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APPARATUS FOR TAKING FLUID SAMPLES

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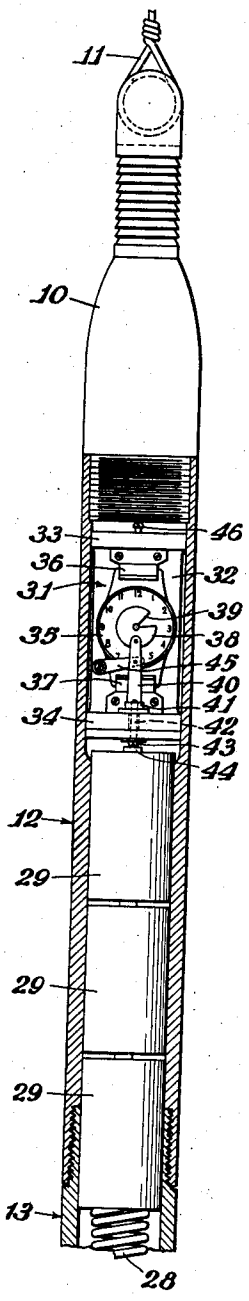


Fig. 1

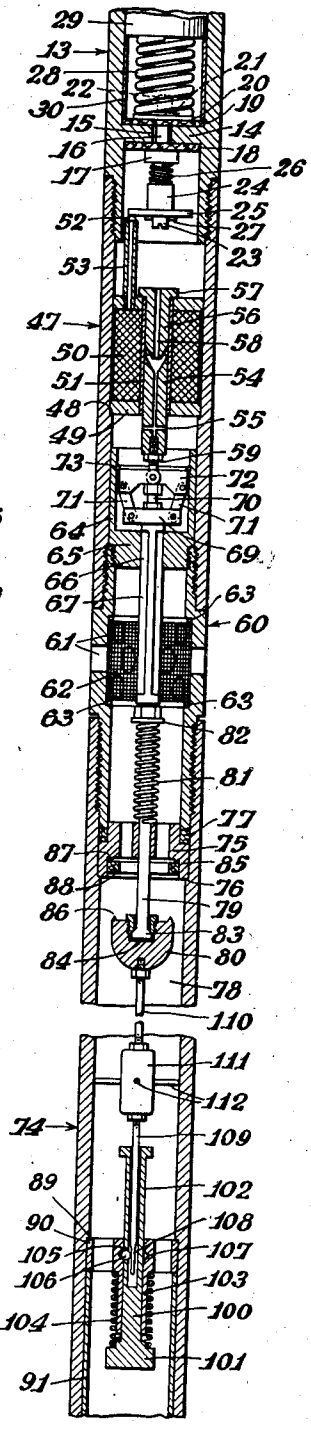


Fig. 2

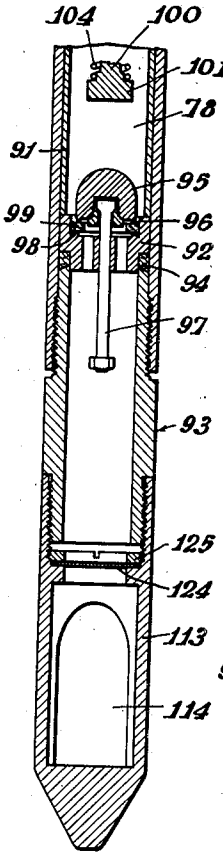


Fig. 3

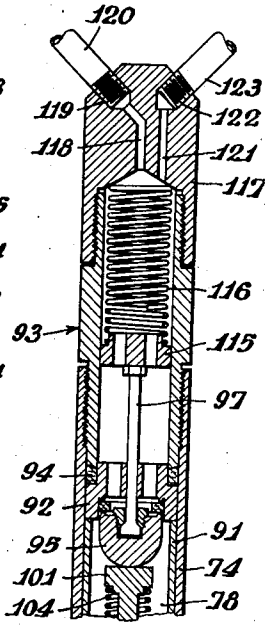


Fig. 4

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APPARATUS FOR TAKING FLUID SAMPLES

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14 Claims. (Cl. 166—1)

This invention relates to an apparatus for taking samples of fluid, and more particularly to bottom hole sampling device for obtaining samples of the fluid in a deep well under the conditions existing therein.

In the study of problems relating to subterranean reservoirs of oil and gas, it is frequently desirable to have data which can only be obtained by testing samples of these fluids taken from the reservoir in as near their original state as is possible. In all high pressure oil reservoirs, there exists both oil and gas; the gas, however, is usually in "solution" in the oil at these pressures. As the pressure is released from the liquid oil-gas mixture, the gas escapes, so that on the surface of the ground, both liquid and gaseous material are produced. However, at the surface, the ratio between gas and oil produced does not necessarily duplicate the ratio between gas and oil co-existing in a single phase in the high pressure reservoir. Thus in order to find out the actual nature of the materials existing in the reservoir, it becomes necessary to obtain a sample of the single-phase oil-gas mixture from the bottom of the oil well, rather than from its surface valves and piping, and to confine this sample so that it may be removed from the well for testing without any loss (or gain) of material.

Various devices have been used for this purpose but none of them is completely satisfactory for a number of reasons. Among these have been the difficulty in insuring the taking of a representative sample at the desired location and in retaining the sample without loss of material in the sampler until it has been raised to the surface of the earth and is ready for transfer to a bomb or other testing apparatus. These difficulties may be easily understood when it is realized that oil wells having a depth in excess of 10,000 feet are now quite common and that the reservoir pressure at which the sample must be retained often exceeds 2500 pounds per square inch.

It is an object of my invention to provide an apparatus for taking samples of the fluid in a well under the pressure and temperature prevailing therein. Another object is to provide a self-contained bottom hole sampling device containing electrical means for sealing a representative fluid sample therein at a predetermined time. A further object is to provide a bottom hole sampler which will retain a sample at high pressure without danger of leakage. Further objects will be apparent from the following detailed description, read in connection with the drawing, in which:

Figure 1 is a vertical section through the upper portion of a preferred embodiment of my invention;

Figure 2 is a vertical section through the middle portion of the same preferred embodiment;

Figure 3 is a vertical section through the lower portion thereof; and

Figure 4 is a vertical section through the lower portion thereof showing this portion in inverted position and equipped with a transfer head through which the sample can be removed.

The description of my invention will proceed with special reference to the preferred specific embodiment thereof illustrated in Figures 1, 2 and 3, in which headpiece 10 having its upper portion shaped to receive a loop on the end of cable 11 is screwed into the upper portion of tubular section 12 so as to make a pressure-tight seal. Attached to the lower end of section 12 by means of cooperating threads is a coaxial section 13 having the same internal and external diameters and an integral partition wall 14, which is provided with an axial bore 15. Bolt 16 having a smaller diameter than bore 15 but an enlarged portion 17 thereon is inserted through bore 15 but is held out of electrical contact with partition wall 14 and centered in bore 15 by means of insulating discs 18 and 19 on opposite sides of wall 14. Resting on upper disc 19 is a somewhat smaller disc 20 of conducting material, and the assembly is held in place by means of washer 21 and nut 22. Integral with bolt 16 but extending below enlarged portion 17 is a downwardly-extending portion 23 having slidably mounted thereon a collar 24 and disc 25 of conducting material. A compression spring 26 urges disc 25 downward along portion 23 but this downward travel is limited by pin 27 through portion 23. This construction provides a pressure-tight electrical connection between disc 25 and disc 20.

Resting upon disc 20 is a compression spring 28, upon which rest a number of single-cell dry batteries 29 of a type commonly used in flashlights placed above each other so that they are in series. An insulating sleeve 30 prevents inadvertent contact between spring 28 and section 13. Spring 28 serves two essential functions: first, it provides an electrical connection between disc 20 and batteries 29; and second, it urges batteries 29 and time switch assembly 31 upward against the bottom of headpiece 10 and thus holds them in position.

Time switch assembly 31 consists essentially of

a member 32 having circular enlarged portions 33 and 34 on its upper and lower ends, respectively, which is contained within tubular section 12 with a sliding fit. A clock mechanism 35, which may be for example an ordinary wrist watch with its crystal and hands removed, is mounted, preferably in rubber, on member 32 by means of clamps 36 and 37. A disc sector 38 made of insulating material having a cutout portion 39 is mounted on the clock 35 in place of one of the hands, preferably the minute hand, so that it is slowly rotated thereby. A spring contact member 40, which is mounted upon the upper terminal 41 of an insulated connection 42 through enlarged portion 34 having a lower terminal 43 resting upon positive terminal 44 of the uppermost of batteries 29, bears upon the disc sector 38 in such a way that it is normally held out of contact with contact member 45, which is mounted on member 32. However, when disc sector 38 has been rotated by clock mechanism 35 until cutout portion 39 registers with spring contact member 40, the latter springs into contact with member 45, thus placing positive battery terminal 44 in electrical contact with member 32, which is grounded to tubular member 12 through enlarged portions 33 and 34 and through capscrew 46 on the upper surface of portion 33. From the above detailed description it is apparent that I have provided an improved time switch whereby the batteries 29 may be placed in electrical contact with tubular member 12 at any predetermined time without the passage of electrical current through clock mechanism 35.

Attached to the lower portion of member 13 by means of cooperating threads and coaxial thereto is tubular member 47, whose lower portion has a somewhat smaller inside diameter than its upper portion, thus forming a shoulder 48, upon which rests a solenoid 49 having windings 50 and an axial cylindrical passage 51 therethrough. One terminal of solenoid windings 50 is grounded to member 47 and the other terminal 52 extends upwardly through tubular insulator 53 and contacts disc 25. An electrical circuit is thus completed so that solenoid windings 50 are energized when cut out portion 39 of disc 38 registers with contact member 40, the circuit running from positive terminal 44 of batteries 29 through insulated connection 42, contact members 40 and 45, member 32, enlarged portions 33 and 34 and capscrew 46, and tubular members 12, 13 and 47 to solenoid windings 50 and from the other terminal 52 of these windings through disc 25, bolt 16, disc 20 and spring 28 to the bottom or negative terminal of batteries 29.

Armature 54, which is elongated in shape, is slidably mounted within solenoid passage 51 and has connecting axial and transverse drill holes 55 for the passage of fluid therethrough. Immediately above armature 54 and also slidably mounted within passage 51 is solenoid stop 56, which is supported therein by means of the enlarged portion 57 bearing on solenoid 49 and has an axial drill hole 58. Armature 54 is adjustably attached at its lower end to armature toggle link 59 by means of threads so that when solenoid windings 50 are not energized and the apparatus is ready for use, as shown, there is a small gap between armature 54 and solenoid stop 56. When solenoid windings 50 are energized by means of the circuit hereinabove described armature 54 and toggle link 59 are raised a short distance by the magnetic energy of the solenoid 49.

Externally threaded screen nipple 60, having a number of holes 61 therethrough covered by screen 62, which is held in place by split ring retainers 63, is attached to the lower end of member 47, by means of the internal threads on the latter, and also supports a special sleeve 64, which is disposed within member 47, by means of internal threads at its upper end. The lower portion 65 of sleeve 64 is formed with an axial opening 66 therethrough for the reception of trigger guide rod 67, which has longitudinal flats 68 formed thereon so as to allow the passage of fluid from the interior of nipple 60 to the interior of member 47, and to aid in preventing sticking of rod 67 in opening 66. Guide rod 67 is attached at its upper end to trigger support member 69, which bears toggle support screw 70 and two oppositely placed links 71 attached at their upper ends to the lower outer portions of two trigger sear links 72 by means of pins. Trigger sear links 72 are both pivoted at the lower end of armature toggle link 59 and are shaped so that when in cocked position, as shown, their upper outer portions engage retaining shoulder 73, which is preferably a strand of wire or similar material placed in an appropriate groove within sleeve 64 so that it may be easily replaced in the field. This arrangement is such that only a small amount of energy exerted to raise armature 54 and armature toggle link 59 will allow trigger sear links 72 to pass over retaining shoulder 73. The sensitivity of this trigger assembly can be varied by threading toggle support screw 70 in or out. The lower screw 70 and therefore the inner portions of links 72 are, the more stable the trigger assembly is to shock and also the more pull by armature 54 is required to release it.

Long sample tube 74 is threaded on the lower portion of nipple 60 in such a way that outlet port member 75 is retained in position by shoulder 76 within tube 74 and gasket 77. By this arrangement increased pressure in sample chamber 78 below outlet port member 75 causes the latter to compress gasket 77 further so that the pressure within gasket 77 exceeds the pressure in sample chamber 78 and a very effective seal is obtained. Outlet valve stem 79 carrying outlet valve 80 is slidably supported within member 75 and is attached at its upper end to trigger guide rod 67. Surrounding valve stem 79 is compression spring 81 which bears on member 75 and on spring seat 82 on the upper end of valve stem 79. A swivel joint 83 is provided between valve stem 79 and valve 80, but the latter is kept in alignment and prevented from vibrating by means of resilient disc 84, which is preferably made of an oil-resisting synthetic rubber. Both valve 80 and valve seat 85 in member 75 are provided with knife edges 86 and 87, respectively, and valve seat 85 is also recessed for the reception of gasket 88, which is held in position by friction, preferably with the aid of circumferential grooves in member 75.

Sample tube 74 is also provided internally with a downwardly-facing shoulder 89 against which hammer rod support 90, sleeve 91 and inlet port member 92 are held by means of nipple 93 and gasket 94, the seal between nipple 93 and member 92 being of the same type hereinabove described in connection with nipple 60 and member 75. The construction of the inlet valve assembly, including inlet valve 95 having knife edge 96, inlet valve stem 97, knife edge 98 and gasket 99, is the same as that of the outlet valve assembly except that no compression spring is provided so

that valve 95 acts as a check valve to allow fluid to flow into but not out of sample chamber 78.

Hammer rod 100 having an enlarged lower portion 101 and an axial bore 102 in its upper portion is slidably mounted in hammer rod support 90, which has a depending sleeve 103. A compression spring 104 surrounds sleeve 103 and bears upon enlarged portion 101 so that hammer rod 100 is urged downwardly into contact with the top of inlet valve 95. Hammer rod 100 also has a trigger ball seat 105 communicating with bore 102 containing trigger ball 106, which is adapted to cooperate with a notch 107 in support 90 to hold hammer rod 100 in the position shown against the action of spring 104 when reduced portion 108 of trigger rod 109 is inserted a sufficient distance into bore 102. Trigger rod 109 is attached to outlet valve 80 by means of rod 110 and turnbuckle 111, which is held in axial position by arms 112. Footpiece 113, which is attached to nipple 93 by cooperating threads, is provided with a number of openings 114, and carries a screen 124 which is held in position by screen retaining ring 125.

In using my improved sampling device to obtain a sample of the fluid in a deep well, headpiece 10 is removed, time switch assembly 31 is removed from tubular section 12, clock mechanism 35 is set so that contact will be made between members 40 and 45 at a predetermined time sufficient to allow the device to be lowered into a well to the depth at which it is desired to take a sample, and time switch assembly 31 and headpiece 10 are returned to their respective positions. The sampling device is then lowered into the well by means of cable 11. During the lowering operation the fluid in the well enters sample chamber 78 through openings 114 and inlet port member 92, valve 95 being lifted by the pressure of the incoming fluid. Since outlet valve 80 is held open, fluid continuously flows from chamber 78 through outlet port member 75 and out the holes 61 in nipple 60. As the well pressure increases some of the fluid also flows through grooves 68 and bores 55 and 58 so that no pressure differential is built up across armature 54 which might cause it to be raised prematurely and close valves 80 and 95. When the level at which the sample is to be taken is reached, the sampling device is raised and rapidly lowered several times to purge sample chamber 78 of well fluid received therein during the lowering of the device so that a representative sample of the well fluid at the desired point may be obtained.

When the predetermined time for taking the sample has arrived, contact is automatically made between members 40 and 45, thus energizing solenoid windings 50 and raising armature 54 a short distance as hereinabove described. This movement raises armature toggle link 59 and allows trigger sear links 72 to pass over retaining shoulder 73, so that outlet valve 80 is free to close by the action of spring 81. Armature 54 and movable solenoid stop 56 also simultaneously are moved upward and solenoid stop 56 has a dashpot effect on the closing of valve 80 due to the oil within tubular member 47 just above it. As outlet valve 80 closes trigger rod 109 is raised and trigger ball 106 is released from contact with reduced portion 108 so that it moves out of notch 107, thereby allowing hammer rod 100 to be propelled by spring 104 against the top of inlet valve 95, which assists in obtaining a perfect seal between valve 95 and inlet port member 92. Furthermore hammer rod 100 is thereafter held against valve 95 by spring 104 so as to hold it in place.

It is apparent from the above that I have provided an improved sampling device which is particularly suitable for obtaining samples of oil well fluids under bottom hole temperatures and pressures and retaining them unaltered and without leakage until they are to be tested.

In my preferred method of transferring the sample to a testing bomb, the device is inverted, footpiece 113 is removed, spring seat 115 and spring 116 are inserted in nipple 93, and transfer head 117 is screwed on nipple 93 to make a pressure-tight joint as shown in Figure 4. Spring seat 115 slides freely within nipple 93 and bears upon the end of valve stem 97, and spring 116 is somewhat stronger than spring 104, so that valve 95 is held in its closed position only by the pressure of the sample within chamber 78. Transfer head 117 is provided with a bore 118 and threads 119 for connection to a testing bomb (not shown) by means of pressure tube 120 and a bore 121 and threads 122 for connection with a source of mercury under pressure by means of pressure tube 123. First, all of the volume above inlet port member 92 is filled with mercury from bore 121, and then the mercury pressure is increased until it is equal to that of the sample. Since the pressure on valve 95 of the mercury and spring 116 is greater than that of the sample and spring 104, the valve opens, allowing mercury to flow into chamber 78 and displace the sample, which rises and flows through bore 118 and tube 120 to the testing bomb.

In order to prepare my sampling device for another trip down a well, the mercury pressure is released, the device is returned to its normal position so that the mercury is drained from sample chamber 78, valve 95 being held open by overbalancing spring 116, members 13 and 47 are detached, solenoid stop 57 is removed and armature 54 is depressed until valve 80 is open and toggle link 59 rests upon toggle support screw 70, so that trigger sear links 72 again engage retaining shoulder 73. Since hammer rod 100 is still held in retracted position, trigger rod 109 enters bore 102 and forces trigger ball 106 into notch 107, thus locking hammer rod 100 in that position. Solenoid stop 57 is replaced and members 13 and 47 again attached. Transfer head 117, spring 116 and spring seat 115 are then removed from nipple 93 and replaced by footpiece 113. Finally headpiece 10 is removed, time switch assembly 31 and discharged batteries 29 are withdrawn, new batteries are inserted, clock mechanism 35 is set, and time switch assembly 31 and headpiece 10 are replaced in their respective positions. The sampling device is then ready to be lowered into a well for the taking of another sample.

While I have described my invention in connection with a specific embodiment thereof, I do not desire to be limited thereto, but only by the following claims, which should be construed as broadly as the prior art will permit.

I claim:

1. Apparatus for taking samples of fluid from a well comprising a sample chamber having inlet and outlet ports, means for preventing back flow of fluid from said chamber through said inlet port, a valve in said outlet port, means for urging said valve to its closed position, means for retaining said valve in its open position against the action of said urging means, means actuated by an electric current for rendering

said valve-retaining means inoperative and means for supplying an electric current to said last-mentioned means at a desired time.

2. Apparatus for taking samples of fluid from a well comprising a sample chamber having inlet and outlet ports, means for preventing back flow of fluid from said chamber through said inlet port, a valve in said outlet port, means actuated by an electric current for closing said valve and means for supplying an electric current to said last-mentioned means at a desired time.

3. Apparatus for taking samples of fluid from a well comprising a sample chamber having inlet and outlet ports, means for preventing back flow of fluid from said chamber through said inlet port, a valve in said outlet port, means actuated by a solenoid when an electric current is passed therethrough for closing said valve, and means for passing an electric current through said solenoid at a predetermined time.

4. Apparatus for taking samples of fluid from a well comprising a sample chamber having inlet and outlet ports, a check valve adapted to prevent back flow of fluid from said chamber through said inlet port, a valve in said outlet port, means actuated by an electric current for simultaneously closing said outlet valve and locking said check valve in its closed position and means for supplying an electric current to said last-mentioned means at a desired time.

5. Apparatus for taking samples of fluid from a well comprising a sample chamber having inlet and outlet ports, a check valve adapted to prevent back flow of fluid from said chamber through said inlet port, a valve in said outlet port, a clock mechanism, means actuated by an electric current for simultaneously closing said outlet valve and locking said check valve in its closed position and means for supplying an electric current to said last-mentioned means at a desired time determined by the setting of said clock mechanism.

6. In a bottom hole sampling device having a sample chamber provided with inlet and outlet ports and inlet and outlet valves controlling flow of fluid through said ports, the combination comprising means for urging said outlet valve toward its closed position, means for retaining said outlet valve in its open position against the action of said urging means, a solenoid, means actuated by said solenoid when an electric current is supplied thereto for rendering said valve-retaining means inoperative, and means for supplying an electric current to said solenoid at a predetermined time.

7. The combination of claim 6 wherein said means for rendering said valve-retaining means inoperative includes an elongated armature slidably mounted within said solenoid along the axis thereof.

8. The combination of claim 6 wherein said current-supplying means includes a source of electromotive force, a clock mechanism and means actuated by said clock mechanism for allowing electric current from said source of electromotive force to flow to said solenoid.

9. The combination of claim 6 wherein said inlet valve is adapted to prevent back flow of fluid through said inlet port and including means responsive to the closing of said outlet valve for sealing said inlet valve in its closed position.

10. In a bottom hole sampling device having a sample chamber provided with inlet and outlet ports, and outlet valve, and an inlet valve adapted to prevent back flow of fluid through said inlet port from said chamber, the combination comprising means for closing said outlet valve at a predetermined time, a slidably mounted hammer member adapted to bear upon said inlet valve when in extended position, means for urging said hammer member into extended position, means for retaining said hammer member in retracted position against the action of said urging means, and means actuated by said valve-closing means for rendering said retaining means inoperative, whereby said hammer member strikes said inlet valve and effectively seals said inlet port.

11. The combination of claim 10 wherein said inlet port is provided with a valve seat having a continuous knife edge thereon and a gasket covering said knife edge and said inlet valve is provided with a second continuous knife edge adapted to come in contact with the upper surface of said gasket when said inlet valve is in closed position.

12. A bottom hole sampling device comprising a tubular case, members having valve ports therethrough mounted within said case and defining a sample chamber therein, valves adapted to close said valve ports, a compressible gasket for each of said members adapted to provide a seal between each of said members and said case, and means whereby fluid pressure within said sample chamber subjects said gaskets to a pressure in excess of said fluid pressure.

13. A bottom hole sampling device comprising a sample chamber provided with inlet and outlet ports, a check valve adapted to prevent back flow of fluid from said chamber through said inlet port, an outlet valve adapted to prevent flow of fluid through said outlet port, means for urging said outlet valve toward its closed position, means for retaining said outlet valve in its open position against the action of said urging means, a solenoid having an axial passage therethrough, an armature slidably mounted in said axial passage adapted to move longitudinally therein when an electric current passes through said solenoid, means actuated by said armature for rendering said valve-retaining means inoperative, an electric circuit including a source of electric current, a switch and said solenoid, a clock mechanism adapted to close said swith at a predetermined time, a slidably mounted hammer member adapted to bear upon said check valve when in extended position, means for urging said hammer member into extended position, means for retaining said hammer member in retracted position, and means actuated by said outlet valve for rendering said means for retaining said hammer member inoperative, whereby said outlet valve is closed and said check valve is sealed simultaneously at a predetermined time.

14. A bottom hole sampling device comprising a tubular case, two members having valve ports therethrough slidably mounted within said case and defining a sample chamber therein, a compressible gasket for each of said members adapted to provide a seal between each of said members and said case, means whereby fluid pressure within said sample chamber subjects said gaskets to a pressure in excess of said fluid pressure, a check valve adapted to prevent back flow of fluid from said chamber through one of said valve ports, an outlet valve adapted to prevent flow of fluid through the other of said valve ports, means for urging said outlet valve toward its closed position, means for retaining said outlet valve in its open position against the action of said urging means,

a solenoid having an axial passage therethrough, an armature slidably mounted in said axial passage adapted to move longitudinally therein when an electric current passes through said solenoid, means actuated by said armature for rendering said valve-retaining means inoperative, an electric circuit including a source of electric current, a switch and said solenoid, a clock mechanism adapted to close said switch at a predetermined time, a slidably mounted hammer member adapted to bear upon said check valve when in extended position, means for urging said hammer member into extended position, means for retaining said hammer member in retracted position, and means actuated by said outlet valve for rendering said means for retaining said hammer member inoperative, whereby said outlet valve is closed and said check valve is sealed simultaneously at a predetermined time.

JOSEPH BALDWIN CLARK.