Feb. 25, 1941. C. H. LARSON 2,232,881

CIRCUIT CONTROLLING APPARATUS

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Fig. 1

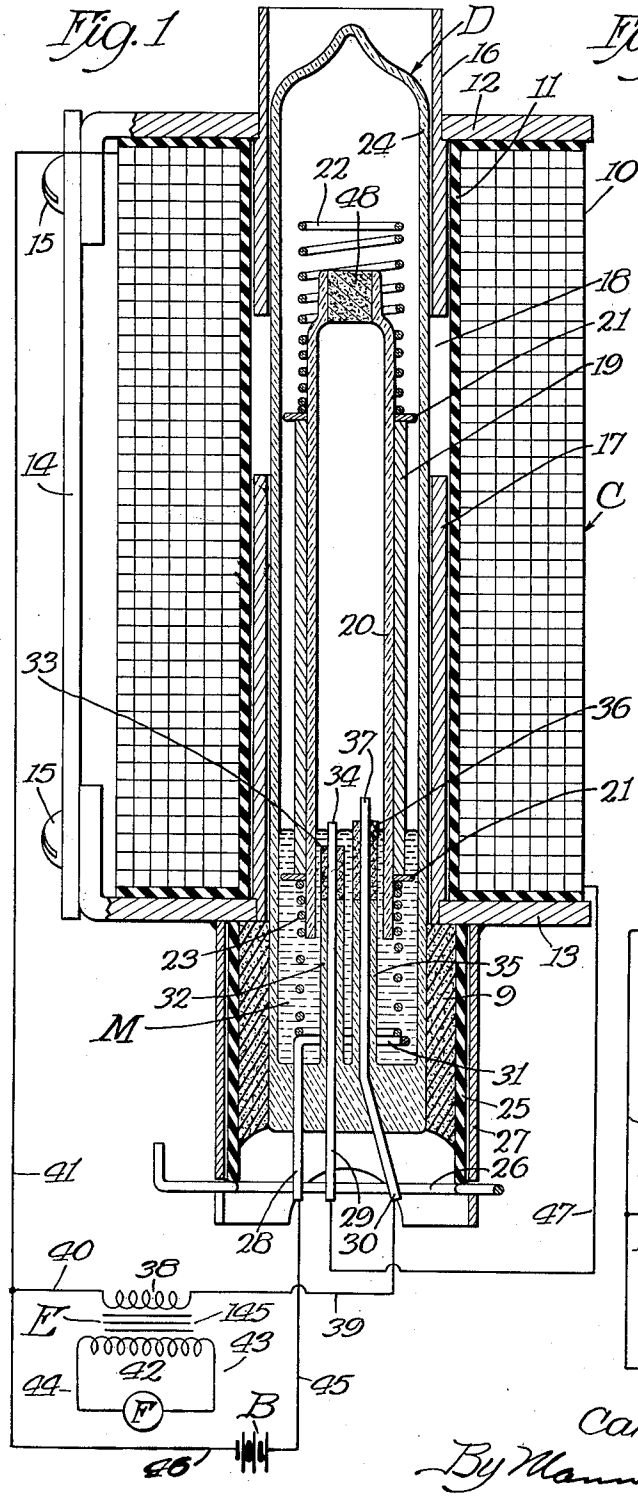
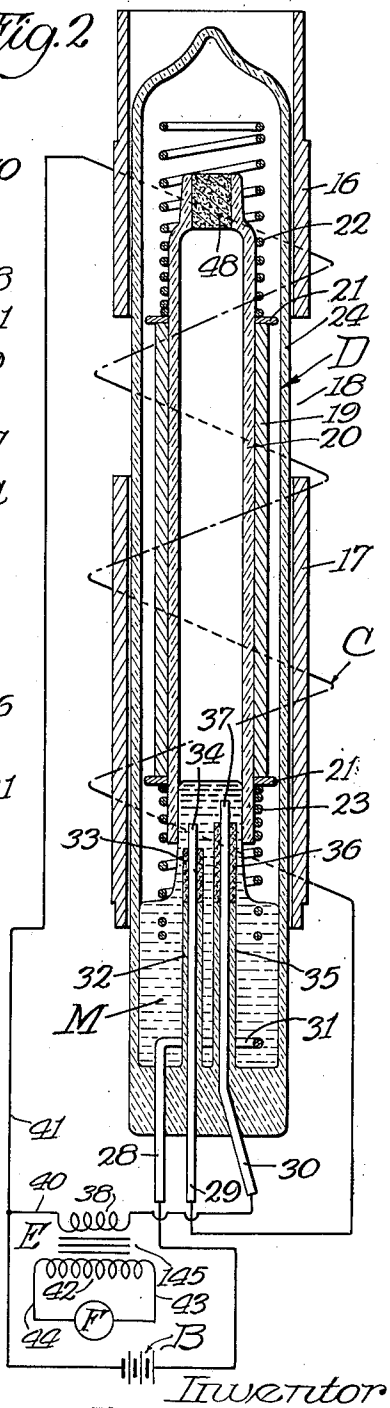


Fig. 2



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Fig. 3

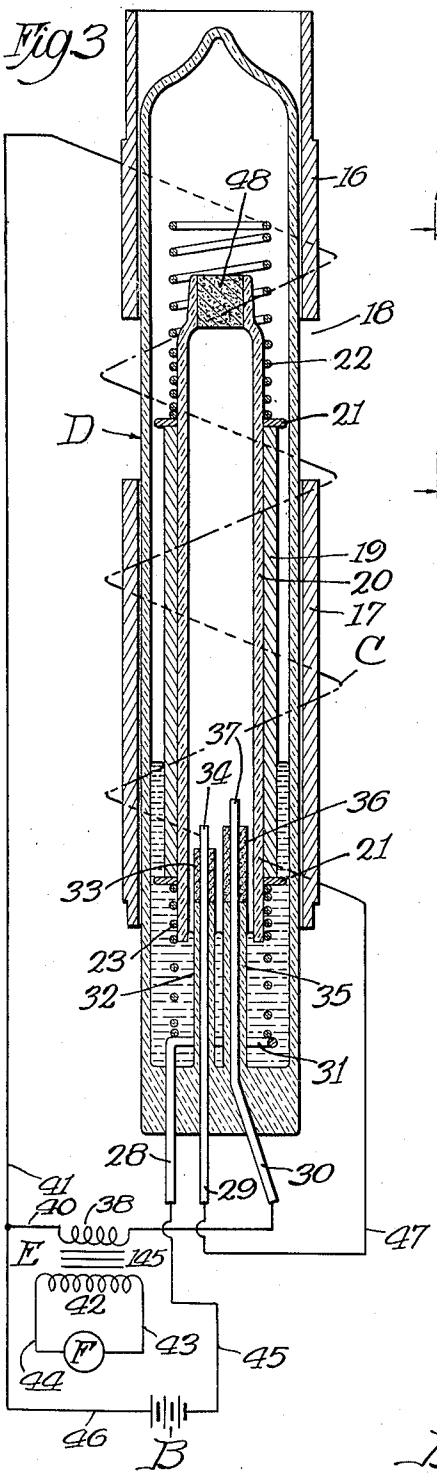


Fig. 4

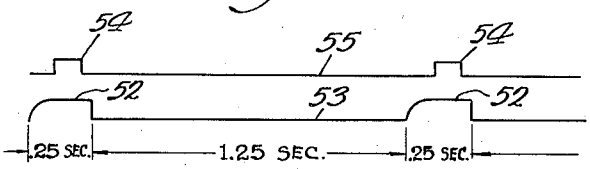


Fig. 5

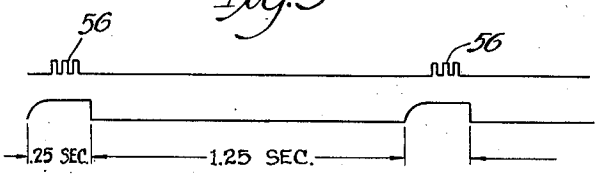
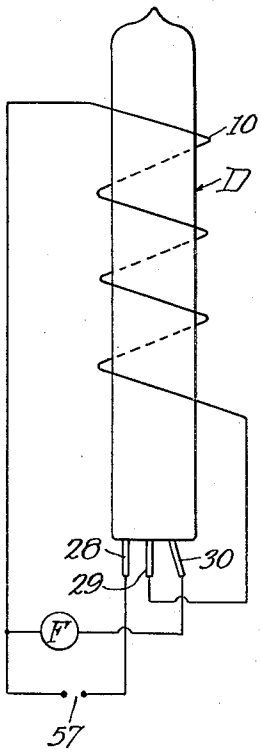


Fig. 6



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UNITED STATES PATENT OFFICE

2,232,881

CIRCUIT CONTROLLING APPARATUS

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Application September 21, 1938, Serial No. 231,038

13 Claims. (Cl. 175—373)

In the intermittent charging of a fence with electricity to protect it without injury to animals, or the flashing of a signal light and such like, it is desirable to close the circuit on the battery (or other source of current) for very brief intervals separated by relative long open circuit intervals, and to break the circuit quickly. The brief closed circuit intervals reduce the current consumption, the relatively long open circuit intervals give the battery a chance to recover after each closed circuit interval, and the quick opening of the circuit steps up the voltage of induced current to make the shock of the fence sharp or the flash of the light bright, as the case may be.

The principal object of this invention is to produce apparatus for obtaining these desirable results that will be practically weather proof and will endure long periods of service with little or no attention or servicing.

Generally speaking, this object is accomplished in this preferred embodiment of the invention by a novel mercury switch relay having its solenoid connected in parallel with the primary of a transformer and its armature equipped with means to delay the closing of the solenoid circuit, then break that circuit and make and break the primary circuit with an accelerated movement.

In the drawings—

Fig. 1 is a vertical section through the mercury switch relay and a diagram of the wiring showing the parts of the relay in the approximate positions they occupy at the closing of the solenoid circuit;

Fig. 2 is a similar view of the same apparatus showing the parts of the relay in the approximate positions they assume as the primary circuit is closed and about to be quickly broken;

Fig. 3 is a similar diagram of the same apparatus showing the parts of the relay in the approximate positions they assume promptly after the armature falls and the circuits are all open;

Figs. 4 and 5 are diagrams illustrating operating characteristics of the apparatus.

Fig. 6 is a diagram showing a circuit adaptable for use with my apparatus when 110 volt current is available.

But these drawings and the corresponding description are used solely for the purpose of disclosure and should not be interpreted as placing unnecessary limitations on the claims.

The battery is generally indicated by B, the solenoid by C, the mercury tube switch by D, the transformer by E and the load, such as an electric fence or a flashing light, by F.

The wiring 10 of the solenoid is wound on a spool 11, held between pole pieces 12 and 13, mounted upon a bar 14 by screws 15. Pole sleeves 16 and 17 fitted into the pole pieces 12 and 13 complete the magnetic circuit except for the air gap 18 which is to be bridged by the cylindrical armature 19, when the solenoid is energized.

The armature is shown as a hollow cylinder telescoping with a hollow glass cylinder 20, and held in place thereon by guide rings 21, which in turn, are secured by coil springs 22 and 23, frictionally engaging the end portions of the glass tube and projecting beyond them to protect the sealed envelope 24, that encloses all the moving parts and contains, in addition to those mentioned, a charge of mercury M and a gas fill of some inert gas, such as helium. A thick layer of sealing compound 9 secures the lower portion of the envelope to a sleeve 25 of Bakelite (or other insulating material) supported by a wire clip 26 in a cylinder 27 secured to the bottom of the pole piece 13.

Lead in wires 28, 29 and 30, are sealed into the base of the envelope, the wire 28 is bent to form the heel electrode 31, the wire 29 is extended through a glass sleeve 32 and a piece of heat resisting ceramic tubing 33 to end in an electrode 34 for controlling the solenoid circuit. The wire 30 is extended through a glass sleeve 35 and a heat resisting ceramic tubing 36 to end in an electrode 37 for controlling the primary circuit.

The primary 38 of the transformer E has one end connected by the wire 39 to the lead in wire 30, and the other end connected by the wires 40 and 41 with one end of the solenoid winding 10. The secondary 42 of the transformer has its ends connected by wires 43 and 44 with the load F. The core 145 of the transformer is laminated iron.

One terminal of the battery B is connected by the wire 45 with the lead in wire 28, leading to the heel terminal 31, the other terminal of the battery B is connected by the wire 46 and the wire 41, with the same end of the solenoid winding 10 that is connected with the primary 38. The opposite end of the solenoid winding 10 is connected by the wire 47 with the lead in 29 leading to the electrode 34 in the solenoid circuit.

It will be readily seen that the primary 38 and the solenoid 10 are connected in parallel with

the battery B; that contact between the mercury M and the electrode **34**, as shown in Fig. 1, will close a circuit containing the battery B and the solenoid C; that contact between the mercury M and the electrode **37**, as shown in Fig. 2, will close a circuit including the battery B and the primary **38** of the transformer E; and that forcing the mercury below the contacts **34** and **37**, as shown in Fig. 3, will break both the primary and the solenoid circuits.

In order to make a suitable delay while the parts move from the position shown in Fig. 3 to that shown in Fig. 1, the lower end of the glass tube **20** is left open to the mercury and the upper end is filled with a plug **48** of porous substance such as, for example, ceramic material known as alundum made by the Norton Company, Worcester, Mass., in several grades including dense, medium and coarse. This material is permeable by the gas fill under pressure and will allow it to flow more or less slowly through the plug **48**, depending on the density and size. Hence, when the displacer drops to the position shown in Fig. 3, the trapped gas fill within the tube **20** will depress the mercury at the lower end of the tube and will thus be put under appreciable pressure under which it will slowly flow through the plug into the upper portion of the envelope **24**, and thus allow the displacer to slowly descend and the mercury to rise within the tube to the positions shown approximately in Fig. 1, when the mercury closes contact with the electrode **34**. By choice of the material in the plug and a suitable proportioning of the parts, this interval can be made to suit the desired operating conditions.

When the solenoid is energized as indicated in Fig. 1, the armature **19** is attracted and attempts to bridge the air gap **18**, thus lifting the displacer to the approximate position shown in Fig. 2. In this movement the plug **48** prevents the flow of the gas fill downwardly into the glass tube **20** and thus a portion of the mercury is lifted with the displacer and the body of mercury takes a form somewhat like that shown in Fig. 2, thus closing contact with the electrode **37** momentarily while maintaining contact with the electrode **34**. The movement of the displacer upwardly is with high acceleration and thus the interval when the circuit is closed through the primary **38** by the mercury and the electrode **37** is short, and when the mercury column breaks that circuit is broken very sharply, along with the circuit through the solenoid. This sharp break of the circuit through the primary **38** steps up the voltage in the induced circuit through the secondary **42** to a very high decree, which makes for a powerful shock in an electric fence, or a bright flash in a lamp, illustrated by the load E.

Opening or breaking the circuit through the solenoid, at the breaking of the circuit through the primary, prevents the surge of current from being choked by the impedance of the solenoid winding and its iron circuit. The iron in the solenoid need not, therefore, be laminated and thus the cost of the apparatus can be correspondingly reduced.

At the beginning of an operation the parts will be approximately in the position shown in Fig. 1. Upon closing a switch (not shown) the solenoid **10** will be energized and the parts will move to the position shown in Fig. 2. Immediately thereafter both circuits will be broken and the light will be flashed or the fence charged. Then the parts will assume the approximate positions shown in Fig. 3 for a time interval measured by the flow of the trapped gas fill through the plug **48** until the parts come again to the approximate positions shown in Fig. 1, when the cycle of operations will be repeated.

The closed circuit period for the solenoid is necessarily long enough to saturate its core, plus an additional time required for the armature to rise and break the circuit. The open circuit period can be made of almost any duration depending upon the porous plug **47** and the proportioning of the parts.

The closed circuit period for the primary should also be long enough to saturate the core of the transformer. The shorter this period the smaller the drain on the source of electricity and the higher the economy.

The selected relationship is shown diagrammatically in Fig. 4 which is composed of two lines of an oscillogram. The curved portion **52** of the lower line represents a closed circuit period on the solenoid of .25 sec., which is followed by an open circuit period of 1.25 sec., indicated by the line **53**. The short straight line **54** indicates the closed circuit period on the primary **38** of the transformer to be followed by the long open circuit period, indicated by the line **55**. The line **54** is much shorter than the curved line **52**, and indicates the relation of the closed period on the primary to the closed period on the solenoid.

The operating characteristics indicated by this oscillogram of Fig. 4, will be preferred by many, for it will give one quick surge in the fence or the signal lamp circuit of a desirable character.

It is possible, however, to break up the closed circuit period on the primary into a number of shorter closed circuit periods, separated by short open circuit periods, and thus produce a series of charges in the fence, or the lamp circuit.

Remembering that the closed circuit period on the primary need only be long enough to saturate the core, the construction can easily be made to permit operation with extremely brief closed circuit periods. Then, by increasing the power of the solenoid and its core (the operating magnet) the movement of the armature will be so highly accelerated that the mercury carried up with the displacer will make and break the circuit through the primary a number of times during one cycle of operations of the displacer. This is probably due to the peculiar characteristics of mercury which makes it pour or run somewhat in the form of a chain of balls, which closes a circuit when they actually contact and open it when any two of them actually separate.

Fig. 5 is an oscillogram corresponding to Fig. 4, but with the power of the magnet increased as indicated. As a result, for a .25 sec. closed period on the solenoid the primary is closed and broken three times, indicated by the short lines **56**, thus there are three charges put on the fence or three flashes given to a signal lamp.

The length of these short closed periods is somewhat fortuitous and necessarily is variable, hence, some of the flashes observed in a neon lamp connected in the secondary of the transformer would be noticeably longer than the others. But, since the neon lamp responds immediately to the impressed charge, the signal would be made much more observable by numerous short flashes than by a single flash. Likewise, a fence will be better protected by a series of short charges coming on in a brief period than it would by a single charge. For this reason some will prefer appara-

tus having the characteristics indicated by Fig. 5 rather than Fig. 4.

Under some conditions it will be preferable to use electricity from an available line and eliminate the transformer, in which case it will be replaced directly by the load—either the fence or an alternating current neon lamp.

Such an arrangement is illustrated diagrammatically in Fig. 6, where the battery B is replaced by 110 volt line 57 and the transformer has been replaced by a load F connected in parallel with the solenoid 10. By changing the iron circuit in the operating magnet either A. C. or D. C. can be used, and for A. C. the solenoid should ordinarily be shorter than is required for the apparatus shown in Figs. 1, 2 and 3. Electricians will readily make the changes in the proportions of the apparatus to give the operating characteristics that are desired for a particular installation.

The relay lends itself to other uses, for instance, where it is desired to have the load circuit closed for a longer period than the solenoid circuit. In that case the wire 39 would be connected to the lead-in 29 and the wire 47 would be connected to the lead-in 30 and the mercury fill would be made correspondingly higher. With those connections the load would receive current as soon as the mercury closed with the electrode 34 and would continue to receive current until the mercury closed with the electrode 37 and the magnet became energized.

In order to give specific data for one particular embodiment the following has been found eminently satisfactory for a relay to operate a Neon flasher and energize a fence from a six volt battery, glass envelope .638" to .648" inside diameter and approximately 5" long, armature .53" outside diameter and 2⅛" long, glass tube .41" outside diameter and 2⅞" long up to the plug 48. The electrodes 34 and 37 are exposed for the length of ⅛" and are ⅛" difference in height, the air gap 18 is ⅓". Other dimensions are in proportion.

Mercury taken up in the bottom of the displacer gathers sufficient momentum to carry it on upwardly into the partial vacuum when the displacer is checked, and from that height it falls around and past the electrodes 34 and 37, closing and opening the circuit rapidly.

I claim as my invention:

1. In a mercury switch relay, a stationary sealed envelope, a charge of mercury and a gas fill therein, a hollow movable displacer within the envelope open to the mercury at the bottom and having a restricted passage for gas above the mercury, spaced electrodes in the envelope including one that is in contact with the mercury only when the latter is raised within the displacer, and a third electrode that is in contact with the mercury only when a portion thereof has been lifted with the displacer.

2. In a mercury switch relay, a stationary sealed envelope, a charge of mercury and a gas fill therein, a hollow movable displacer within the envelope open to the mercury at the bottom and having a restricted passage for gas above the mercury, spaced electrodes in the envelope including one that is out of contact with the mercury except when the displacer is partly sunk and mercury has risen within the displacer, and a third electrode that is out of contact with the mercury except when the displacer has been lifted and has carried enclosed mercury up with it.

3. In a mercury switch relay, a stationary sealed envelope, a charge of mercury and a gas fill therein, a hollow movable displacer within the envelope open to the mercury at the bottom and having a restricted passage for gas above the mercury, spaced electrodes in the envelope including one within the displacer above the low level of the mercury therein but within reach of displaced mercury rising therein, and a third electrode within the displacer above the level of the displaced mercury rising therein, but within reach of mercury carried up with the displacer when it is raised.

4. In a device of the class described, a circuit including a source of current and the primary of a transformer, a relay including a solenoid in parallel with the primary, and means operated by the solenoid to break the circuit through the solenoid with an accelerated movement and momentarily close the circuit through the primary.

5. In a device of the class described, a circuit including a source of current and the primary of a transformer, a relay including a solenoid in parallel with the primary, a stationary sealed envelope associated with the solenoid, a charge of mercury and a gas fill therein, a hollow displacer for the mercury including an armature for the solenoid and being open to the mercury at the bottom and having a restricted passage for gas above the mercury, spaced electrodes in the envelope including one that is in contact with the mercury only when the latter has risen within the displacer, and a third electrode that is only in contact with the mercury when a portion thereof has been lifted with the displacer.

6. In a device of the class described, a circuit including a source of current and the primary of a transformer, a relay including a solenoid in parallel with the primary, a stationary sealed envelope associated with the solenoid, a charge of mercury and a gas fill therein, a hollow displacer for the mercury including an armature for the solenoid and being open to the mercury at the bottom and having a restricted passage for gas above the mercury, spaced electrodes in the envelope including one that is out of contact with the mercury except when the displacer is partly sunk and mercury has risen within the displacer, and a third electrode that is out of contact with the mercury except when the displacer has been lifted and has carried enclosed mercury up with it.

7. In a device of the class described, a circuit including a source of current and the primary of a transformer, a relay including a solenoid in parallel with the primary, a stationary sealed envelope associated with the solenoid, a charge of mercury and a gas fill therein, a hollow displacer for the mercury including an armature for the solenoid and being open to the mercury at the bottom and having a restricted passage for gas above the mercury, spaced electrodes in the envelope including one with the displacer above the low level of the mercury therein but within reach of displaced mercury rising therein, and a third electrode within the displacer above the level of the displaced mercury rising therein, but within reach of mercury carried up with the displacer when it is raised.

8. In a device of the class described, a solenoid circuit and a primary circuit in parallel with a source of current, contacts, an armature for the solenoid and means moved by the armature to close the circuits in the order named, and open them in the reverse order.

9. In a device of the class described, a source of current, a primary circuit and a solenoid connected in parallel with the source, an armature associated with the solenoid and a sealed-in mercury connector operated by downward movement of the armature to close the solenoid circuit, and operated by an upward movement of the armature to close the primary circuit, and by further upward movement of the armature to open both the circuits.

10. In a device of the class described, a source of current, a primary circuit and a solenoid connected in parallel with the source, an armature associated with the solenoid and a sealed-in mercury connector operated by downward movement of the armature to close the solenoid circuit, and operated by an highly accelerated movement of the armature to close and open the primary circuit in rapid succession.

11. In a device of the class described, a primary circuit and a solenoid circuit in parallel with a source of current, contacts, an armature for the solenoid, and means associated with the contacts and operated by the armature for periodically making and breaking the primary circuit a number of times in rapid succession and breaking the primary circuit for a relatively long interval.

12. In a device of the class described, a solenoid, a mercury switch including a stationary sealed envelope, a charge of mercury and a gas fill therein, spaced electrodes in the envelope adapted to be connected by the mercury to energize the solenoid, a displacer lifted by the solenoid when energized and having a mercury trap telescoped over one of the electrodes, whereby the circuit through the solenoid is maintained for a predetermined period after the solenoid receives the lifting energy, and a third electrode adapted to be temporarily immersed in the mercury only by upward movement of the displacer.

13. In a device of the class described, a circuit including a source of current and the primary of a transformer, a relay for controlling the circuit including a solenoid in parallel with the primary, and means operated by the solenoid to break the circuit through the solenoid at the breaking of the circuit through the primary whereby the surge in the latter is not choked by the impedance in the solenoid.

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