March 25, 1930. W. C. CARTER 1,751,975

ELECTRICALLY OPERATED FUEL PUMP FOR INTERNAL COMBUSTION ENGINES

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Fig. 2.

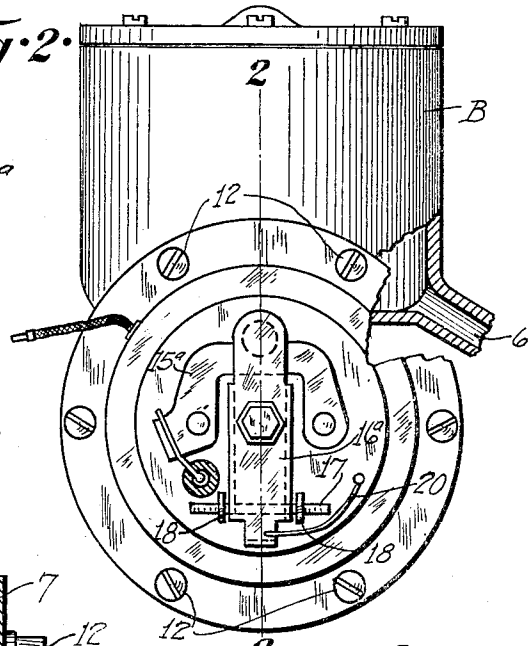


Fig. 1.

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ELECTRICALLY-OPERATED FUEL PUMP FOR INTERNAL-COMBUSTION ENGINES

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This invention relates to devices of the kind that are used for pumping a liquid from a lower to a higher level, and has for its main object to provide an electrically-operated pump, which, in addition to having a great pumping capacity, is reliable in operation, inexpensive to construct, economical in the consumption of electric current and of such design that the contacts will be separated with a quick break, thereby tending to prevent the current from arcing and burning the contacts or rendering them defective.

Another object is to provide a highly efficient and compact electrically-operated fuel pumping apparatus for internal combustion engines in which the electrically-operated means that actuates the pumping element is of novel construction and is so designed that the electric circuit from which said means receives its source of power will be opened automatically after the fuel in the reservoir rises to a certain predetermined level and will remain open so long as the fuel in said reservoir stands above said predetermined level. Other objects and desirable features of my invention will be hereinafter pointed out.

While I have herein illustrated my invention embodied in a liquid fuel supplying apparatus for internal combustion engines that is particularly adapted for use on power-operated vehicles for pumping gasolene from a supply tank into a relatively small feed reservoir that may either form part of a carburetor or from which fuel is conducted to the float chamber of a carburetor, I wish it to be understood that my invention is applicable to various other kinds of apparatus that are used for pumping liquid from a lower to a higher level.

Figure 1 of the drawings is a vertical sectional view of an apparatus constructed in accordance with my invention, taken on the line 2—2 of Figure 2; and

Figure 2 is an end view of the apparatus on a reduced scale, showing the cover or cap piece of the intermittent switch removed and a portion of the feed reservoir broken away so as to show the outlet from same.

Referring to the drawings which illustrate the preferred form of my invention, A designates the pumping element of the apparatus which consists of a member that is adapted to be moved in one direction so as to suck liquid fuel into a pumping chamber 1 from a supply pipe 2, and thereafter moved in the opposite direction so as to force the fuel out of the chamber 1 into a feed reservoir B that is equipped with an automatic inlet valve 3 that is normally held seated by a spring 4 which is strong enough to prevent the valve 3 from opening in the event the fuel tank (not shown) from which the supply pipe 2 leads becomes arranged at a higher level than the feed reservoir B. The inlet valve 3 of the feed reservoir B also constitutes the discharge valve of the pumping chamber 1, and said pumping chamber is also equipped with an automatically-operating inlet valve, preferably a ball check valve 5, arranged between the supply pipe 2 and the pumping chamber 1, as shown in Figure 1. The feed reservoir B may either form part of a carburetor, or it may be used for supplying liquid fuel to the float chamber of a carburetor, the reservoir B of the apparatus herein illustrated being provided with a discharge opening 6, as shown in Figure 2, from which the fuel escapes from said reservoir. The pumping element A may consist of a reciprocating plunger, or a vibrating member, such as a diaphragm, it being preferable to use a diaphragm composed of a number of disk-shaped pieces of treated fabric arranged so as to form one wall of the pumping chamber 1 and having their peripheral edge portions secured by a clamp 7 to a member 8 in which the pumping chamber 1 is formed, said member 8 preferably consisting of a casting that carries the valves 3 and 5, the feed reservoir B and the electrically-operated mechanism that actuates the pumping element A.

The electrically-operated mechanism just referred to consists of a solenoid that comprises a coil C and a core composed of a movable member D and a stationary member D'. In the form of my invention herein illustrated the solenoid is intended to be operated by direct current, but in view of the fact that the core pieces of the solenoid pull together, regardless of the direction of flow of the cur-

rent, it is possible to use alternating current to operate the solenoid. The members D and D′ of the core which are formed of magnetic material, are normally held spaced apart by an expansion spring 9, and said movable member D is rigidly connected to the pumping element A preferably by a screw 10 that passes through a pair of metal plates 11 that embrace the central portion of the diaphragm that constitutes the pumping element A. The coil C of the solenoid is surrounded by a metal housing E of magnetic material that bears against the part 7 and which is detachably connected by screws or other suitable fastening devices 12 to the member 8 in which the pumping chamber 1 is formed, said part 7 also being of magnetic material. A sleeve 13, preferably formed of brass, is arranged inside of the coil C so as to serve as a bearing or slideway for an annular fibre member 14 that surrounds the movable member D of the core of the solenoid. By constructing the solenoid in this way I insure the movable member D of the core being maintained in properly spaced relation with the coil and moving freely relatively to same without the use of a lubricant, as the annular fibre piece 14 that surrounds the movable part D of the core does not require a lubricant to make it slide freely inside of the brass sleeve 13. While I prefer to contruct the solenoid in the manner above described, it is not absolutely essential that the movable element of the solenoid be supported and guided in this particular way.

The electric circuit that is used to energize said solenoid is provided with two switches, one a manually-operated switch (not shown) that is closed when the apparatus is in use, and the other an automatically-operating, intermittent switch that opens and closes said circuit intermittently so as to cause the movable member D of the core to reciprocate, and thus actuate the pumping element A. The intermittent switch just referred to is arranged inside of a removable cap piece or cover E′ on the end wall of the housing E and comprises a stationary contact 15 and a movable contact 16. The cover E′ may be formed either of magnetic or non-magnetic material. The stationary contact 15 is carried by a member 15ª that is secured to the end wall of the housing E and insulated from same, which member 15ª is electrically connected with one end of the coil C of the solenoid, as shown in Figure 2. The movable contact 16 is carried by a movable member 16ª herein illustrated as a lever that is pivotally connected at one end by a pin 17 to ears 18 on the end wall of the housing E, said lever being adapted to be moved towards and away from the stationary contact carrying member 15ª and being provided at its lower end with an angularly-disposed arm or extension 19 that limits the movement of the contact 16 when said lever is moved to break the circuit. In order to insure a good electrical connection between the lever 16ª and the housing E, which is grounded, said lever is electrically connected by a piece of wire 20, commonly referred to as a "pig tail" to the end wall of the housing or to some other suitable grounded member.

The means that I prefer to use for separating the contacts 15 and 16 to break the circuit that energizes the solenoid consists of a hammer F of magnetic material, arranged so that it will impart a sharp blow to the lever 16ª on which the movable contact 16 is mounted at or about the time the movable member D of the core of the solenoid reaches the end of its inward stroke. During the inward stroke of said member D energy is stored in a spring 21, due to the movement imparted to the hammer F in one direction by magnetic force, and when the movable member D of the core comes in contact with the stationary member D′, the hammer F moves in the reverse direction under the influence of the spring 21 and strikes the lever 16ª a blow in a direction to cause the contacts 15 and 16 to be separated with a quick break. As shown in Figure 1, the hammer F is formed by a tubular member that is reciprocatingly mounted inside of a sleeve 22 of non-magnetic material, preferably brass, said hammer being arranged so that the outer end of same bears against the inner side of the lever 16ª. Said hammer and lever 16ª are connected together by the spring 21, previously referred to, which is a contractile spring connected at one end to the lever 16ª and at its opposite end to the tubular hammer F inside of which said spring is arranged, the spring 21 being herein illustrated as connected to the hammer F by solder 23. The brass sleeve 22, inside of which the hammer F is reciprocatingly mounted is provided at its outer end with a flange 22ª that serves as an abutment for one end of the spring 9 and which is held by the expansive force of said spring pressed tightly against a stationary plate 24 of magnetic material on the end wall of the housing E. The means used to move the lever 16ª in a direction to close the circuit in which the contacts 15 and 16 are arranged consists of a rod 25 attached at its inner end to the movable member D of the core of the solenoid and having its outer end projecting through a hole in the lever 16ª and threaded so as to receive an adjustable stop 26 that is arranged on the outside of the lever 16ª, said stop being adapted to bear against the lever 16ª and move it towards the stationary contact carrying member 15ª when the movable member D of the core of the solenoid reaches the end of its outward stroke. If the circuit of the solenoid is closed when the parts of the intermittent switch are in the position shown in Figure 1, the member D of the core of the solenoid will move inwardly towards the stationary

member D′ of said core and the hammer F will move inwardly towards the center of attraction, due to the magnetic force produced by the current flowing through the coil C of the solenoid, the path of the magnetic flux being from D to D′ and through the housing E and part 7 back to the core piece D. In view of the fact that the hammer F is arranged inside of the core piece D′, the flux will also flow through said hammer, thence through the plate 24, thence through the housing E and thence through the part 7 back to the core pieces. When the movable core piece comes into engagement with the stationary core piece, the magnetic flux takes the path of least resistance and cuts out the lines of force through the hammer, with the result that the spring 21 will jerk the hammer outwardly and cause it to strike the lever 16ª a sharp blow that separates the contacts. This inward movement of the hammer F not only holds the contacts 15 and 16 tightly together, due to the pull which the spring 21 exerts on the lever 16ª, but it also builds up energy in the spring 21 by increasing the tension of same.

As soon as the circuit is opened or interrupted by the blow imparted to the lever 16ª by the hammer F, the movable member D of the core of the solenoid moves outwardly under the influence of the spring 9 which was placed under tension by the inward stroke of said member D. During this outward movement of the member D the circuit is held open by the cramping action of the hammer F on the lever 16ª, due to the change in angularity of said lever and hammer. When the contacts 15 and 16 are closed, the lever 16ª will be arranged at right angles to the longitudinal axis of the hammer F, thereby causing the flange 27 on the outer end of said hammer to bear squarely against the inner side of said lever. When, however, the hammer F strikes the lever 16ª a blow, said lever swings into an inclined position, wherein the inner face of said lever is disposed at a sufficiently sharp angle to the end face of the flange 27 on the hammer to cause the lower edge of said flange to bear against the lever 16ª and hold it in the slightly inclined position into which it was moved by the blow of the hammer, it being remembered that the hammer and lever 16ª are connected together by the tension spring 21. When the movable member D of the core of the solenoid reaches the end of its outward stroke, the stop 26 on the rod 25 that is attached to said member engages the lever 16ª just before the member D reaches the end of its outward stroke, and thus causes the lever 16ª to swing back to its former position in parallel relation with the flange or head piece 27 on the end of the hammer F, thereby causing the circuit to be closed automatically as soon as the contact 16 engages the contact 15. Immediately thereafter the movable member D of the core and the hammer F will move inwardly towards the center of attraction, as previously described. If desired, a compression spring 21ª can be arranged at the inner end of the hammer F in such a manner that energy will be stored up in said spring 21ª by the inward movement of the hammer F and the movable member D of the core, it being possible to design the spring 21ª so that it will assist in the operation of moving the hammer F outwardly.

From the foregoing it will be seen that in my improved pumping apparatus the hammer F, which is reciprocatingly mounted inside of the stationary member D of the core, is reciprocated or moved in opposite directions by the magnetic force of the solenoid. When the coil of the solenoid is energized, the hammer is attracted, with the result that the hammer will move inwardly towards the movable member of the core, which is in the same circuit as the hammer F. When the movable member of the core strikes against the stationary member, and thus closes the air gap, then the power of attraction of the magnet becomes greatest at the outer ends of the core pieces, with the result that the hammer will be subjected to a force tending to move it outwardly or towards the lever 16ª. During the inward movement of the hammer energy is stored in the spring 21, and when the movable member D of the core comes in contact with the stationary member D′, said spring 21 causes the hammer to move outwardly and impart a sudden blow to the lever 16ª, thereby causing the contacts 15 and 16 to be separated with a quick break.

In a structure of the kind above described the magnetic force produced in the solenoid is used for the two-fold purpose of holding the contacts closed during the stroke of the core in one direction, and to effect the separation of the contacts with a quick break at the end of the said stroke of said core. While the construction above described is what I prefer to use, I do not wish it to be understood that my invention is limited to an apparatus of the particular construction herein illustrated, and instead of using the electric current flowing through the coil of the solenoid to hold the contacts closed and use a spring to separate said contacts, the apparatus might be constructed in such a way that the contacts will be held closed by a spring and opened by the movement imparted to a member by the electric current flowing through the coil of the solenoid.

The feeding reservoir B is provided with a float G that is used for actuating a mechanism which causes the pumping element A to automatically cease operating after a certain quantity of fuel has been pumped into said reservoir and to remain inactive for a certain period, for example, until the reservoir is

nearly empty, or so long as the level of the fuel in said reservoir remains above a certain point. The mechanism just referred to comprises a member 30 arranged so that when the float G in the reservoir B rises to a certain height the position of the member 30 will change automatically, and thus cooperate with a rod or other suitable part 31 attached to the movable member D of the core of the solenoid to arrest the movement of said member D on its outward stroke before said member D reaches such a position that the stop 26 on the rod 25 engages and moves the lever 16^a in a direction to bring the contacts 15 and 16 together. In the apparatus herein shown the member 30 consists of a rod pivotally mounted adjacent its lower end in the casting 8 and arranged so that it projects upwardly through a center hole in the float G, the pivotal connection between said rod 30 and casting 8 being of such a character that said rod can wobble or rock in various directions. An oscillating member H that is pivotally connected at 32 to a bearing 32^a on the underside of the cover of the feed reservoir B is provided with a roller 33 and two arms 34 and 35 arranged above and below the float G, said arms being rigid with the member H, so that when pressure is exerted on either of said arms by the float G, the member H will rock on its pivot. When the float G moves upwardly, due to a rise in the level of the fuel in the reservoir B, the float G will exert pressure on the arm 34 and rock the member H upwardly, thereby causing the roller 33 on said member to exert pressure against the side of the upper end portion of the rod 30 and move the upper end of said rod to the left, looking at Figure 1. This, of course, causes the rod 30 to assume a slightly inclined position, wherein the lower end portion of said rod is positioned a trifle farther to the right than the position which the lower end portion of said rod occupies in Figure 1. Assuming that this change in the position of the rod 30 was effected at a time when the movable member D of the core of the solenoid was moving outwardly, the rod or part 31 attached to said member D will strike the lower end portion of the float-governed member 30 and be arrested by same before the movable member D of the core of the solenoid moves far enough to move the contacts 15 and 16 of the intermittent switch into engagement with each other, with the result that the pumping element A immediately ceases operating. So long as the fuel in the reservoir B remains at such a level that the float G exerts pressure on the member H in a direction tending to hold the rod 30 in an inclined position, the energizing circuit of the solenoid will remain open and the pumping element will remain inactive. As soon as the level of the fuel in the reservoir B drops, however, far enough to relieve the pressure on the member H, and thus permit the rod 30 to assume a vertical position, the contacts 15 and 16 of the intermittent switch will close, due, of course, to the fact that the movable element D of the core is then free to move to the end of its outward stroke, and immediately thereafter the pumping element A will start operating, thereby resuming the pumping of fuel into the reservoir B. The arm 35 on the oscillating member H that is arranged under the float G is used to positively move the member 33 in a direction to relieve the sidewise pressure on the upper end of the rod 30 in the event gravity fails to move the member H downwardly when the float G moves out of engagement with the arm 34, due to a drop in the level of the fuel in the reservoir B. The arm 35 being so arranged that the float G will exert downward pressure on same, thus pulling the roller 33 away from the rod 30 when said float is in its extreme lower position. In order to eliminate the possibility of fuel escaping from the reservoir B through the opening in the bottom of said reservoir up through which the float-governed member 30 passes, and at the same time permit said member 30 to rock or wobble freely, I prefer to support the member 30 by a diaphragm 36 whose inner edge portion is clamped between collars 37, soldered on the rod 30, and whose peripheral edge portion is clamped between gaskets 38 that are held pressed tightly together by an annular-shaped clamping member 39 that is screwed into a threaded recess in the bottom of the feed reservoir B.

Assuming that the reservoir B is empty and that the manually-operated switch (not shown) in the solenoid circuit is moved into its closed position, the movable member D of the core of the solenoid and the hammer F will both start to move inwardly towards the center of attraction as soon as the electric current starts to flow through the coil C of the solenoid, the inward movement of the member D imparting a suction stroke to the pumping element A, and thus causing a charge of fuel to be drawn into the pumping chamber 1 through the supply pipe 2. When the member D of the core engages the stationary member D′ the magnetic pull on the hammer member becomes diminished and the hammer F immediately flies outwardly under the influence of the spring 21, thereby separating the contacts 15 and 16 with a quick break, whereupon the movable member D of the core will move outwardly under the influence of the spring 9 and impart a power stroke to the pumping element A that causes the charge of fuel in the pumping chamber 1 to be forced out of same past the valve 3 and into the reservoir B. As the movable member D of the core of the solenoid nears the end of its outward stroke the stop 26 on the rod 25 attached to said member D engages the lever 16^a and moves said lever in a direc-

tion to close the contacts 15 and 16, whereupon current will again flow through the coil C of the solenoid and cause the movable member D of the core to move inwardly. The above operations are repeated until the level of the fuel in the reservoir B has risen high enough to cause the float G to exert sufficient pressure on the oscillating member H to move the rod 30 into an inclined position. After said rod 30 has been shifted into an inclined position the pumping element A automatically ceases operating, due to the fact that the lower end portion of said rod 30 co-operating with the part 31 on the movable element D of the solenoid prevents said member D from moving far enough to cause the stop 25 to engage and move the lever 16^a in a direction to close the contacts of the intermittent switch. It will thus be seen that when the pumping element A ceases operating the energizing circuit of the solenoid remains open, and accordingly, no electric current is consumed at such times, namely, when the reservoir B is full or when the float G in said reservoir occupies such a position that it does not exert pressure on the arm 35 of the rockable member H. However, when the level of the fuel in the reservoir B drops low enough to cause the float G to exert pressure on the arm 35, the rod 30 will spring back to its normal vertical position, and immediately thereafter the contacts 15 and 16 will close and the movable element D of the solenoid will start reciprocating and cause the pumping operation to be resumed.

While I have herein illustrated my invention embodied in an electrically-operated pumping apparatus in which the reciprocating core of a solenoid is connected with a pumping element which said core actuates, I wish it to be understood that it is immaterial, so far as my broad idea is concerned, whether the pumping element of the apparatus is formed by an integral portion of the core of a solenoid or by a member actuated by or operatively connected with the core of a solenoid. Moreover, while I have herein illustrated the circuit-closing device in the solenoid circuit arranged so that the magnetic force is utilized to hold the contacts closed when the core of the solenoid is moving in one direction and a spring is used to thereafter close the contacts after they have been separated, I wish it to be understood that the circuit-closing device could be arranged in various other ways without departing from this feature of my invention, which, broadly stated, consists in using magnetic force produced by electric current flowing through a coil to hold contacts in the energizing circuit in one condition during the stroke or a certain portion of the stroke of the core of a solenoid, said contacts being subsequently separated to permit the core to move in the opposite direction, and said contacts being thereafter closed, preferably by a spring, so as to impart another stroke to the core of the solenoid.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In an electrically-operated pumping apparatus, a solenoid provided with a reciprocating core, contacts in the circuit used to energize the solenoid, and means for utilizing the magnetic force produced in the solenoid for holding said contacts closed during the stroke of the core of the solenoid in one direction, and to effect the separation of said contacts with a quick break at the end of the said stroke of said coil.

2. In an electrically-operated pumping apparatus, a solenoid provided with a reciprocating core, contacts in the circuit that energizes the solenoid, a means operated by the magnetic force in the solenoid for holding said contacts closed during the stroke of the core in one direction and for separating said contacts with a quick break at the end of said stroke, and a spring for closing said contacts when the core approaches the end of its stroke in the opposite direction.

3. In an electrically-operated pumping apparatus, a solenoid provided with a reciprocating core, contacts in the circuit that energizes the solenoid, a means operated by the magnetic force in the solenoid for holding said contacts closed during the stroke of the core in one direction and for separating said contacts with a quick break as the core nears the end of its said stroke, and an independent means for closing said contacts when the core nears the end of its stroke in the opposite direction.

4. In an electrically-operated pumping apparatus, a solenoid provided with a movable core, a circuit-closing device in the energizing circuit of the solenoid, and a hammer for imparting a sharp blow to said circuit-closing device arranged so that the magnetic force produced by the current flowing through the coil of the solenoid causes said hammer to move, first in a direction away from said circuit-closing device, and thereafter in the reverse direction into sudden engagement with said circuit-closing device.

5. In an electrically-operated pumping apparatus, a solenoid provided with a movable core that is adapted to be moved inwardly by the magnetic force produced by the current flowing through the coil of the solenoid, a spring for moving said core outwardly, a circuit-closing device in the energizing circuit of the solenoid arranged so that movement of said core in one direction effects a closing of said circuit closing device, and an independent means rendered operative by the magnetic force produced in the solenoid for imparting a sudden blow to said circuit-clos-

ing device so as to separate the contacts with a quick break.

6. In an electrically-operated pumping apparatus, a solenoid provided with a movable core, a movable circuit-closing device in the energizing circuit of the solenoid, a hammer for imparting a sudden blow to said device so as to open the circuit when the core of the solenoid nears the end of its stroke in one direction, and a spring for actuating said hammer arranged so that the magnetic force produced by the current flowing through the solenoid causes energy to be stored up in said spring.

7. In an electrically-operated pumping apparatus, a solenoid provided with a movable core arranged so that it will move in one direction when current flows through the coil of the solenoid, a movable circuit-closing device in the energizing circuit of the solenoid, and a spring-actuated hammer for moving said device in a direction to effect a change in the condition of the circuit, arranged so that said hammer will move away from said device towards the center of attraction when current flows through the coil of the solenoid and thereafter will move in the reverse direction under the influence of its actuating spring and impart a blow to the circuit-closing device so as to change the position of same.

8. In an electrically-operated pumping apparatus, a solenoid provided with a movable core arranged so that it will move in one direction when current flows through the coil of the solenoid, a movable circuit-closing device in the energizing circuit of the solenoid, a hammer for moving said circuit-closing device into its open position, arranged so that after it has actuated said device it will maintain said device in its open position, and an independent means for moving said circuit-closing device into its closed position.

9. In an electrically-operated pumping apparatus, a solenoid provided with a movable core arranged so that it will move in one direction when current flows through the coil of the solenoid, a movable circuit-closing device in the energizing circuit of the solenoid, a hammer for moving said circuit-closing device in one direction, and a spring that joins said hammer to said device, said hammer being so arranged that it will be moved by magnetic force in a direction to store up energy in said spring, and upon the core reaching the end of its stroke in said direction, will move in the reverse direction under the influence of said spring and impart a blow to said circuit-closing device.

10. In an electrically-operated pumping apparatus, a solenoid having a core composed of a stationary member and a movable member, the movable member of said core being adapted to be moved inwardly by the magnetic force produced by current flowing through the coil of the solenoid, a spring for moving said movable member outwardly, a movable circuit-closing device in the energizing circuit, a hammer arranged so that it will be moved by the magnetic force towards the center of attraction of the coil, a contractile spring attached to said hammer and to said circuit-closing device, said hammer being adapted to be moved in a direction to impart a blow to the circuit-closing device after the magnetic force has been shunted from the hammer to the stationary core member, thereby causing the energizing circuit to be opened, and a means rendered operative by the movement of the movable member of the core on its outward stroke for moving said circuit-closing device in a direction to close the circuit.

11. In an electrically-operated pumping apparatus, a solenoid having a core composed of a stationary member and a movable member, a spring for holding the members of said core separated, a pivotally-mounted circuit-closing device in the energizing circuit of the solenoid, a hammer that bears against one side of said device, a contractile spring connected to said device and to said hammer, said hammer being adapted to be moved away from said device towards the center of attraction by the magnetic force produced by current flowing through the coil of the solenoid, thereby causing said contractile spring to be placed under greater tension, the engagement of the movable and stationary members of the core causing the hammer to be released, whereupon the hammer imparts a blow to the circuit-closing device, and a means operated by the movable member of the core for moving said circuit-closing device in a direction to close the circuit when the movable member of the core nears the end of its outward stroke.

12. In an electrically-operated pumping apparatus, a solenoid comprising a coil and a movable core, a metallic sleeve arranged on the inner side of the coil, a non-metallic means on the core that slides in said sleeve and holds the core in spaced relation with the coil, and means for automatically opening the circuit that energizes the coil when said core nears the end of its stroke in one direction and for automatically closing said circuit when said core nears the end of its stroke in the opposite direction.

13. In an electrically-operated pumping apparatus, a solenoid having a core composed of a stationary member and a movable member, a bearing arranged on the inside of the coil of the solenoid, a part on the movable member of the core that slides in said bearing, a spring that normally holds the movable and stationary members of the core separated, a circuit-closing device in the circuit that energizes the coil of the solenoid, means for imparting a sharp blow to said circuit-

closing device so as to separate the contacts in the circuit with a quick break when the movable member of the core nears the end of its stroke in one direction, and means for thereafter moving said circuit-closing device in a direction to close the circuit when the movable member of the core nears the end of its stroke in the opposite direction.

14. In an electrically-operated pumping apparatus, a solenoid having a core composed of a stationary member and a movable member, a spring that normally exerts pressure on the movable member of the core in a direction tending to hold it spaced away from the stationary member of the core, a bearing arranged inside of the coil of the solenoid, a part on the movable member of the core that slides in said bearing, an intermittent switch in the energizing circuit of the coil comprising a lever that carries the movable contact of said circuit, a reciprocating hammer arranged at the center of the stationary member of the core and adapted to be moved by magnetic force towards the center of attraction when current is flowing through the coil, the outer end of said hammer bearing against the inner side of said lever, a contractile spring connected to said hammer and lever, and a device connected to the movable member of the core and arranged on the opposite side of said lever for moving the same in a direction to close the circuit when the movable member of the core nears the end of its outward stroke.

15. In an electrically-operated pumping apparatus, a solenoid having a core composed of a stationary member and a movable member, a spring that exerts pressure on the movable member of the core in a direction tending to hold it spaced away from the stationary member, an intermittent switch in the circuit that energizes the solenoid coil provided with a pivotally-mounted circuit-closing device, a tubular-shaped hammer reciprocatingly mounted inside of the stationary member of the core and arranged with the outer end of same bearing against said circuit-closing device, a contractile spring connected to said device and to said hammer, and a compression spring at the inner end of the hammer arranged so that it will be placed under compression by the inward movement of the movable member of the core.

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