

June 25, 1946.

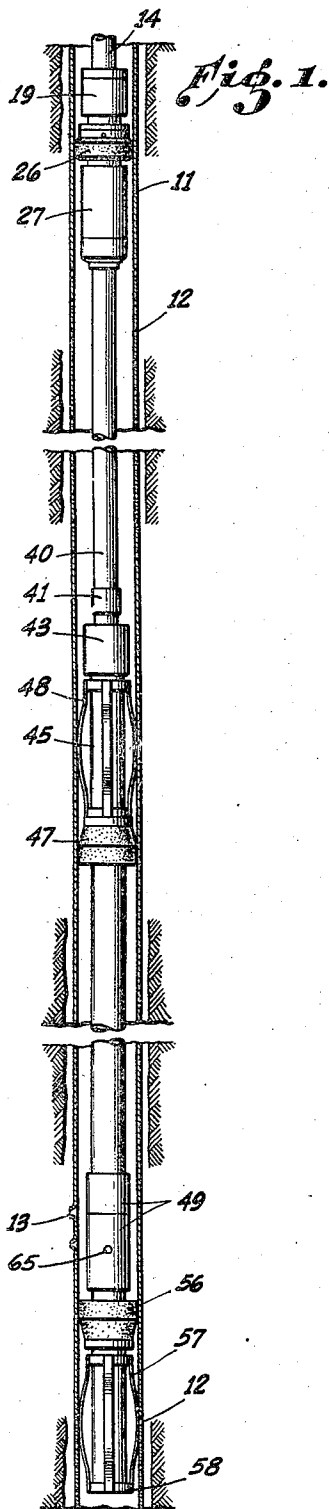
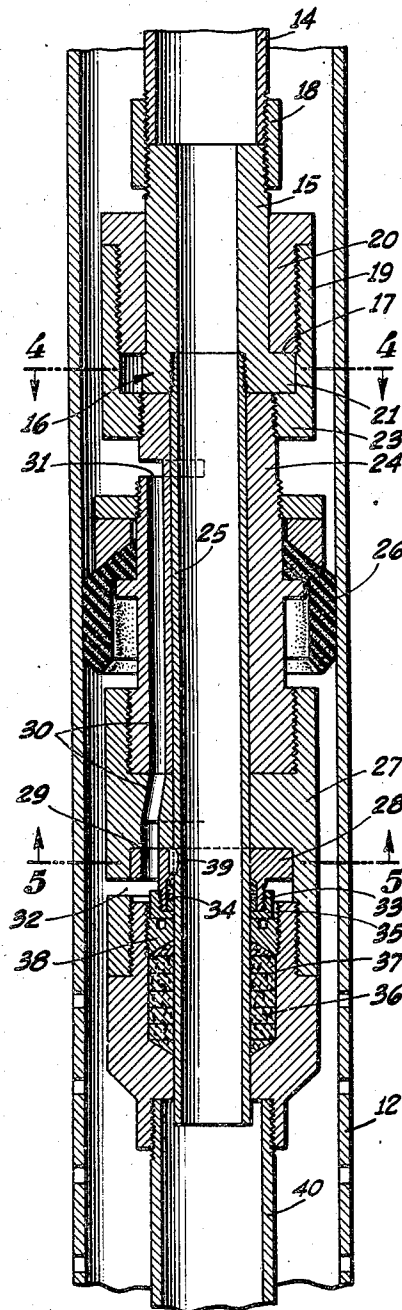
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2,402,886

OIL WELL DEVICE

Filed Nov. 3, 1941

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

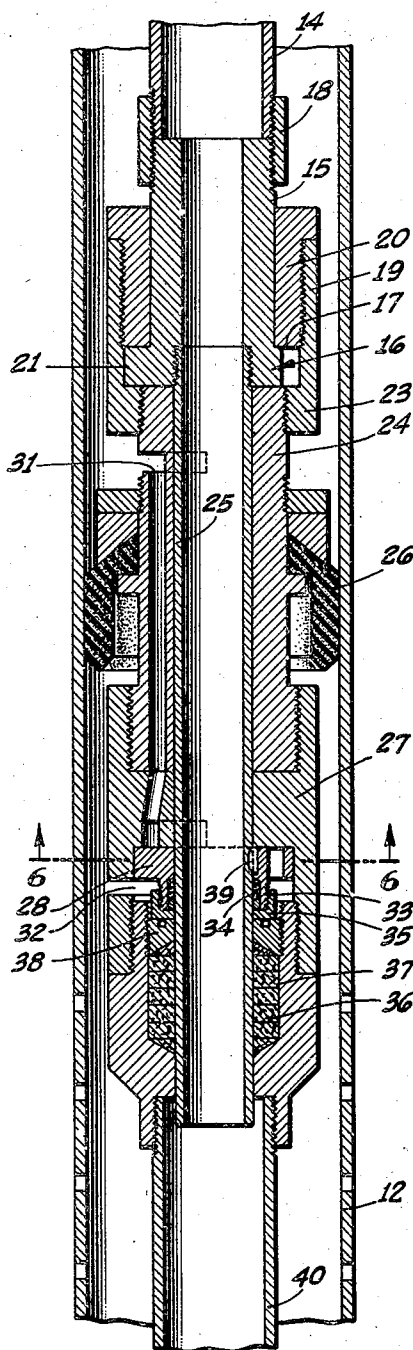


Fig. 3.

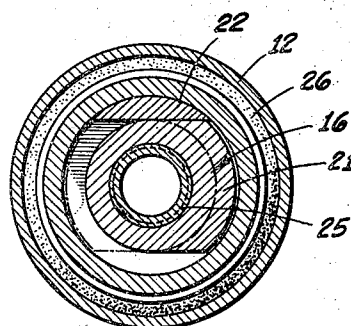


Fig. 4.

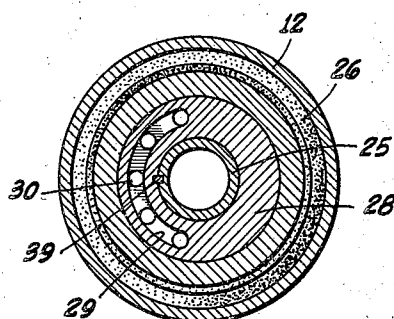


Fig. 5.

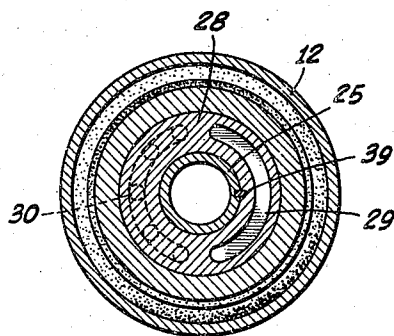


Fig. 6.

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3 Sheets-Sheet 3

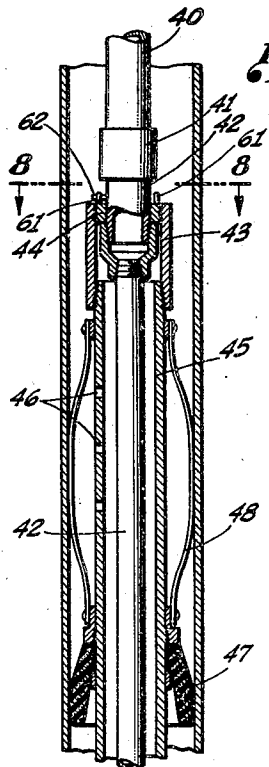


Fig. 7.

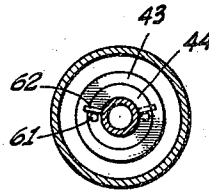


Fig. 8.

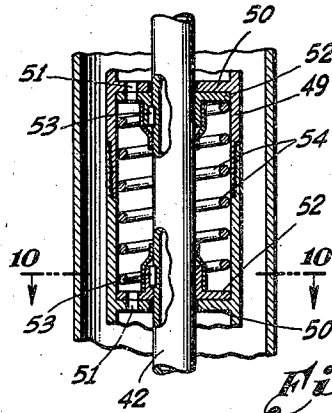


Fig. 9.

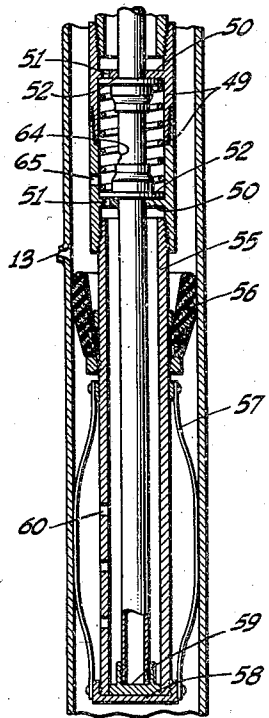
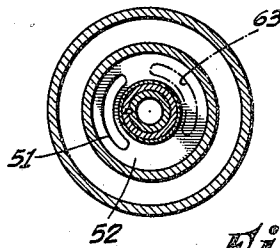


Fig. 10.

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UNITED STATES PATENT OFFICE

2,402,886

OIL WELL DEVICE

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Application November 3, 1941, Serial No. 417,583

12 Claims. (Cl. 166—11)

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This invention relates to apparatus for and methods of ejecting fluids into the annular area of casing-lined deep wells around the casing, and contemplates more specifically the discharge of fluent cement acid, or any fluid utilized for increasing production, cleaning the bore of clogging detritus, sealing off water-bearing stratum, etc., through ports or screen in the casing at predetermined levels.

In order to maintain unobstructed access to the oil sands after a well is drilled, the bore is usually lined with casing which includes as a part of the string stands of perforated pipe or screen positioned opposite the oil producing measures. It is common practice to cement the casing in the well bore, i. e. fill all or part of the annular zone of the bore around the casing above and below the perforated pipe with cement to preclude seepage of water from a water-bearing stratum nearer the surface into the producing sands where it may displace the oil. Approved methods of cementing wells contemplate pumping volumes of fluent cement downwardly through the casing or through a string of tubing placed in the casing for the purpose, and the ejection of the cement from ports in the casing into the annular area of the hole around the casing at the lower end of the zone to be cemented. In order to accomplish this operation it is ordinarily necessary that circulation be preliminarily established through the casing and ports from which the cement is to be subsequently ejected, and thence upwardly to the well surface so as to insure an unrestricted passage for the cement to the zone to be sealed. It occasionally happens that after the upper portion of the water string is thus cemented, water from a lower theretofore unsuspected water-bearing stratum will appear in the oil pumped. In such case circulation to the well surface is prevented by the cement thereabove sealing the upper bore of the well casing, which presents a problem of spot cementing with which the present invention is concerned.

Where the area to be cemented is located below a productive measure and circulation from the point of discharge of the cement to the well surface through the upper sands is possible, the pressure necessary for the ejection of the cement will cause the cement or the mud fluid which precedes the cement into the casing or tubing, to rise around the casing into the oil-bearing stratum, thus tending to seal off the oil sands from the casing or impeding flow of the oil to the well.

It is a general object of the present invention

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to provide apparatus and methods by which fluent cement, acid, or other fluids may be expelled through ports in the casing at any predetermined level and confined to a limited area of the surrounding well bore whereby the fluid may be spotted at any unrestricted annular area of the well around the casing without the necessity of establishing circulation to the well surface exteriorly of the casing.

More specifically an object of the invention is the provision of apparatus embodying a tubing string through which the fluid to be placed in the well bore may be pumped to the zone of the casing having the ports therein through which the fluid is to be discharged, carrying a series of packers adapted to seal off the area of the casing in which the discharge ports are disposed and an upper ported section of the casing communicable with the discharge port through an unrestricted section of the well bore in which the device may be located, in combination with a valve-controlled by-pass through the upper packer whereby circulation to the well surface for relief of the hydrostatic head in the zone to be cemented may be effected if desired.

Another object is to provide apparatus of the character alluded to embodying means to close off circulation to the well surface through ports in the casing string above the zone into which the fluid is to be ejected so as to confine the area of the well opposite the discharge port in the casing and prevent upward movement of the fluid ejected into the well bore from the casing beyond predetermined limits.

Another object is the provision of a method of spotting a quantity of fluid in a predetermined location of a well bore below a perforated section of casing which contemplates the sealing of the casing bore above and below the perforations in the casing whereby the fluid in the bore of the well encircling the casing above the zone intended to receive the discharge will create a hydrostatic head sufficient to resist movement of the fluid ejected from the casing to a point above the zone to be treated.

Another object is to provide a tubing string carrying a casing packer assembly having a valve-controlled by-pass therethrough adapted to facilitate the lowering of the tool into the well and to control circulation of fluid ejected from the tubing string to the well surface through a part of the annular area in the well bore encircling the casing.

Other objects and important features of my invention, such for example as simplicity of con-

struction, positive performance in use, and ease of operation, will be apparent from the following description read in the light of the accompanying drawings in which:

Fig. 1 is a sectional view of a portion of the casing intermediate its upper and lower ends, illustrating in elevation the tool of my invention as positioned for use.

Fig. 2 is a sectional view of the upper packer of the device, illustrating particularly a by-pass through the packer and the means for operating the same;

Fig. 3 is a view similar to Fig. 2, depicting the valve which controls the by-pass through the upper packer in closed position;

Figs. 4 and 5 are sectional views taken on correspondingly numbered lines of Fig. 2;

Fig. 6 is a sectional view of lines 6—6 of Fig. 3;

Fig. 7 is a sectional view of the casing and lower part of the tool of my invention disposed therein;

Fig. 8 is a sectional view on lines 8—8 of Fig. 7;

Fig. 9 is an enlarged fragmentary view of the housing for the valves and associated mechanism controlling the by-pass through the lower packers;

Fig. 10 is a sectional view taken on lines 10—10 of Fig. 9 with the lower valve closed.

Referring to the drawings in detail which illustrate the use and application of my invention as a cementing device, the numerals of which drawings indicate similar parts throughout the several views, 11 designates a length of casing comprising an oil string, lining the well bore intermediate the surface and the bottom of the well. The casing string includes two sections of perforated pipe or screen 12 disposed opposite spaced levels. The upper part of the bore of the well (not shown) is sealed to protect the oil sands from water thereabove as is required in producing wells. In order to place fluent cement in the annular area of the hole encircling the imperforate casing between the perforated sections 12 thereof, holes 13 are punched in the casing by a suitable perforating tool, the number, arrangement and size of the holes being within the skill of those engaged in the art. It will be understood, however, that the casing may be provided with pre-formed ports for the ejection of cement or other fluid, if desired.

In carrying out the method of my invention I utilize the apparatus about to be described, suspended on the end of a tubing string 14 which is lowered into the casing. A mandrel 15 having an exterior circumferential enlargement 16 forming an annular shoulder 17 is secured to the lower end of tubing 14 by a collar 18. Encircling the lower portion of mandrel 15 is a sleeve 19 having a bushing 20 threaded into the upper part thereof so as to turn on mandrel 15 and be supported by the shoulder 17. The sleeve 19 is of sufficient inside diameter to accommodate a laterally projecting lug 21 integral with the periphery of enlargement 16 of the mandrel 15. A depending lug 22 integral with the lower edge of bushing 20 limits rotary movement of tubing string 14 relative to sleeve 19 to approximately 180°.

The bore of sleeve 19 is restricted below the enlargement 16 of the mandrel as at 23 and is threaded to receive the upper end of a packer barrel 24. The barrel 24 fits closely around a pipe 25 having its upper end threaded into the bore of mandrel 15 so as to rotate therewith. A downwardly directed cup packer 26 of any conventional design and construction is secured on the

packer barrel 24 by suitable means so as to snugly engage the walls of casing 11. A member 27 threaded to the lower end of packer barrel 24 forms a continuation of the latter. The lower bore of the member 27 is enlarged to receive an annular valve 28 having an arcuate slot 29 therein parallel to its periphery and of a length less than 180° but sufficient to register with a series of spaced passages 30 extending upwardly through member 27 and packer barrel 24 and terminating in lateral ports 31 through the wall of the barrel. A series of lateral ports 32 through the wall of member 27 below valve 28 are thus communicated with passages 30 through the valve to provide a valve-controlled by-pass through the packer. A hollow neck 33 extending downwardly from the valve 28 forms a packing box 34 in which packing is compressed by a gland 35. A heavy packing box 36 encircling the lower end of pipe 25 is threaded into the member 27, for the compression of packing 37 therein by a gland 38. The bore of valve 28 is formed with a vertical slot or key way to receive a key 39 carried by pipe 25 when valve 28 is fitted against member 27 at the lower end of the passages 30. It will thus be seen that by rotation of tubing 14 in a clockwise direction from the position with the by-pass open, as shown in Figs. 2, 4 and 5, the pipe 25 may be rotated within packer barrel 24 and member 27. As the valve 28 is keyed to pipe 25 the valve will likewise be rotated to move its arcuate slot 29 out of registry with the passages 30 through the member and barrel, thus closing the by-pass.

A string of tubing 40 is suspended from the lower end of the packing box 36, the length of which tubing is preferably greater than the length of perforated pipe 12 below which the cement is to be placed. On the lower end of the tubing string 40 a tool of the character described and claimed in my Patent No. 2,248,169, dated July 8, 1941, is connected and comprises a reducing coupling 41 threaded to the lower end of tubing 40 for connection to a diametrically reduced tubing string 42. A collar 43 encircling the lower end of the tubing string 40 and the coupling 41 has threaded therein a bushing 44 which snugly but rotatably engages tubing 40 for the suspension of collar 43 and associated mechanism therebelow. A packer barrel 45 threaded into collar 43 and suspended therefrom is formed with a series of perforations 46 for a purpose later referred to. A downwardly directed conventional type cup casing packer 47 is mounted on barrel 45 by suitable means. Vertically arranged bowed spring members 48 having their ends secured to barrel 45 protrude laterally intermediate their ends into engagement with casing 11 to frictionally resist relative rotation between the packer barrel 45 and casing 11. A two part tubular valve housing 49 is secured to the lower end of the packer barrel 45 and embodies a pair of spaced annular diaphragms 50 closely encircling the tubing section. Each of the diaphragms 50 is formed with a port 51 controlled by a slotted annular valve 52 encircling the tubing section 42 between the diaphragms. A pair of keys 53 carried by tubing 42 engage in key ways formed in the bores of the respective valves 52. A helical spring 54 encircles tubing 42 between valves 52 to maintain the latter firmly against the diaphragms 50 with which they cooperate respectively.

A third packer barrel 55 is threaded into the lower end of the lower valve housing 49 for the support of an upwardly directed cup casing pack-

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er 56. A second set of bowed spring members 57 similar in construction, operation and function to spring members 48 are carried by barrel 55 below packer 56 for engagement with casing 11. The lower end of barrel 55 and tubing section 42 are closed by members 58 and 59, respectively. A series of ports 60 are formed in packer barrel 55 for admission of fluid during the lowering of the tool into the well and for draining the tool when it is removed.

In order to insure the desired operation of the valves 52 a pair of stops 61 are mounted on the upper surface of the bushing at diametrically opposite sides of the tubing string which are adapted to be engaged by a pin 62 extending laterally from the tubing so as to limit the relative movement of tubing 40 and packer barrels to approximately 180°. At the opposite ends of this relative movement the slots 63 of the valves 52 will be in registry and out of registry respectively with the ports 51 in diaphragms 50. The valve housing 49 is provided with a lateral port 65 through which fluid pumped through the port 64 may pass for ejection into the well bore through port 13 in the casing.

The operation of my invention as employed for cementing wells is briefly described as follows: After the holes 13 through which the cement is to be discharged are punched in the casing by the perforating tool the device of my invention is lowered into the well by the assembly of successive stands of tubing string 14 until the packers 47 and 56 are disposed above and below the section of casing in which the holes are formed. Prior to the lowering of the tool, valves 28 and 52 are opened in order that the tool may by-pass fluid in the casing through the packers while lowering the device. As the tool is lowered, the fluid enters the lower packer barrel 55 through ports 60 and passes through slots 63 and ports 51 in the valves 52 and diaphragms 50 respectively, to re-enter the annular area of the casing bore around the tool above the packers through ports 46. The fluid is by-passed through the packer 26 through slot 29 in valve 28 and the passages 30 in member 27 and packer barrel 24, respectively, as heretofore described. During the lowering operation, fluid in the well is also permitted access to the interior of the tubing 42, 40 and 41 through port 65 and port 64 in the portion of the tubing section 42 between the valves 52.

When it is determined that the tool is properly placed with the lower set of packers 47 and 56 confining the zone of casing 11 containing the ports or perforations 13 through which the fluid discharge is to be effected, cementitious fluid may be introduced into the tubing string at the well surface. It will be noted, however, that the fluid which enters tubing 14 during the lowering operation must be displaced while pumping the cement down to the point of subsequent ejection. Accordingly, the valves 28 and 52 may be permitted to remain open until the cement reaches the tool. This enables the fluid ejected from the ports 64 in advance of the cement to by-pass upwardly through packer barrel 45, casing 11 and packers 47 and 26 without entering the bore of the well around the casing, and thus avoids the possibility of "mudding off" an upper oil producing measure. It may be desirable, however, to clear the portion of the bore of the well in which the cement is to be placed, of debris, in which case the tubing string 14 may be rotated in a clockwise direction until the lug 21 contacts the depending lug 22 of

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bushing 20 and transmits the rotary motion of tubing 14 to the lower sections of tubing 40 and 42 so as to turn the valves 28 and 52 and shift the slots in said valves out of alignment with the ports controlled thereby. The tubing string 14 may then be turned back (counter clockwise) approximately 180° to re-open the upper by-pass through packer 26. Thereafter fluid ejected from the tubing string under pump pressure may be forced out of the casing through the perforations 13 and upwardly in the well bore to return into the casing through the upper screen 12 and thence to the well surface carrying the debris therewith. The operator may thus be assured that cement introduced into the casing will have access to the annular area of the hole around the casing.

In either event the fluid in the casing may be displaced from the path of the cement, the volume of which is carefully approximated as sufficient to fill the area of the hole from the point of discharge upwardly to a point below the upper screen 12. When it is determined that the fluent cement has reached the tool, the tubing string 14 is again turned in a clockwise direction approximately half a revolution to close the upper valve 28. Pressure is then applied to the fluid column introduced on top of the cement to force the cement out of the tubing and casing through port 64, port 65 and holes 13 into the hole against the pressure of the well. With the upper by-pass closed, none of the cementitious fluid will be permitted to rise into the upper productive measures or enter the casing through the upper screen 12. As a result, the cement under compulsion of sufficient pressure at the well head will be forced into the crevices and pores of the strata encircling the casing at the point of ejection of the fluid, and thus form a barrier to the flow of water entering the hole at that point into the lower oil producing sands.

Upon ejection of substantially all the cement from the tubing, of which the operator will be informed by the pumping into the casing of an equal volume of mud fluid at the well surface after the cement reaches the tool, a tight head is maintained on the well and the cement is allowed to partially set, i. e. for a length of time sufficient to insure coagulation of the cement to a degree that will not permit its return into the casing when pressure at the well head is relieved. Tubing string 14 is then rotated in a counter-clockwise direction to register the slots in valve 28 with the passages 30 and thereafter transmit motion to the lower tubing section 42 to similarly open the valves 52. The tool may then be raised from the well. The fluid pumped into tubing string 14 on top of the cement will accordingly drain out of the tubing string and associated parts so as to wash the tubing of cement tailings.

While my invention is particularly adapted for use in discharging cement into the annular area of the hole around the casing below a productive measure or particular producing oil sand, it will be appreciated that the tool is useful for placing cement behind the wall of a casing at any point in the well, and that if circulation is desired in the annular zone to be cemented in order to determine that an area of the bore is clear to receive the cement and to clean the bore of detritus which might otherwise prevent the formation of an effective seal, this may be accomplished through an upper ported section of casing. The spotting of any fluid such as acid or the like

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behind the casing may be done in a like or similar manner.

It will be observed that I have provided a device which is adapted to not only seal off a portion of the casing from which the ejection of fluid is to be effected but which is also adapted for the closing off of communication between the bore of the hole above the point of ejection of fluid with the well surface around the tubing string through which the fluid passes, whereby the hydrostatic pressure of fluid in the well will prevent the upward movement of the fluid discharged from the casing beyond a short distance above the point of ejection and insure thorough permeation of the crevices and pores of the strata by the fluid under high pressure.

While I have illustrated and described but one embodiment of my invention, it will be understood that numerous changes in size, design, number and proportion of the various parts may be made, and particularly that the structures forming the valve-controlled by-passes through the packers 26, 47 and 56 are interchangeable and only illustrative of many such apparatuses that may be adopted from the art, without departing from the spirit of my invention as defined by the appended claims.

What I claim and desire to secure by Letters Patent is:

1. In a device for ejecting fluids through a tubing string from the top of the well into a well bore, a casing string having a pair of vertically spaced ports therein, means to eject fluid by pump pressure through said tubing string and from the lowermost port in the casing, and means to control the ingress of fluid into the casing through the upper port.

2. In a device for ejecting fluids into a well bore, a casing string having a pair of vertically spaced lateral ports therein, a tubing string in the casing, a pair of packers carried by said tubing string closing the annular area of the casing around the tubing above and below the lower port, an upper packer closing the area of the casing around the tubing above the upper port, and means to by-pass fluid in the casing through said last-named packer.

3. In a device for ejecting fluids through a tubing string into a well bore, a casing string having a pair of vertically spaced lateral ports therein, a tubing string in and extending from upper end of said casing string, a pair of packers carried by said tubing string closing the annular area of the casing around the tubing above and below the lower port, an upper packer closing the area of the casing around the tubing above the upper port, means forming a by-pass through said last-named packer, and means to control fluid movement through said by-pass.

4. In a method for the ejection of fluids into a casing-lined well bore, pumping fluid through a tubular member to a point in the casing adjacent the point at which the fluid is to be ejected, communicating the area of the well bore with the well surface through a port in the casing above the point of ejection, and ejecting a quantity of fluid from the casing while maintaining communication with the well surface through said upper port.

5. In a method for the ejection of fluids into a casing-lined well bore, pumping fluid through a tubular member to a point in the casing adjacent the point at which the fluid is to be ejected, communicating the area of the well bore with the well surface through a port in the casing

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above the point of ejection, ejecting a quantity of fluid from the casing while maintaining communication with the well surface through said upper port, closing said communication to the well surface through the upper port, and ejecting fluid into the well bore from the member and casing against the pressure of the well.

6. In an apparatus for placing a fluent mixture at a selected point through a port in the casing of a previously cemented casing-lined well, a tubing string having a discharge port therein adapted to be placed within the well casing adjacent said port in said casing, means to seal a zone of the annular area of the casing around said tubing in which said discharge port is located so as to direct fluid ejected under pressure from said discharge port into the well bore around the casing through said port therein, and means to prevent fluid from rising in the annular bore above predetermined limits around the casing in response to said ejection of fluid.

7. In an apparatus for placing a fluent mixture at a selected point through a port in the casing of a previously cemented casing-lined well, a tubing string having a discharge port therein adapted to be placed within said well casing adjacent said port in said casing, means to eject fluid through said tubing string through said discharge port, and means to prevent fluid in the well around the casing from entering the upper port in the casing.

8. In a method of placing a fluent mixture at a selected point through the casing of a previously cemented casing-lined well bore, the steps of: (1) perforating the casing at the selected point; (2) packing off an area in said casing extending above and below said perforation; (3) pumping the fluent mixture through tubing to a point adjacent said perforation and within said packed-off area; and (4) coincidentally with said pumping, by-passing fluid displaced from said packed-off area of the casing through the casing to the top of the well.

9. In a method of shutting off water in an area of a casing-lined cemented oil well below an oil producing stratum, the steps of: (1) perforating the casing at a selected point below said stratum; (2) packing off an area in said casing extending above and below said perforation; (3) pumping a fluent cement mixture through tubing and adjacent said perforation; (4) coincidentally with said pumping, by-passing fluid displaced from said area through casing thereabove to the top of the well; (5) shutting off circulation through casing to the top of the well; (6) forcing said fluent cement mixture through said perforation into the bore of the well; and (7) permitting the cementitious mixture to set.

10. In a method of shutting off water in an area of a casing-lined previously cemented oil well between the well screens of two spaced apart oil bearing strata, the steps of: (1) perforating the casing at a selected point in said area; (2) packing off an area in said casing extending from the lower to a point above the upper of said strata; (3) pumping a fluent mixture through tubing to a point adjacent said perforation in said casing; (4) coincidentally with said pumping by-passing fluid from said area through casing thereabove to the top of the well; (5) shutting off circulation through casing to the top of the well; (6) forcing said fluent cement mixture through said perforation into the bore of the

well; and (7) permitting the cementitious mixture to set.

11. In a method of shutting off water in an area of the casing-lined previously cemented oil well between the well screens of two spaced apart oil bearing strata, the steps of: (1) perforating the casing at a selected point between said well screens; (2) packing off an area within the casing between said well screens and extending above and below said perforation; (3) packing off an additional area within said casing above and adjoining said first packed off area, said last-mentioned area including that occupied by the upper of said well screens; (4) pumping a fluent cement mixture through tubing within said casing adjacent said perforation; (5) coincidentally with said pumping, by-passing fluid displaced from the area of said perforation through casing thereabove to the top of the well; (6) shutting off circulation to the top of the well; and (7) forcing fluent cement mixture through said perforation against pressure in the bore of the well.

12. In a method of shutting off water in an

area of a casing-lined previously cemented oil well between the well screens of two spaced apart oil bearing strata, the steps of: (1) perforating the casing at a selected point between said well screens; (2) packing off an area within the casing between said well screens and extending above and below said perforation; (3) packing off an additional area within said casing above and adjoining said first packed off area, said last-mentioned area including that occupied by the upper of said well screens; (4) establishing circulation from the area between said well screens through casing to the top of the well; (5) pumping a fluent cement mixture through tubing within said casing and adjacent said perforations; (6) coincidentally with said pumping, by-passing fluid displaced from the area of said perforation through casing thereabove to the top of the well; (7) shutting off circulation to the top of the well; and (8) forcing fluent cement mixture through said perforation against pressure in the bore of the well.

PAUL H. GRANGER.