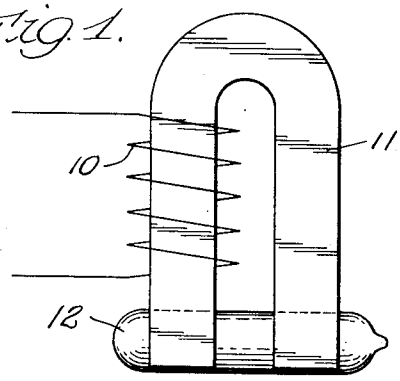


Fig. 2.

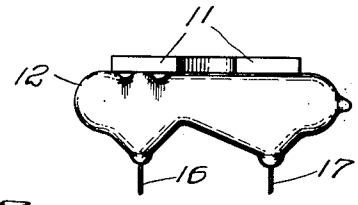


Fig. 3.

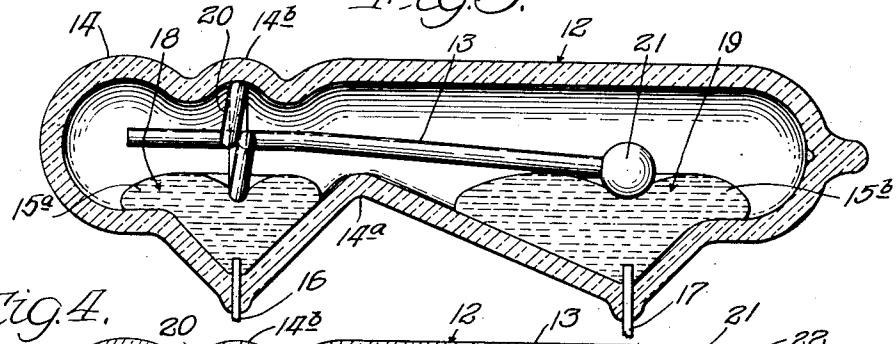


Fig. 4.

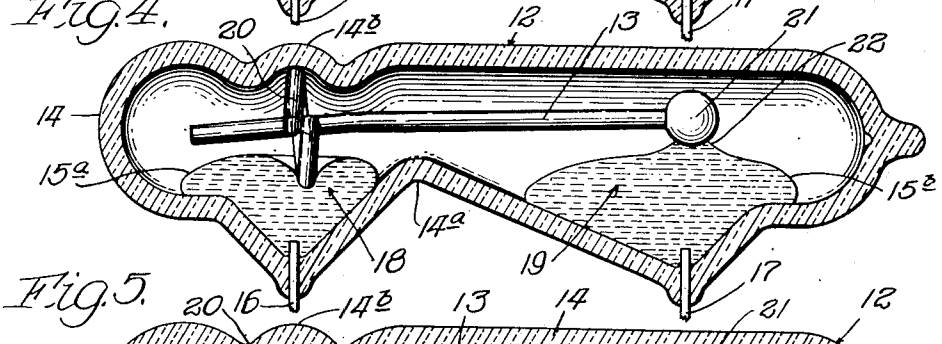
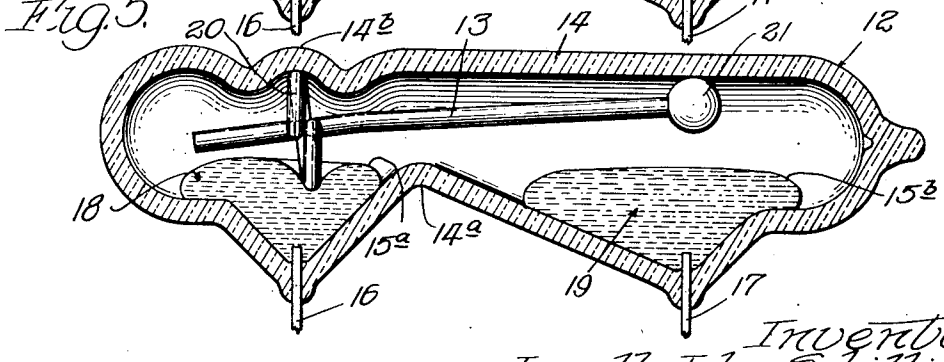


Fig. 5.



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UNITED STATES PATENT OFFICE

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MERCURY SWITCH

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5 Claims. (Cl. 200—97)

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This invention relates to a mercury switch, and more particularly to a magnetically operated mercury switch particularly adapted for use in an electric fence energizer, for example.

One feature of this invention is that it provides an improved mercury switch; another feature of this invention is that it provides a mercury switch with improved means to create a time delay before the circuit associated with said switch is closed; a further feature of this invention is that it provides a mercury switch adapted to provide improved stability in the circuit in which it is used; yet another feature of this invention is that it provides a mercury switch allowing more exact predetermination of magnetic circuit conditions in the apparatus wherein it is used; still a further feature of this invention is that it provides a mercury switch wherein inertia of a portion of the mercury is utilized to retard the movement of the terminal bridging means; yet a further feature of this invention is that it provides a mercury switch wherein a portion of the mercury follows the movement of the terminal bridging means before the circuit is broken, thereby causing the terminal bridging means to move a greater distance in order to close the circuit; still another feature of this invention is that it provides a mercury switch including a dividing portion between the terminals so located as to insure that almost all vaporized mercury returns to the proper terminal upon condensation. Additional features and advantages of this invention will be apparent from the following specification and the drawings in which:

Figure 1 is a plan view of my new mercury switch showing its relation to the operating electromagnet;

Figure 2 is an elevational view of the switch and magnet shown in Figure 1;

Figure 3 is an enlarged longitudinal section through my new switch showing the parts in one stage of operation;

Figure 4 is a longitudinal section of the switch shown in Figure 3, showing the parts in another stage of operation;

And Figure 5 is a longitudinal section through the switch shown in Figure 3 showing the parts in still another stage of operation.

Magnetically operated mercury switches are used in many types of apparatus, and the switch I am here disclosing is capable of such general application and use. My new switch, however, has been especially designed and is particulary adapted for use in intermittently making and breaking the circuit in electric fence energizing equipment. Electric fences are intended to stop animals and keep them within a desired enclosure, by the effect of electrical shocks rather than by sheer mechanical strength, the shock used being strong enough to cause the animal to avoid the fence after it has been shocked once or twice, but not strong enough seriously to injure the animal or anyone accidently coming in contact with the fence wire. Where the fence wire is briefly periodically energized it has been determined that, for reasons of safety, the maximum current deliverable to the fence should not exceed 25 milliamperes, and the shock impulse duration should not exceed $\frac{1}{10}$ of a second nor occur more often than once a second; and certain States have incorporated these and similar requirements in their codes. Accordingly, energizing devices for electric fences provide a series of brief periodic impulses to the fence and incorporate a circuit interrupting switch actuated by timing means in such manner that each shock impulse has less than $\frac{1}{10}$ second duration and occurs less than 60 times per minute, usually in the neighborhood of 50 impulses per minute.

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In my application for an electric fence energizer filed November 26, 1945 as Serial No. 630,811 I disclosed an electric fence energizer particularly designed for battery operation incorporating a novel timing system adapted to use hermetically sealed contacts, and which utilized electrical rather than mechanical factors for regulation of the timing. Such an electric fence energizer may use a mercury switch, for providing the periodic shock impulses, of the character shown in my co-pending application Serial No. 597,991, filed June 7, 1945 which was subsequently abandoned; but I have devised and am here disclosing and claiming a novel and improved mercury switch which may be used in apparatus such as is disclosed in my prior application Serial No. 630,811.

Such energizing apparatus as is disclosed in my prior application last above mentioned may use a transformer with a winding of a large number of turns on a magnetic core structure of considerable weight and size, so that the inductance of the winding is so high as to require more than a second for the current and magnetic field to build up to maximum when the winding is connected to a D. C. source, as a battery. The apparatus is so constructed that when a desired operating current is reached means are provided (as by utilizing a portion of flux in the core structure) to open the switch for a brief period.

This disconnects the winding from the D. C. source, the magnetic field around the winding collapses, and a high voltage, steep wave front shock impulse is delivered to the fence by transformer action.

For a number of reasons it is desirable to hold the switch open until the winding has discharged completely. One of the principal reasons is that I have found that unless the switch stays open until the energy in the coil has been completely discharged, variations in the load conditions on the fence will have a tendency to vary the time between impulses. For example, if, when the fence wire is in its normal open circuited condition, the transformer discharges only ¾ of its energy between pulses, a certain length of time will be required for the current and magnetic field to build up to the point necessary to open the mercury switch. Should the fence wire become partially shorted, as by contacting wet weeds or the like, the transformer winding would completely discharge in the same time interval (by reason of the partial short), and consequently a longer time would be necessary to build the current and the magnetic field up to the proportions necessary to operate the switch, changing the period of operation.

My new switch provides a novel means of obtaining the desired time delay to allow the winding to completely discharge after each impulse, first by causing a portion of the mercury to be moved by the terminal bridging means and utilizing the inertia of the mercury to slow down or retard the movement of the terminal bridging means, and secondly by providing means whereby a portion of the mercury moves with and remains in contact with the terminal bridging means for a portion of the distance which said terminal bridging means moves in breaking the circuit. Consequently, when the terminal bridging means falls back to reclose the circuit, it must travel a greater distance before again contacting the mercury.

A further advantage of my new mercury switch is that it is so constructed that the mercury within the container is properly divided and the division point is so located that almost all of the mercury which vaporizes through occasional arcing within the switch returns, upon condensation, to the terminal from which it was vaporized.

Referring now to the drawings, in Figure 1 a winding **10** encloses a portion of a core **11**, the pole pieces of the core being adjacent the top of the mercury switch designated generally as **12**. Since the action of such a device is described in detail in my application Serial No. 630,811 it will not be described further here except to say that the members **10** and **11** form an electromagnet connected through the mercury switch to a D. C. source, as a battery, and the magnetic field around said members increases to a point where the armature **13** (at least the right end of which is of magnetic material) within the mercury switch is drawn up from the position shown in Figure 3 to the position shown in Figure 5 and the circuit is momentarily broken. Since this circuit provides the energizing current for the electromagnet, the magnetic field immediately collapses and the armature **13** falls by gravity back to the position shown in Figure 3, the circuit is closed, the current and magnetic field start to build up again, and the cycle is repeated.

My new mercury switch here provides an advantage over many conventional mercury switches wherein the entire armature is drawn up toward the magnet and the circuit may be broken at either terminal, for in my switch one end only of the armature moves upward, and the circuit is always broken at the same terminal. Thus the air gap between the poles of the electromagnet may be small, and the distance between the poles and circuit breaking end of the armature may be predetermined with accuracy.

The mercury switch **12** comprises a sealed container **14** constructed of glass or some other insulating material. Within the sealed container is a quantity of a conducting liquid, as mercury **15**, and two contact elements **16** and **17** which enter the sealed container through the bottom near the respective ends of such container. By reason of the fact that the container is so constructed that a well portion surrounds each of the contact elements **16** and **17**, the mercury is divided into two portions and one portion **15***a* together with the contact element **16** forms one terminal means **18** of the switch. The other portion **15***b* together with the contact element **17** forms the other terminal means **19** of the switch.

It is to be especially noted that I construct the container **14** with a restricted waist portion **14***a*, and that at least two advantages are gained thereby: first, the mercury is properly divided to form the two terminal means **18** and **19** with no possibility of a shorting action through overflow of the mercury between the terminals; and secondly, if arcing occurs within the switch with a consequent vaporization of some of the mercury from terminal **19**, this vaporized mercury will, upon condensation, flow back to terminal **19**, since the restricted portion is considerably nearer terminal **18** than terminal **19**.

The armature or terminal bridging means **13** includes a portion **20** near one end thereof extending transverse to the main body of the armature and adapted to be in constant contact with terminal **18**, which portion is formed by a loop in the armature in the particular embodiment of my invention illustrated herewith. The lower portion of this loop **20** contacts and floats upon the surface of the mercury at terminal **18**. It will be noted that this contacting portion extends below the normal surface of the mercury at such terminal, the normal surface of the mercury being defined as the surface line of the quantity of mercury illustrated in such a container in the absence of the portion **20**. The upper side of the portion **20** of the armature extends into and contacts the surface of a dome portion **14***b* of the container, which dome portion is located immediately above the terminal **18**. Thus it will be apparent that upon movement of the armature **13**, the armature will pivot about the point where the upper side of the portion **20** meets the surface of the dome **14***b*, and as the right hand portion (in the drawing) of the armature is moved upward, the lower side of the portion **20** will move to the right in the mercury thus moving the mercury. The inertia of the mercury will retard or slow down the movement of the armature, thus providing a portion of the desirable time delay between the time when the circuit is broken and the time when the circuit is again completed.

An additional factor in providing this time delay comes from the enlarged or ball-shaped portion at the right end of the armature **13**, the surface of this portion being of mercury-wettable material, as for example, copper or nickel. The ball shaped portion may be formed of such a mercury-wettable material, or it may be formed of highly magnetic material, as iron, and be sur-

faced with a mercury-wettable material, as by plating. As may be most clearly seen in Figure 4, when the electromagnet starts to draw the armature upward, the mercury will tend to cling to the enlarged or ball-shaped portion of the armature and will form the elongated meniscus 22. When the armature has moved upward slightly farther than as shown in Figure 4 the weight of the mercury will cause it to fall away from the portion 21 and the circuit will be broken. The magnetic field immediately collapses, but the inertia of the armature causes it to continue to move upward to the position shown in Figure 5, from which position it falls back onto the now normal surface of the mercury at terminal 19. It will be readily seen that the armature must fall back a greater distance before it again contacts the mercury, thus providing an additional time delay which is cumulative with the time delay created by the dashpot or paddle action of the portion 20 with the mercury at terminal 18, and the parts of the electric fence energizer may readily be so constructed that the energy in the transformer winding is completely discharged during this time delay before the circuit is remade.

The restricted waist portion 14a is located considerably closer to the terminal 18 than to the terminal 19 because, while the portion 20 of the armature is in constant contact with terminal 18, the portion 21 of the armature intermittently makes and breaks contact with terminal 19. Any arcing which occurs within the switch, therefore, will occur at terminal 19, and since terminal 19 is in the larger portion of the container all or almost all of the mercury which vaporizes upon this arcing will return to terminal 19.

Obviously a washer or the like could be used in place of the loop portion 20, any other enlarged shape could be used in place of the ball-shaped portion 21, and various other means of pivoting the armature might be employed. However, I prefer the wire loop rather than the washer in order to keep the construction as light as possible and insure that the member 20 floats on the mercury so that its upper side constantly contacts the upper surface of the dome 14b. I also prefer to use a ball-shaped portion 21 rather than some other enlarged shape because it acts advantageously in causing the elongated meniscus, as shown in Figure 4, and the pivoting means disclosed is extremely simple and effective.

I have found that a mercury switch constructed in accordance with this specification results in an improved time delaying action which is desirable in electric fence energizers, as heretofore explained; results in improved stability—that is, voltage and current in the periodic pulses delivered to the fence remain almost constant to the very end of the life of the battery used in the fence energizer even though the frequency of the pulses may slow down as much as 50 per cent as the battery is used up; and results in allowing a more accurate predetermination of magnetic conditions, as the circuit breaking always takes place at one terminal and consequently the flux path may be made across a very short air gap always with reference to that terminal without the necessity of allowing for a change of distance such as would be necessary if the circuit was broken at either or both terminals.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from

the spirit and scope of the invention, as disclosed in the appended claims.

I claim:

1. A magnetically operated switch of the character described, including: a sealed container having a conducting liquid therein and a dome portion providing a fulcrum; a first terminal within the container, said terminal including a portion of said conducting liquid; a second terminal within the container, said second terminal including a separate portion of the conducting liquid; and a movable member of conducting material for selectively bridging said terminals, at least a portion of such bridging member near one end thereof being of magnetic material for selectively causing said bridging member to make and break contact with said first terminal, the other end of such bridging member having a portion in constant contact with the second terminal and with the container dome portion and so formed as to cause substantial movement of the conducting liquid at said second terminal for retarding the movement of the bridging member.

2. A magnetically operated mercury switch of the character described, including: a sealed container having a quantity of mercury therein; a first terminal within the container, said terminal including a portion of said mercury; a second terminal within the container, said second terminal including a separate portion of the mercury; a movable member of conducting material for selectively bridging said terminals, at least a portion of such bridging member near one end thereof being of magnetic material for selectively causing said bridging member to make and break contact with said first terminal, the other end of such bridging member having a portion in constant contact with the second terminal and in pivotal engagement with the inner surface of the container and so formed as to cause substantial movement of the mercury at said second terminal upon movement of the bridging member for retarding the movement of the bridging member; and structure for pivoting said bridging member.

3. A magnetically operated mercury switch of the character described, including: a sealed container having a quantity of mercury therein and a dome portion in the upper side; a first terminal within the container, said terminal including a portion of said mercury; a second terminal within the container below the dome portion, said second terminal including a separate portion of the mercury; and a movable member of conducting material for selectively bridging said terminals, at least a portion of such bridging member near one end thereof being of magnetic material for selectively causing said bridging member to make and break contact with said first terminal, the other end of such bridging member including a portion extending transverse to the main body of the bridging member, the upper side of such transverse portion extending into engagement with the dome portion of the container, and the lower side of such transverse portion contacting said second terminal and extending below the normal surface of the mercury at said second terminal to cause substantial movement of the mercury upon movement of the bridging member for retarding the movement of the bridging member.

4. A magnetically operated mercury switch of the character described, including: a sealed container having a quantity of mercury therein

and a dome portion in the upper side; a first terminal within the container, said terminal including a portion of said mercury; a second terminal within the container below the dome portion, said second terminal including a separate portion of the mercury; and a movable member of conducting material for selectively bridging said terminals, at least a portion of such bridging member near one end thereof being of magnetic material for selectively causing said bridging member to make and break contact with said first terminal, the other end of such bridging member including a loop extending transverse to the main body of the bridging member, the upper side of said loop extending into pivotal engagement with the dome portion of the container for fulcruming the bridging member, and the lower s'de of said loop contacting said second terminal and extending below the normal surface of the mercury at said second terminal to cause substantial movement of the mercury upon movement of the bridging member for retarding the movement of the bridging member.

5. A magnetically operated mercury switch of the character described, including: a sealed container having a quantity of mercury therein and a dome portion in the upper side; a first terminal within the container, said terminal including a portion of said mercury; a second terminal within the container below the dome portion, said second terminal including a separate portion of the mercury; and a movable member of conducting material for selectively bridging said terminals, one end of such bridging member being magnetically operated to selectively make and break contact with said first terminal, said

bridging member including an enlarged ball portion having a diameter at least twice the width of said bridging member, said ball portion being near said end of the bridging member and having a mercury-wettable portion for causing an elongated meniscus in the surface of the mercury at said first terminal before breaking contact with said terminal, the other end of such bridging member including a loop extending transverse to the main body of the bridging member, the upper side of said loop extending into the dome portion of the container, and the lower side of said loop contacting said second terminal and extending below the normal surface of the mercury at said second terminal to cause substantial movement of the mercury upon movement of the bridging member for retarding the movement of the bridging member.

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