June 3, 1952 J. D. HAYNES 2,599,386

WELL TREATMENT APPARATUS

Filed July 15, 1946 4 Sheets-Sheet 1

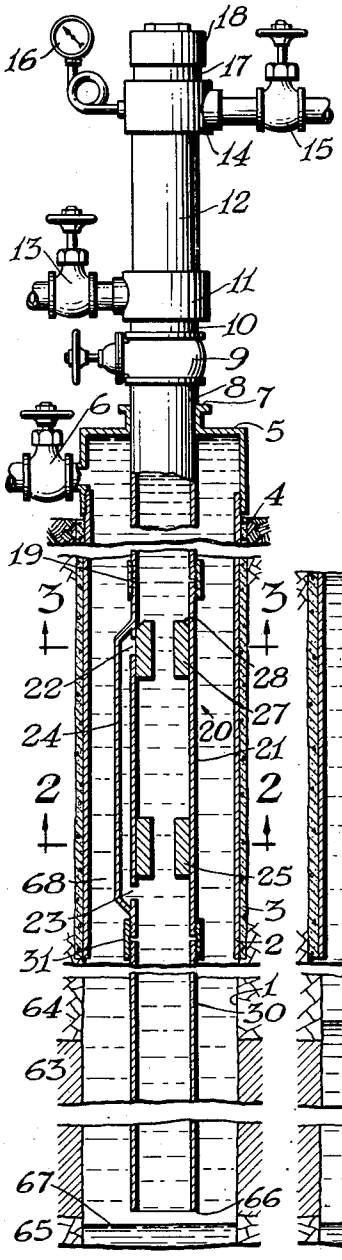

Fig. 1

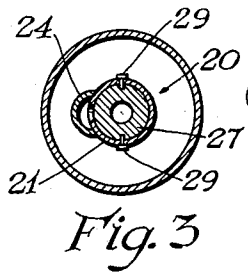

Fig. 3

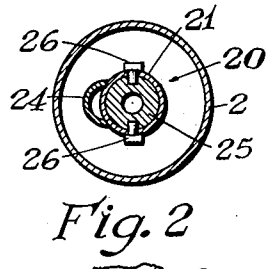

Fig. 2

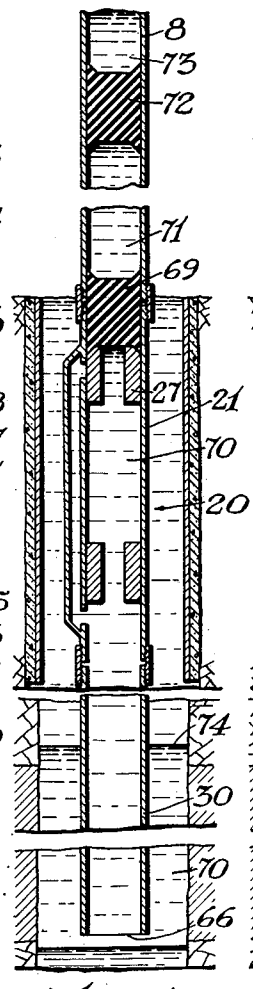

Fig. 4

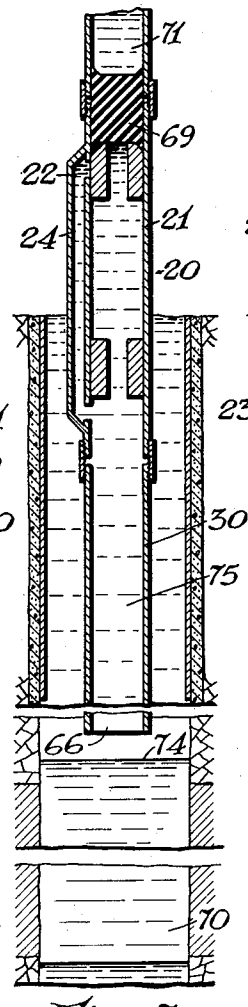

Fig. 5

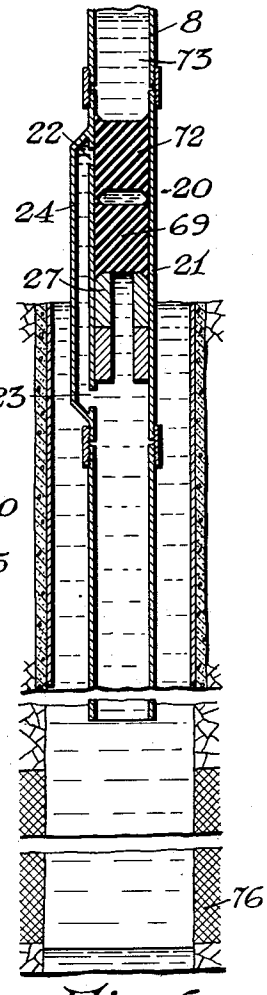

Fig. 6

INVENTOR.
James D. Haynes

BY

Griswold & Burdick
ATTORNEYS

June 3, 1952 J. D. HAYNES 2,599,386

WELL TREATMENT APPARATUS

Filed July 15, 1946 4 Sheets-Sheet 2

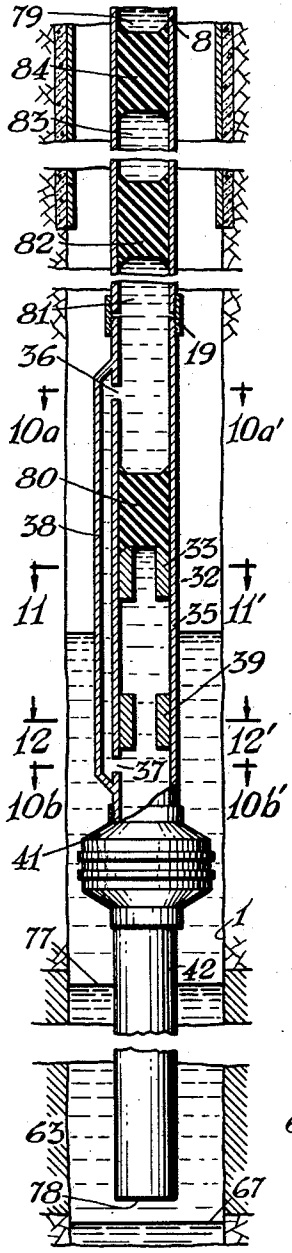

Fig. 7

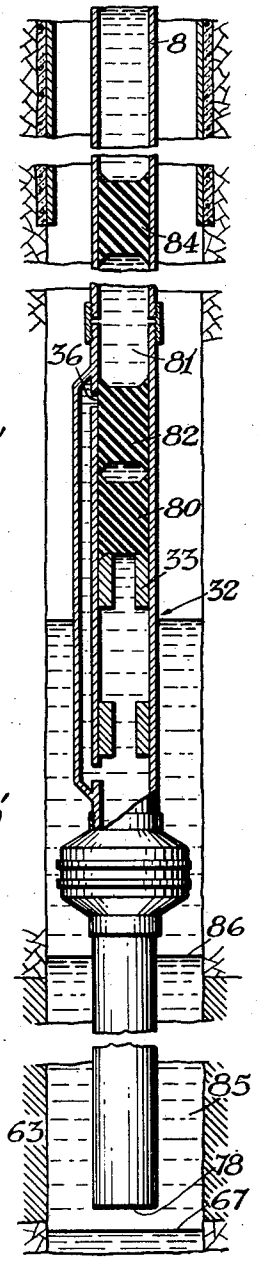

Fig. 8

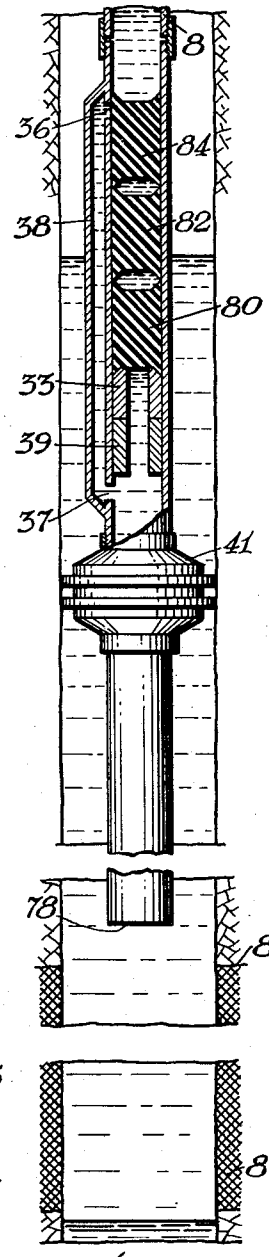

Fig. 9

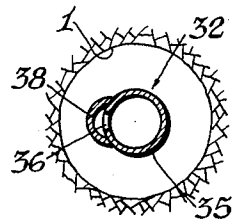

Fig. 10

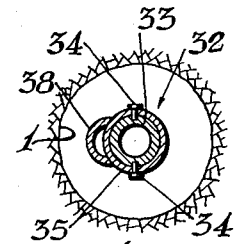

Fig. 11

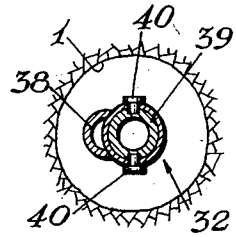

Fig. 12

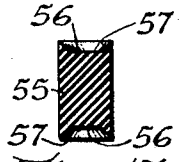

Fig. 17

INVENTOR.
James D. Haynes
BY
Griswold & Burdick
ATTORNEYS

June 3, 1952 J. D. HAYNES 2,599,386

WELL TREATMENT APPARATUS

Filed July 15, 1946 4 Sheets-Sheet 3

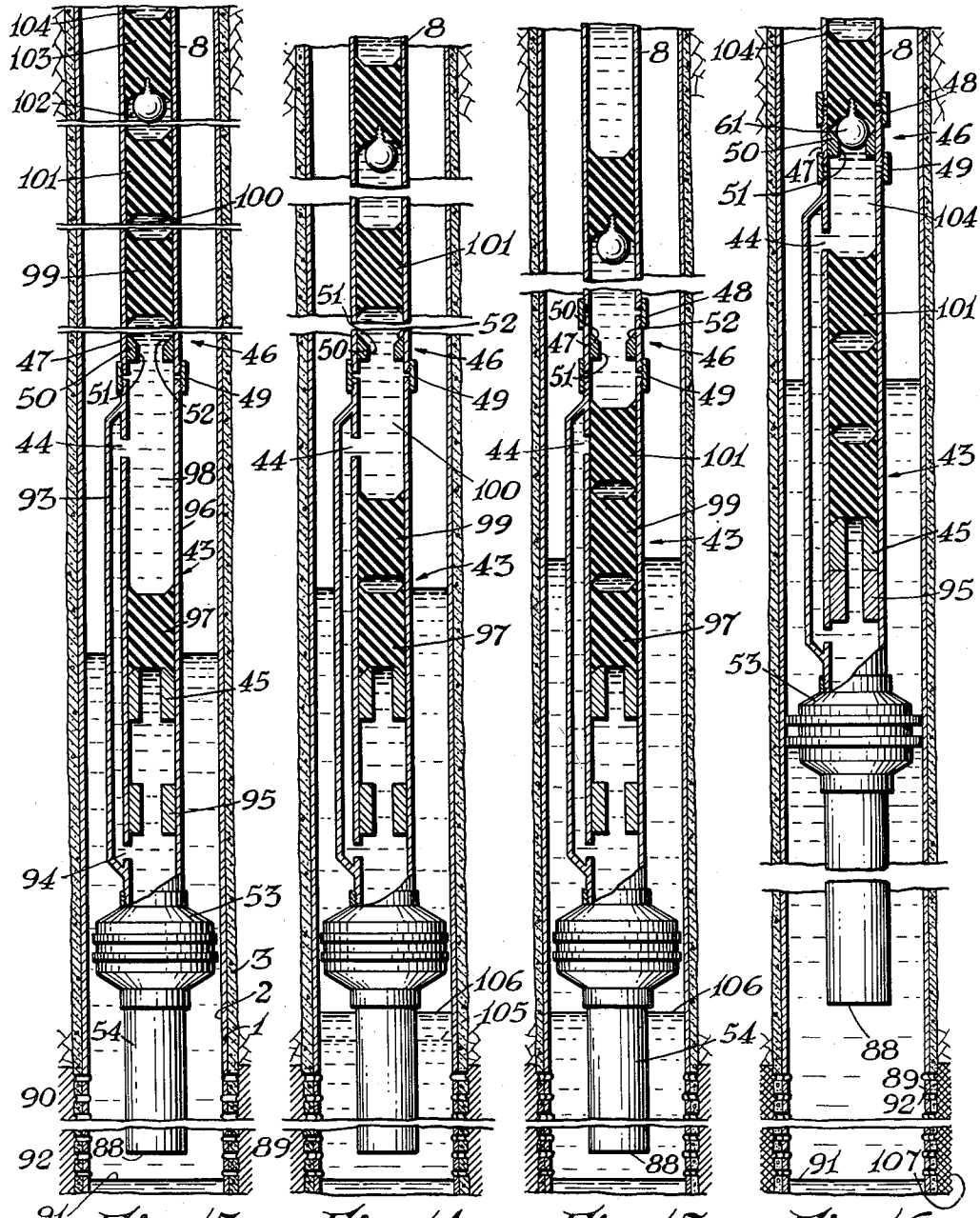

Fig. 13 Fig. 14 Fig. 15 Fig. 16

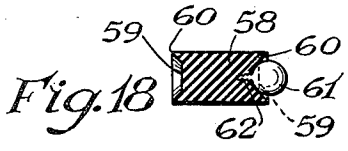

Fig. 18

INVENTOR.
James D. Haynes
BY
Griswold & Burdick
ATTORNEYS

June 3, 1952 J. D. HAYNES 2,599,386

WELL TREATMENT APPARATUS

Filed July 15, 1946 4 Sheets-Sheet 4

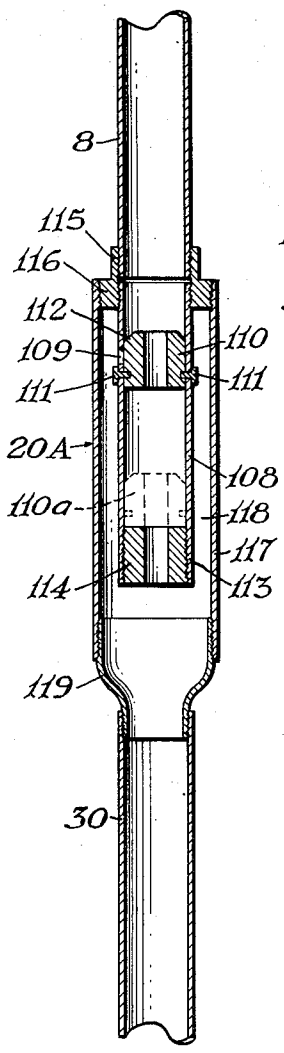

Fig. 19

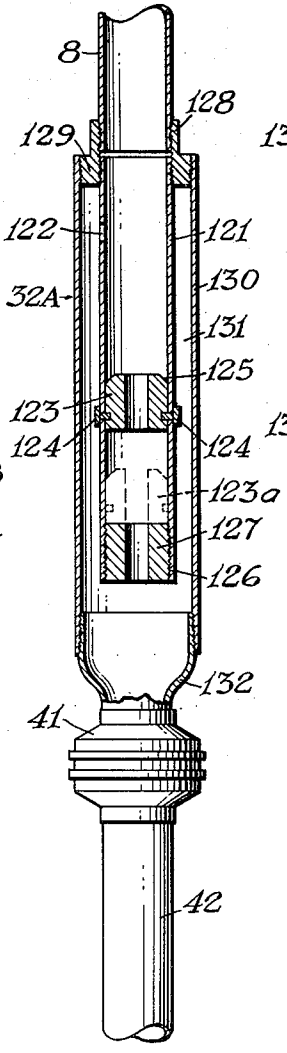

Fig. 20

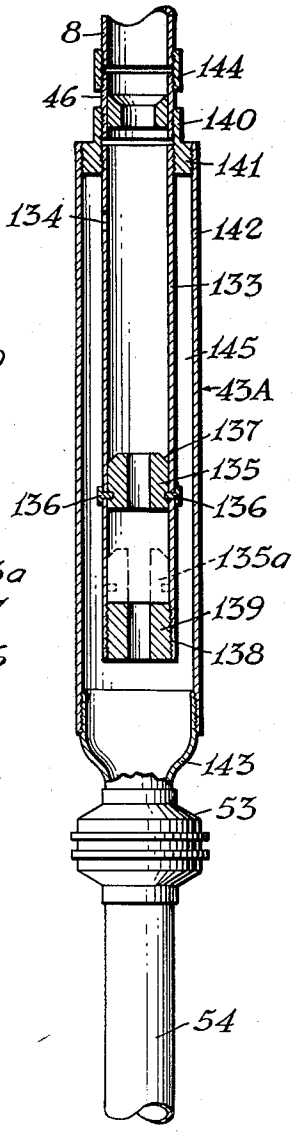

Fig. 21

INVENTOR.
James O. Haynes
BY
Griswold & Burdick
ATTORNEYS

Patented June 3, 1952 2,599,386

UNITED STATES PATENT OFFICE

2,599,386

WELL TREATMENT APPARATUS

James D. Haynes, Kilgore, Tex., assignor to The Dow Chemical Company, Midland, Mich., a corporation of Delaware

Application July 15, 1946, Serial No. 683,628

17 Claims. (Cl. 166—1)

1

The invention relates to means for treating wells with a fluid agent. It more particularly concerns means for delivering a liquid or fluid material to a selected elevation or zone in a deep well through a tubing string.

In the construction and operation of deep wells, it is oftentimes desirable or necessary to deliver a charge of fluid material of one kind or another to a specific elevation in a well bore and to displace it therefrom into the adjacent formation, as for example, when the producing formation is to be treated with an acid solution or when a water-bearing formation adjacent to an oil-bearing formation is to be sealed with a cementing fluid. The operation of injecting a liquid or fluid into a formation at a specific elevation in a well bore is generally referred to as spotting. Spotting of liquid or fluid materials is usually attempted through the tubing and the liquid or fluid involved may be delivered from the tubing into either the uncased or cased well bore, in the latter case usually opposite perforations in the casing, and displaced from the well through the perforated casing or uncased well wall into the adjacent formation with a displacing liquid.

Several disadvantages inure to such practice among which are that there is no satisfactory way of determining just when the fluid material begins to emerge from the tubing and when the delivery is complete. Without this knowledge, accurate control of the level or elevation in the well of the delivered liquid is difficult, if not impossible, to achieve. A part of the difficulty arises from the nature of the tubing in that its volume is not precisely predictable under the conditions of use due to variations in its distention under pressure, variations in the amount of space at the tubing collars or joints, and various dimensional inaccuracies in the tubing itself. In addition, the volume of fluid retained, if any, in the tubing is not predictable. Similar difficulties arise on attempting to displace the delivered fluid from the well hole either into space behind the casing, if one be present, or into the adjacent formation by means of a displacing liquid, because no method is available for ensuring the delivery of the proper volume of displacing fluid at the right elevation. Another factor militating against accurate spotting is occasioned by the mixing which inevitably occurs at the interface between the fluid to be spotted and any liquid which proceeds or follows it through the tubing for displacing purposes. When the volume of fluid to be delivered is relatively small, many of these difficulties are accentuated. For example, in the application of resin-forming liquids to sealing, plugging, and other operations in well bores, as described in U. S. Patent No. 2,274,297, cases arise in which it is highly desirable to deliver a small but precisely known amount of resin-forming liquid at a specific elevation in a well bore, as in sealing a zone of water infiltration adjacent to an oil zone without sealing the latter and forming a seal behind the casing through perforations as in cement squeezing operations. In carrying out such operations, the success of the work is largely determined by the accuracy with which a precisely known volume of cementing fluid can be spotted in the well.

2

The principal object of the invention is to provide an improved means for spotting a fluid in a well and accurately displacing it into adjacent areas. A particular object is to provide an improved means for accurately spotting a relatively small volume of a resin-forming liquid which functions as a binding or cementing agent in a well and signalling the completion of the spotting and displacement into an adjacent area. Other objects and advantages will appear from the following description taken in conjunction with the accompanying drawing in which:

Fig. 1 is a side elevation largely in section of a well equipped with spotting apparatus constructed in accordance with the principles of the invention for use with two tubing plugs, the apparatus including a tubing string and a plug catcher for catching the tubing plugs and signalling completion of delivery and displacement of fluid.

Fig. 2 is a cross section on the line 2—2 of Fig. 1.

Fig. 3 is a cross section on the line 3'—3' of Fig. 1.

Fig. 4 is a side elevation largely in section of a lower portion of Fig. 1 showing the position of the tubing plugs in the first stage of the spotting operation.

Fig. 5 is a similar view to Fig. 4 showing the position in the well of the apparatus in the next stage of the operation.

Fig. 6 is a similar view to Fig. 5 showing the position of the apparatus and plugs in the final stage of the operation.

Fig. 7 is a side elevation largely in section of a lower portion of the well of Fig. 1 showing apparatus modified for use with three tubing plugs which are in a position of the first stage of the spotting operation.

Fig. 8 is a similar view to Fig. 7 showing the position of the plugs and apparatus in a later stage of the operation.

Fig. 9 is a similar view to Fig. 8 showing the position of the plugs and apparatus in a still later stage of the operation.

Fig. 10 is the cross section taken on line 10*a*—10*a*' and also the line 10*b*—10*b*' of Fig. 7.

Fig. 11 is the cross section on the line 11—11' of Fig. 7.

Fig. 12 is the cross section on the line 12—12' of Fig. 7.

Fig. 13 is a side elevation of a cased portion of the well of Fig. 1 and shows the apparatus of Fig. 7 modified for use with four tubing plugs, the position of the plugs and apparatus being in a first stage of the operation of spotting a fluid adjacent to a perforated portion of the casing.

Fig. 14 is a similar view to Fig. 13 and shows the position of the plugs and apparatus in the next stage of the operation.

Fig. 15 is a similar view to Fig. 14 and shows the position of the plugs and apparatus in the next stage of the operation.

Fig. 16 is a similar view to Fig. 15 and shows the position of the plugs and apparatus in the last stage of the operation.

Fig. 17 is a side elevation in cross section of a resilient compressible tubing plug suitable for use with the apparatus.

Fig. 18 is a side elevation in cross section of a form of tubing plug suitable for use with the apparatus of Figs. 13–16, inclusive.

Fig. 19 is a side elevation in section showing an alternate form of the plug catcher of Figs. 1–6, inclusive.

Fig. 20 is a side elevation in section showing an alternate form of the plug catcher of Figs. 7–12, inclusive.

Fig. 21 is a side elevation in section showing an alternate form of the plug catcher of Figs. 13–16, inclusive.

In the several figures, like numerals refer to like parts.

Referring to the drawings in detail, a well is shown having a bore 1, the upper portion of which is provided with a casing 2 cemented in place with cement 3. The casing extends above the ground level 4 and is provided with a casing head 5 having a valved connection 6 leading to the interior of the casing and a packing gland 7 through which the tubing string 8 extends into the well. The upper end of the tubing string carries the gate valve 9 having an unobstructed bore therethrough when the valve is open. The gate valve is connected by a nipple 10 and T 11 to a lock chamber 12. Valve 13 on T 11 provides a connection to the interior of the tubing string below the lock chamber. The upper end of the lock chamber carries a cross 14 having a valved connection 15 and pressure gauge 16 for showing the pressure applied through the lock chamber. The upper side of the cross carries a short nipple 17 which is closed by a removable cap 18.

In Figs. 1, 4, 5, and 6, there is shown attached to the lower end of the tubing string 8, by a collar 19, a two plug catcher designated generally by numeral 20. This comprises a cylinder 21 having a bore of the same diameter as that of the tubing with a lateral port 22 in the wall near the upper end and another similar port 23 near the lower end. Ports 22 and 23 are connected by a by-pass 24 comprising a half section of pipe welded onto the external side of the cylinder 21 to form a fluid passage from port 22 to port 23 outside the cylinder 21. Near the lower end of the cylinder, just above port 23, is a lower stop member 25 having an axial bore. It is held in place by heavy pins 26 (Fig. 2). An axially bored movable tubing plug stop 27 having an externally beveled upper edge 28 is located opposite port 22 and secured to the inside of cylinder 21 by shear pins 29 (Fig. 3). It also serves as a sleeve valve closing port 22, when in the position shown in Figs. 1, 4, and 5, while permitting fluid to pass through its axial bore longitudinally. Shear pins 29 may be designed to give way when the downward pressure tending to move plug stop 27 exceeds about 1000 pounds, although other strengths of shearable pins may be used. A tail pipe 30 is secured to the lower end of the plug catcher 20 by a collar 31. Stop 25 is longitudinally spaced in the cylinder so that the upper end of the stop 25 is about 1.5 tubing plug lengths from the lower end of stop 27 (before the pins are sheared).

A modification of the plug catcher 20 is shown in Figs. 7 to 12 inclusive, and designated generally by numeral 32. It is intended for use with three tubing plugs. Its construction is similar to the plug catcher of Figs. 1 to 6 except that the axially bored movable tubing plug stop 33, which is held in place by shear pins 34 (Fig. 11), is mounted in the cylinder 35 below the upper port 36, a distance equal to about 1.5 tubing plug lengths. The shear pins may be designed similarly to those used in the apparatus of Fig. 1. The upper port 36 is connected to the lower port 37 by a by-pass 38 of similar construction to that of plug catcher 20. A lower axially bored stop member 39 is provided in the cylinder 35 and is secured in place with heavy pins 40 which will not shear under several thousand pounds of load. The distance between the lower end of the tubing plug stop and the upper end of the lower stop (before the pins are sheared) is about 1 tubing plug length. The plug catcher 32 is attached to the tubing string 8 by a collar 19. The upper portion of the well and apparatus is the same as that of Fig. 1.

Below the plug catcher 32 is a packer 41 (shown unset in Figs. 7 and 8 and set in Fig. 9) for sealing the annular space in the well at the top of the tail pipe 42 while permitting the passage of fluid from the plug catcher through the packer to the tail pipe 42 attached to the bottom of the packer.

Another modification of the plug catcher designated generally by numeral 43, and arranged for use with four tubing plugs in a cased portion of the well is shown in Figs. 13 to 16, inclusive. Plug catchers 32 and 43 are identical in construction except that the distance between the upper port 44 and tubing plug stop 45 in plug catcher 43 is about 2.5 tubing plug lengths. As with plug catcher 32, a plug catcher 43 is provided with a by-pass 93, a lower port 94, and a lower stop 95, and the lower end of the tubing plug stop 45 is about 1 tubing plug length above the upper end of the lower stop 95.

Interposed between the tubing string 8 and the plug catcher 43 is a bore constricting and ball seating element designated generally by numeral 46 (best shown in Figs. 15, 16, and 21). It comprises a short length of tubing 47 connected to the tubing string 8 by a collar 48 and to the plug catcher 43 by a collar 49. Secured within the tubing 47 is a bore constricting element 50 in the form of an annular ring having an axial bore 51 and inwardly beveled upper edge 52. The bore 51 is made about 10 to 40 per cent less in diame-

ter than that of the tubing string so that resilient compressible tubing plugs adapted for use with the apparatus may be pumped through it when a sufficient differential pressure (i. e. 500–1500 pounds per square inch or more) is applied.

Attached to the lower end of the plug catcher 43 is a packer 53 (shown unset in Figs. 13, 14, and 15 and set in Fig. 16) for sealing the annular space in the casing 2. The packer is provided with a through passage for fluid from the plug catcher 43 to the tail pipe 54 attached to the bottom of the packer.

The form of tubing plug shown in Fig. 17 is suitable for use with all the forms of the apparatus, although other similar plugs may be used. It comprises a cylindrical body 55 having a length preferably about 2 to 4 times its diameter. The ends 56 are recessed to form the lips 57 which produces a squeegee or wiping action as the plug moves along the bore of the tubing in which it is used. The body is preferably made entirely of a resilient compressible material, such as either natural or synthetic rubber, so as to enable it to contract in diameter and pass through the bore 51 of the bore constricting element 50 under pressure. Neoprene is a satisfactory plug material. The diameter of the plug should be slightly larger than the bore of the tubing string so as to make a sliding sealing fit with the bore wall while being driven by fluid pressure through the bore of the tubing.

The tubing plug of Fig. 18 is for use particularly with the apparatus of Figs. 13–16 and its alternate form, Fig. 21. Its cylindrical body portion 58, recessed ends 59, and lips 60 are similar to the corresponding parts of the tubing plug of Fig. 17 and is made of similar material. To one end of the plug is secured the closure ball 61 by screw means 62, the ball being adapted to seat upon the upper beveled edge 52 of the annular ring 50 to form a closure for bore 51.

The two plug catcher shown in Fig. 19, designated generally by 20A, is an alternate form of the two plug catcher 20 and assembled in the same way with the tubing string 8 and tail pipe 30 as the two plug catcher 20. The two plug catcher 20A comprises the cylinder 108 having a lateral port 109 near the upper end, the bore of the cylinder being the same as that of the tubing string. The lateral port 109 is closed by the movable tubing plug stop 110 when in the position shown and also functions as a sleeve valve. The tubing plug stop is held in place by shear pins 111 which may be designed to give way under a downward thrust of about 1000 pounds, although other strengths of pins may be used which are capable of being sheared. The upper edge of the tubing plug stop is provided with an external bevel 112 for engaging the end lip of a tubing plug (e. g. Fig. 17). The lower end of the cylinder 108 is provided with an internal thread 113 into which the externally threaded axially bored stop means 114 is screwed. The length of the cylinder 108 is such that the distance between the bottom of the tubing plug stop 110 and the top of the stop means 114 is about 1.5 tubing plug lengths (before the pins are sheared).

The upper end of the cylinder 108 is externally threaded and the thread engages the internal thread of the collar 115. Collar 115 is provided with an externally threaded boss 116, the thread of which engages the internal thread on the upper end of the outer tube or cylinder 117, thereby closing the annular space 118 between the two cylinders at their upper ends. The outer cylinder 117 has sufficient length to extend downwardly below the lower end of the cylinder 108. The lower end of tube 117 is internally threaded to receive the reducing coupling 119 by means of which the tail pipe 30 is secured to the plug catcher assembly 20A. The plug catcher assembly 20A is secured to the lower end of the tubing string 8 in place of plug catcher 20 by the collar 115.

The plug catcher shown in Fig. 20, designated generally by numeral 32A, is an alternate form of the plug catcher 32 and assembled with the tubing string 8, packer 41, and tail pipe 42 in the same manner as the plug catcher 32. The plug catcher of Fig. 20 comprises the cylinder 121 having a lateral port 122 near the upper end, the bore of the cylinder being the same as that of the tubing string. Below the lateral port, a tubing plug stop 123 held in place by shear pins 124 designed to give way when the downward pressure on the plug stop reaches about 1000 pounds, although other strengths of shear pins may be used. The upper edge of the plug stop 123 is provided with an external bevel 125 adapted to engage the end lip of a tubing plug.

The distance between the upper end of the plug stop 123 and the lateral port 122 (before the pins are sheared) is about 1.5 tubing plug lengths. The lower end of the cylinder 121 is provided with an internal thread 126 into which is screwed the externally threaded stop means 127, the distance between the upper end of the stop means 127 and the lower end of the tubing plug stop 123 being about 1 tubing plug length. The upper end of the cylinder 121 is externally threaded and the thread engages the internal thread of the collar 128. Collar 128 is provided with an externally threaded boss 129, the external thread of which engages the internal thread on the upper end of the outer tube 130. The boss 129 thus closes the annular space 131 at the top of the inner and outer tubes. The outer tube 130 has sufficient length to extend downwardly below the lower end of the cylinder 121. The lower end of the tube 130 is internally threaded to receive the reducing coupling 132 by means of which the packer 41 is secured to the plug catcher assembly 32A together with the tail pipe 42 to which there is a continuous passage for fluid from the plug catcher through the packer. The plug catcher assembly 32A is secured to the lower end of the tubing string 8 in place of plug catcher 32 by collar 128.

The alternate form of plug catcher shown in Fig. 21, designated generally by numeral 43A, is assembled with the tubing string 8, packer 53 and tail pipe 54 in the same manner as the plug catcher 43. This alternate form of plug catcher is similar to that of Fig. 20 differing only in the lengths of its tubular elements. As shown, plug catcher 43A comprises the inner cylinder 133 having a lateral port 134 near the upper end, the bore of the cylinder being the same as that of the tubing string. Below the lateral port 134 is a tubing plug stop 135 held in place by shear pins 136 designed similarly to those of the other figures. The upper edge of the plug stop is provided with an external bevel 137 adapted to engage the end lip of a tubing plug.

The distance between the upper end of the plug stop 135 (before the pins 136 are sheared) and the lateral port 134 is about 2.5 tubing plug lengths. The lower end of the cylinder 133 is provided with an internal thread 138 into which is screwed the externally threaded stop means 139,

the distance between the upper end of the stop means 139 and the lower end of the tubing plug stop 136 (before the pins 136 are sheared) being about 1 tubing plug length. The upper end of the cylinder 133 is externally threaded and the thread engages the internal thread of the collar 140. The collar 140 is provided with an externally threaded boss 141, the thread of which engages the internal thread on the upper end of the outer tube 142 which has sufficient length to extend below the lower end of the cylinder 133. The lower end of the tube 142 is externally threaded to receive the reducing coupling 143 by means of which the packer 53 is secured to the plug catcher assembly 43A, together with the tail pipe 54 to which there is a continuous passage for fluid from the plug catcher through the packer. The bore constricting and ball seating element 46 is attached to the upper end of the plug catcher assembly 43A by collar 140 and 46 is secured to the lower end of the tubing string 8 by the collar 144.

In carrying out a spotting operation of a liquid or fluid material, any one of the various embodiments of the apparatus described may be used, the choice depending upon the specific needs of the case. The following is cited as illustrative of a preferred mode of operation in spotting a liquid in a formation adjacent to an uncased portion of a well hole using the apparatus illustrated in Figs. 1 to 6, wherein the formation 63, between formations 64 and 65, is to be treated with a fluid sealing agent. The alternate form of apparatus which is shown in Fig. 19 may be used in similar manner and such use is indicated in what follows. In carrying out this operation, the tubing string 8 is assembled, together with the plug catcher 20 (or 20A if used) and tail pipe 30, and lowered into the well until the lower end 66 of the tail pipe is adjacent to the bottom of the stratum 63. The tail pipe is preferably made several feet longer than the thickness of the formation or section thereof to be treated. In some instances, the tail pipe may be made of a plastic or synthetic resin, so that the pipe can be parted by a strong pull in the event it becomes cemented in the well hole, the tubing string assembly with the plug catcher being pulled away leaving the parted portion of the tail pipe in the well hole. The uncased portion of the well hole 1 below the formation 63 may be filled with a blanket or otherwise temporarily plugged back, as with drilling mud or other fluid material that does not readily drain away into the formation, or with sand, to a level 67 near the lower level of formation 63.

Thereafter, the well may be filled with a liquid, such as water or oil, which does not interfere with the action of the fluid to be spotted, so as to render the well hydrostatically controllable. Some wells cannot be filled to the top without drainage into thief sands and in such cases filling need be carried out only to a level that can be attained without undue drainage. As illustrated in Fig. 1, the well is shown filled to the top of the casing with a filling liquid 68, although the spotting operation can be accomplished in similar manner without filling the well completely. In placing filling liquid in the well, the filling liquid may be introduced into the tubing through valve 15 while valve 13 is closed and valves 9 and 6 are open, the introduction of filling liquid being continued until the filling liquid attains its natural level or begins to escape from the casing through valve 6.

The sealing fluid to be spotted is then introduced into the tubing string immediately following the filling liquid, in similar manner thereto, in an amount calculated to fill at least the well bore between strata 64 and 65, the plug catcher 20 (or 20A if used), and tail pipe 30. Valves 9 and 15 are then closed, valve 13 opened, cap 18 removed, and a resilient compressible tubing plug, such as shown in Fig. 17, inserted in the lock chamber 12. The cap is then replaced, valve 13 closed, and valve 9 opened.

A displacing fluid, such as oil or water, is introduced through valve 15 into the tubing behind the first plug in amount preferably just equal to the volume of the sealing fluid, whereupon valves 9 and 15 are closed, valve 13 opened, cap 18 removed, and another similar tubing plug inserted in the lock chamber. Cap 18 is replaced, valve 13 closed, valve 9 opened, and a driving liquid, such as water or oil, is introduced into the tubing through valve 15 so as to drive the sealing fluid, plugs, and displacing liquid down the tubing. The introduction of driving fluid is continued until an abrupt rise in pressure is obtained on the gauge 16, indicating that the first tubing plug 69 has passed the lower end of the tubing string and landed on the upper plug stop 27 in the plug catcher 20 (or on plug stop 113 if 20A is used). Referring to Fig. 4, illustrating this stage of the operation, there is shown the first tubing plug 69 landed on the movable plug stop 27, the sealing fluid 70, the displacing fluid 71, the second tubing plug 72, and the driving fluid 73 in their respective positions.

In this stage, the sealing fluid passes through the cylinder 21 (or 108 if 20A is used) and tail pipe 30 and the well hole where it reaches a level 74 above formation 65 and displaces filling liquid upwardly in the well, and, if filled, the excess of filling liquid escapes from valve 6 at the casing head. After the sealing fluid has passed the lower end of the tubing string, the valve 6 may be closed and the assembly of the tubing string 8, plug catcher 20 (or 20A if used), and tail pipe 30 raised in the well so that the lower end 66 of the tail pipe 30 is well above the level 74 of the sealing fluid. When the tubing assembly is raised as in Fig. 5, filling liquid enters the space 75 in the tail pipe as the sealing fluid therein drains and rises in the well hole.

The sealing fluid is then displaced from the well hole into the adjacent formation. This is accomplished by increasing sufficiently the pressure produced by the pump (not shown) supplying the driving fluid to valve 15 to force the shear pins 29 of the plug stop 27 to give way (or shear pins 111 of plug stop 110 if 20A is used), thereby allowing plug 69 and stop 27 to move downwardly in the plug catcher cylinder 21 (or in cylinder 108 if 20A is used). As plug 69 moves downwardly with plug stop 27 (or 110 if 20A is used), port 22 (or 109 is 20A is used) is thereby uncovered allowing the displacing fluid 71 to flow through the by-pass 24 and port 23 (or through the annular space 118 if 20A is used) into the tail pipe 30 and thence into the well hole. As the displacement proceeds, plug 72 moves downwardly in the tubing string 8 until all the displacement fluid has passed from the tubing string into the tail pipe and well hole and the travel of the plug is arrested by landing upon plug 69, as shown in Fig. 6, thereby closing port 22 (or in like manner closing port 109 if 20A is used) and abruptly increasing the pressure on the gauge 16 as a result of the sudden stoppage of fluid flow. The action of the displacement

fluid is to force the sealing fluid into the wall of the well hole. The well may be left closed in at this stage for a time sufficient to permit the sealing fluid to harden, thereby forming a treated sheath 76 of the wall of the well hole.

After the sealing fluid has hardened, the apparatus may be withdrawn from the well and the filling liquid and the temporary plug back material removed in any convenient manner.

The modification of the apparatus of Figs. 7–12, inclusive, (or its alternate form 32A, Fig. 20), provides a means to obtain a pressure signal when the tail pipe and passage through the packer have been cleared of fluid by the displacing liquid so that when a packer is used, in confining a cementing fluid below it, retrieving the packer is possible after the operation.

In operating the modification of the apparatus of Figs. 7–12 (or its alternate form 32A as shown in Fig. 20), the assembly of the tubing string 8, plug catcher 32 (or 32A if the alternate form is used), packer 41 and tail pipe 42 is lowered into the well until the lower end 78 of the tail pipe is adjacent to the bottom of the formation 63 to be treated. Similar considerations to those already mentioned in connection with tail pipe 30 apply to the choice of material for tail pipe 42 and its length. The liquid to be spotted is then introduced into the tubing string 8, the amount employed being determined by the formation 63 to be treated. Usually, an amount sufficient to fill the well hole from the top of the temporary fill 67 to near the top of the formation to be treated is sufficient.

A tubing plug of the type shown in Fig. 17 is then introduced into the tubing string in the manner already described followed by a volume of displacing fluid equal to the combined volume of by-pass 38 (or the annular space 131 if 32A is used), passage through the packer 41, and tail pipe 42. A second similar tubing plug is then introduced into the tubing followed by a volume of displacing fluid about equal to that of the fluid to be spotted. This is followed by a third tubing plug and a driving fluid. The introduction of driving fluid is continued and serves as the means to drive the fluid to be spotted from the tubing string into the well while the plugs produce pressure signals indicating when the various fluids have passed the end of the tubing string and reached or passed the plug catcher.

As the driving fluid is introduced into the tubing string, the plugs and fluids therein descend, the first plug 80 being thereby driven into the plug catcher where it is arrested by stop 33 (or 123 if 32A is used). At this stage, shown in Fig. 7, all the fluid to be spotted is displaced from the tubing string through port 36, by-pass 38, port 37 (or through the corresponding ports of 32A if used, viz. port 122, and annular space 131), the passage through packer 41, and thence through the tail pipe 42 into the well hole 1 where it reaches a level 77 near the top of the formation 63 to be treated; and the tail pipe volume of displacing liquid 81, second plug 82, fluid displacing liquid volume 83, and driving fluid 84 occupy the positions shown in Fig. 7.

Introduction of driving fluid is continued until the pressure gauge 16 shows an abrupt rise in pressure indicating that plug 82 has landed upon plug 80 and closed port 36 (or port 122 if 32A is used). The abrupt pressure rise is the signal that the displacement from the tail pipe of the fluid to be spotted is complete and the introduction of driving fluid is thereupon stopped. The fluid so-spotted occupies the well hole as a fluid column 85 with its upper surface at a level 86, as shown in Fig. 8.

The tubing string assembly is then raised so that the lower end 78 of the tail pipe is above the level 86, as shown in Fig. 9. The packer 41 is then set against the well wall so as to prevent the liquid in the well hole from raising above the packer. After setting the packer, the pressure is raised upon the driving fluid so as to shear pins 34 (or pins 124 if 32A is used) and allow the plugs and liquids to descend in the tubing string and plug catcher, thereby causing the upper plug stop 33 (or plug stop 123 if 32A is used) to descend onto the lower stop 39 (or onto stop 127 of 32A and occupies position 123A). At the same time, plug 82 descends uncovering port 36 (or port 122 in 32A if used), thereby allowing the displacing liquid 81 to pass through port 36 into the by-pass 38 and thence through port 37 (or through port 122 and annular space 131 if 32A is used) and packer 41, and tail pipe 42 into the well. When the transfer of displacing fluid from the tubing to the well hole is completed plug 84 comes to rest on plug 82 and closes port 36 (or port 122 if 32A is used), thereby causing an abrupt increase in the pressure reading on gauge 16, the pressure increase being the signal indicating the completion of the spotting operation. In the completion of the spotting operation, the displacing liquid enters the well hole and displaces the fluid spotted therein into the wall 87 of the formation 63. Thereafter, pressure is maintained upon the driving fluid so as to prevent return flow until the fluid spotted in the formation has hardened. Afterward, the packer 41 may be unseated and the apparatus removed from the well. Any residual sealing fluid hardened in the well hole may be drilled out, if necessary, and the temporary filling material removed.

The modification of the apparatus, shown in Figs. 13–16, inclusive (or the alternate form shown in Fig. 21), provides means for keeping separate each of the several liquids involved in the spotting operation and producing pressure increases for signalling when the various fluids have passed the lower end of the tubing so as to indicate the completion of the various stages of the operation. These pressure signals enable the operator to properly manipulate the apparatus to perform an accurate spotting operation.

The operation of the apparatus of Figs. 13–16 is set forth herein as used in spotting a resin-forming cementing material through a perforated section of the casing of a well, although this modification of the apparatus may be used similarly in an uncased portion of a well and for spotting other fluid materials. In these operations, the alternate form 43A of the plug catcher may be used in similar manner as indicated in what follows. As shown, the bore constricting and ball seating element 46, plug catcher 43 (or 43A if the alternate form is used), retrievable retainer or packer 53, and tail pipe 54 are assembled on the lower end of the tubing string 8 and the assembly is lowered into the well until the end 88 of the tail pipe is adjacent to the bottom of the perforated section 89 of casing 2, the perforations being opposite the formation 90 to be treated. Before lowering the assembly, the portion of the well below the perforated section 89 may be filled with a temporary filling material to a level 91 just below the perforations 92.

After placing the tubing assembly in the well, the spotting operation may be carried out as

follows: A filling liquid may be introduced, if necessary, to ensure thre being liquid in the well in amount sufficient to fill the well to a depth substantially above the zone to be treated. In many instances, fluid produced by the well may be used by allowing the well to produce the required amount. A tubing plug of the type shown in Fig. 17 is introduced into the tubing string 8 followed by the required volume of cementing material (e. g. a liquid plastic or resin-forming liquid) for the work in view, such as an amount which will fill the casing to a depth equal to the thickness of formation 90. A second tubing plug, like the first, is introduced into the tubing string followed by a displacing liquid, such as oil or water, in amount about equal to the volume of the tail pipe 54. A third tubing plug, like the first, is introduced into the tubing string behind the displacing liquid and then a second quantity of displacing liquid having a volume about equal to the volume of cementing material to be displaced from the well casing through the perforations. As a fourth or last plug, one of the type shown in Fig. 18, is introduced into the tubing string behind the second displacing liquid, and this is followed by a driving fluid, such as water, delivered under suitable pressure through valve 15 as by a pump (not shown).

As the driving fluid is introduced into the tubing string, the various plugs and materials aforementioned descend in the tubing 8. When the first plug is about to be driven through the bore constricting and ball seating element 46, this fact is signalled by an increase in pressure which is shown on the pressure gauge 16. Sufficient additional pressure is then applied to force the first plug through the bore element 51 into the cylinder 98 (or the cylinder 133 if 43A is used) where it comes to rest on the tubing plug stop 45 (or plug stop 135 if 43A is used). As soon as the plug passes through the bore 51 in element 46, there is an abrupt decrease in the pressure on the driving fluid. Similar abrupt increases followed by abrupt decreases in pressure are obtained when any of the tubing plugs pass through the constricting bore 51 in element 46. When the first plug comes to rest on the plug stop in the plug catcher, the relative positions of the plugs and liquid materials are as shown in Fig. 13, wherein 97 designates the first plug, 98 the material to be spotted, 99 the second plug, 100 the tail plug volume of displacing liquid, 101 the third plug, 102 the casing volume of displacing fluid, 103 the fourth plug, and 104 the driving liquid. Similar relative positions of the fluids and plugs are held when the alternate form 43A of plug catcher is used. After the first plug 97 has passed below port 44 (or port 134 if 43A is used) and the introduction of driving fluid 104 is continued, the cementing material 98 passes through port 44, by-pass 93, and thence through port 94 (or the material passes through port 134 and the annular space 145 if 43A is used), packer 53, and the tail pipe 54 into the casing 2, reaching a level 105 (Fig. 14) when plug 99 enters the plug catcher and comes to rest upon plug 97. Just prior to the entry of plug 99 into the plug catcher, as plug 99 is forced through the bore 51 in constricting element 46, a pressure rise is obtained on gauge 16 as increased pressure is needed to force the plug through the bore constriction 51 and this is followed by an abrupt decrease in pressure as the downward movement of the plugs 101 and 103 still in the tubing string continues.

After plug 99 comes to rest upon plug 97, the tail pipe displacing fluid 100 is displaced from beneath plug 101 through port 44, by-pass 93, port 94 (or through port 134 and the annular space 145 if 43A is used), and thence through the packer 53 and tail pipe 54 into the well hole whereby the level of the cementing material therein is raised to a height, designated by 106, adjacent to the stop of the formation to be treated, and the tail pipe and appended passages are cleared of cementing material. Completion of this displacement is signalled by abrupt stoppage of flow of driving fluid as the third plug 101 enters the plug catcher and comes to rest upon plug 99, as shown in Fig. 15, and closes port 44 (or closes port 134 if 43A is used).

The abrupt cessation of flow of driving fluid occasioned by the closure of port 44 (or port 134 if 43A is used) is the signal that the tail pipe 54 is cleared of cementing material, which then occupies the well casing, and that the tubing string assembly is to be raised until the end 88 is above the level 106.

After raising the tubing assembly so that the lower end of the tail pipe is above the level 106, the retrievable retainer (packer) 53 is set so as to seal off the casing below the packer, thereby preventing fluid from rising above the packer and then the pump supplying driving fluid is called upon to increase the pressure to a point which will cause the shear pins supporting the upper plug stop 45 to shear (or the pins 135 of plug stop 135 if 43A is used). After shearing the plug stop pins, the introduction of driving fluid is continued, thereby causing the stop 45 (or stop 135 if 43A is used) to descend in the plug catcher with plugs 97 and 99 until the plug stop comes to rest upon stop 95 (Fig. 16) (or stop 139 of Fig. 21 if 43A is used). Coincidentally plug 101 moves downwardly in the plug catcher and uncovers port 44 (or port 134 if 43A is used).

As soon as port 44 (or port 134 if 43A is used) is opened by forcing plug 101 below the port 44 (or port 134 if 43A is used), the displacing fluid 104 passes from the tubing string through port 44 (or port 134), by-pass 93 (or annular space 145), and thence through port 94 (or annular space 145), the packer 53 and tail pipe 54 into the casing 2 and displaces the cementing material through perforations 92 into the voids in the formation behind the perforated section of casing. The displacement is complete when the ball closure 61 of the fourth plug 103 comes to rest upon the annular ring 50, thereby preventing further downward travel of driving fluid 104, as shown in Fig. 16, and causing an abrupt pressure rise on the gauge. At this stage, flow of driving fluid is stopped and pressure is maintained upon the driving fluid so as to prevent return flow of the cementing material while it is allowed to harden, thereby forming the cementing deposit 107 behind the perforated section of the casing 89.

After the cementing material has hardened, the pressure on the driving fluid is released, the packer 53 unseated, and the tubing assembly removed from the well. Thereafter, the temporary filling 91 below the perforations may be removed and the casing cleared, if necessary, of set cementing material.

Although the invention has been described particularly for use in spotting resin-forming liquids or plastic-sealing agents in a well, I do not wish to limit myself to the spotting of any particular material as it is apparent that the apparatus can

be employed for spotting any material with fluid characteristics, such as that of oil, cement slurries, and the various chemical solutions and fluid agents used in well treating, construction, and conditioning. It will be apparent also that the various embodiments of the plug catcher and its alternate forms may be used under some conditions without either a tail pipe or a packer, if desired. In addition, the apparatus of Figs. 1–6 (or its alternate form, Fig. 19) may be used with a packer, if desired, by including in the assembly of the plug catcher and tubing string a packer between the lower end of the plug catcher and the upper end of the tail pipe. The preferred assembly includes with the plug catcher a tail pipe connected with the bore of the same so that fluid which passes through the plug catcher by way of either the by-pass or bore of the catcher is delivered to the tail pipe and thence into the well.

It will be apparent, also, that it is not always necessary to raise the assembly of the tubing, plug catcher and tail pipe (with or without a packer) before displacing the agent from the well hole into the adjacent area. For instance when the treating agent used does not have a cementing action (as when an acidizing solution, paraffin solvent, etc. is used) the apparatus may be left in its original position in the well before the final displacing step. Again when the tail pipe is made of a material which is more easily rupturable than ordinary tubing (e. g. when the tail pipe is made of plastic tubing, or the like, as already described), the assembly need not be raised before displacing the agent used from the well hole even though the agent is a cementing fluid as in such cases the tail pipe can be pulled away from any cementing fluid which may set around it in the well.

Among the advantages of the invention are that a relatively small volume of a liquid-treating agent can be introduced into a deep well through a string of tubing and accurately located in the well as to the point of delivery; substantially all the liquid-treating agent introduced into the tubing string reaches the point of delivery; a definite signal is obtained which accurately informs the operator of the completion of the delivery of the fluid material into the well.

I claim:

1. A well treating apparatus for spotting a fluid material in a well for use with a string of well tubing and tubing plugs making a sliding sealing fit with the bore of a well tubing comprising a pair of tubular members arranged concentrically so as to provide an annular passageway lengthwise of the members; means joining their upper ends together so as to close the said annular passageway at its upper end, the inner one of the tubular members having a lateral port near its upper end communicating with the said annular passageway; a tubing plug stop in the inner tubular member opposite the lateral port so as to form a closure therefor, said tubing plug stop having a longitudinal bore extending therethrough, said longitudinal bore being smaller than that permitting the passage of a tubing plug; shearable means initially holding the said tubing plug in place, said tubing plug stop as in place closing the said lateral port; a stop means mounted in the inner tubular member a distance below the tubing plug stop equal to about 1.5 tubing plug lengths, said stop means having a longitudinal bore extending therethrough for the passage of fluid from above to below the stop means; and coupling means at the upper end of the inner tubular member for connection to the end of a tubing string.

2. A well treating apparatus for spotting a fluid material in a well for use with a string of well tubing and tubing plugs making a sliding sealing fit with the bore of the well tubing comprising a pair of tubular members arranged concentrically so as to provide an annular passageway lengthwise of the members, means joining their upper ends together so as to close the said annular passageway at its upper end, the inner one of the tubular members having a lateral port near its upper end communicating with the said annular passageway; a tubing plug stop in the inner tubular member below the lateral port a distance equal to about 1.5 tubing plug lengths, said tubing plug stop having a longitudinal bore extending therethrough, said longitudinal bore being smaller than that permitting the passage of a tubing plug; shearable means initially holding the said tubing plug stop in place, said tubing stop as in place closing the said lateral port; a stop means mounted in the inner tubular member a distance below the tubing plug stop equal to about 1 tubing plug length, said stop means having a longitudinal bore extending therethrough for the passage of fluid from above to below the stop means; and coupling means at the upper end of the inner tubular member for connection to the end of a tubing string.

3. A well treating apparatus for spotting a fluid material in a well for use with a string of well tubing and tubing plugs making a sliding sealing fit with the bore of a well tubing comprising a pair of tubular members arranged concentrically so as to provide an annular passageway lengthwise of the members; means joining their upper ends together so as to close the said annular passageway at its upper end, the inner one of the tubular members having a lateral port near its upper end communicating with the said annular passageway; a tubing plug stop in the inner tubular member below the lateral port a distance equal to about 2.5 tubing plug lengths, said tubing plug stop having a longitudinal bore extending therethrough, said longitudinal bore being smaller than that permitting the passage of a tubing plug; shearable means initially holding the said tubing plug stop in place, said tubing plug stop as in place closing the said lateral port; a stop means mounted in the inner tubular member a distance below the tubing plug stop equal to about 1 tubing plug length, said stop means having a longitudinal bore extending therethrough for passage of fluid from above to below the stop means; and coupling means at the upper end of the inner tubular member for connection to the end of a tubing string.

4. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passageway for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a tubing plug stop in the cylinder near the upper end thereof having an axial bore extending therethrough, said axial bore being smaller than that permitting the passage of a tubing plug; shearable holding means initially holding the tubing plug stop in place, said tubing plug stop as in place closing the said upper lateral port; and a lower stop

having a bore extending therethrough permitting the passage of fluid longitudinally through the cylinder mounted in the cylinder between the upper and lower lateral ports, said lower stop retaining the said tubing plug stop in the cylinder.

5. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passageway for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a slidable sleeve valve slidable within the cylinder adapted to close the upper lateral port while permitting the passage of fluid longitudinally through the cylinder; shearable holding means initially holding said sleeve valve in place, said sleeve valve as in place closing the said upper lateral port, said sleeve valve being adapted to arrest the downward movement of a tubing plug in the cylinder; a lower stop having an axial bore extending therethrough mounted in the cylinder between the upper and lower lateral ports so that the distance between the lower end of the sleeve valve and the upper end of the lower stop is about 1.5 times the length of a tubing plug adapted for use with the apparatus, said lower stop retaining the said tubing plug stop in the cylinder; and means for connecting the upper end of the cylinder to the lower end of a tubing string.

6. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passageway for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a tubing plug stop mounted in the cylinder below the upper lateral port, said tubing plug stop having an axial bore extending therethrough, said axial bore being smaller than that permitting the passage of a tubing plug; shearable holding means initially holding the tubing plug stop in place; and a lower stop having an axial bore extending therethrough to permit the passage of fluid longitudinally through the cylinder mounted in the cylinder between the upper and lower lateral ports so that the distance between the upper end of the lower stop and the lower end of the tubing plug stop is about 1 tubing plug length, the lower end of said tubing plug stop being adapted to rest upon the upper end of said lower stop after the holding means have been sheared allowing the tubing plug stop to descend in the cylinder.

7. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passageway for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a tubing plug stop mounted in the cylinder below the upper lateral port, said tubing plug stop having an axial bore extending therethrough, said axial bore being smaller than that permitting the passage of a tubing plug; shearable holding means initially holding the tubing plug stop in place, the distance between the upper lateral port and the top of the tubing plug stop being equal to about 1.5 times the length of a tubing plug adapted for use with the apparatus; a lower stop having an axial bore extending therethrough permitting the passage of fluid longitudinally through the cylinder mounted in the cylinder between the upper and lower lateral ports so that the distance between the bottom of the tubing plug stop and the top of the lower stop is equal to about the length of a tubing plug, the lower end of said tubing plug stop being adapted to rest upon the upper end of said lower stop after the holding means have been sheared allowing the plug stop to descend in the cylinder.

8. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passageway for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a tubing plug stop mounted in the cylinder between the upper and lower lateral ports, said tubing plug stop having an axial bore extending therethrough, said axial bore being smaller than that permitting the passage of a tubing plug; shearable holding means initially holding the tubing plug stop in place, the distance between the upper lateral port and the top of the tubing plug stop being about equal to 2.5 times the length of a tubing plug adapted for use with the apparatus; a lower stop having an axial bore extending therethrough to permit the passage of fluid longitudinally through the cylinder mounted in the cylinder between the lower and the upper lateral ports so that the distance between the upper end of the lower stop and the lower end of the tubing plug stop is about 1 tubing plug length, the lower end of said tubing plug stop being adapted to rest upon the upper end of said lower stop after the holding means have been sheared allowing the tubing plug stop to descend in the cylinder.

9. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passageway for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a tubing plug stop in the cylinder near the upper end thereof having an axial bore extending therethrough, said axial bore being smaller than that permitting the passage of a tubing plug; shearable holding means initially holding the tubing plug stop in place; and a lower stop having an axial bore extending therethrough to permit the passage of fluid longitudinally through the cylinder mounted in the cylinder between the upper and lower lateral ports, the lower end of said tubing plug stop being adapted to rest upon the upper end of said lower stop after the holding means have been sheared allowing the plug stop to descend in the cylinder; means for connecting the upper end of the cylinder to the lower end of a tubing string; and a tail pipe connected to the lower end of the cylinder adapted to conduct fluid passed through the cylinder into the well.

10. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passageway for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a slidable sleeve valve slidably

mounted within the cylinder adapted to close the upper lateral port while permitting the passage of fluid longitudinally through the cylinder; shearable holding means initially holding said sleeve valve in place, the said sleeve valve as in place closing the upper lateral port, said sleeve valve being adapted to arrest the downward movement of a tubing plug; a lower stop having an axial bore extending therethrough to permit the passage of fluid longitudinally through the cylinder mounted in the cylinder between the upper and lower lateral ports so that the distance between the lower end of the sleeve valve and the upper end of the lower stop is about 1.5 times the length of a tubing plug adapted for use with the apparatus, said lower stop retaining the said sleeve valve in the cylinder; means for connecting the upper end of the cylinder to the lower end of a tubing string; a packer on the lower end of the cylinder adapted to seal the annular space in the well; and a tail pipe on the lower end of the packer adapted to conduct fluid passed through the cylinder into the well.

11. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passageway for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a tubing plug stop mounted in the cylinder below the upper lateral port, said tubing plug stop having an axial bore extending therethrough, said axial bore being smaller than that permitting the passage of a tubing plug; shearable holding means initially holding the tubing plug stop in place; a lower stop having an axial bore extending therethrough to permit the passage of fluid longitudinally through the cylinder mounted in the cylinder between the upper and lower lateral ports so that the distance between the upper end of the lower stop and the lower end of the tubing plug stop is about 1 tubing plug length, the lower end of said tubing plug stop being adapted to rest upon the upper end of said lower stop after the holding means have been sheared allowing the tubing plug stop to descend in the cylinder; means for connecting the upper end of the cylinder to the lower end of a tubing string; and a tail pipe connected to the lower end of the cylinder adapted to conduct fluid passed through the cylinder into the well.

12. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passageway for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a tubing plug stop mounted in the cylinder between the upper and lower lateral ports, said tubing plug stop having an axial bore extending therethrough, said axial bore being smaller than that permitting the passage of a tubing plug; shearable holding means initially holding the tubing plug stop in place, the distance between the upper lateral port and the top of the tubing plug stop being about equal to 1.5 times the length of a tubing plug adapted for use with the apparatus; a lower stop having an axial bore extending therethrough to permit the passage of fluid longitudinally through the cylinder mounted in the cylinder between the upper and the lower lateral ports so that the distance from the bottom of the tubing plug stop to the top of the lower stop is about 1 tubing plug length, the lower end of said tubing plug stop being adapted to rest upon the upper end of said lower stop after the holding means have been sheared allowing the plug to descend in the cylinder; means for connecting the upper end of the cylinder to the lower end of a tubing string; and a tail pipe connected to the lower end of the cylinder adapted to conduct fluid passed through the cylinder into the well.

13. A well treating apparatus adapted for use with a string of well tubing and tubing plugs for spotting a fluid material in a well comprising the combination of a cylinder having a lateral port near the upper end and another near the lower end thereof; a passage for fluid exteriorly of and secured to the cylinder connecting the said lateral ports; a tubing plug stop mounted in the cylinder between the upper and lower lateral ports, said tubing plug stop having an axial bore extending therethrough, said axial bore being smaller than that permitting the passage of a tubing plug; shearable holding means initially holding the tubing plug stop in place, the distance between the upper lateral port and the top of the tubing plug stop being about equal to 2.5 times the length of a tubing plug adapted for use with the apparatus; a lower stop having an axial bore extending therethrough to permit the passage of fluid longitudinally through the cylinder mounted in the cylinder between the lower and the upper lateral ports so that the distance between the upper end of the lower stop and the lower end of the tubing plug stop is about 1 tubing plug length, the lower end of said tubing plug stop being adapted to rest upon the upper end of said lower stop after the holding means have been sheared allowing the tubing plug stop to descend in the cylinder; means for connecting the upper end of the cylinder to the lower end of a tubing string; and a tail pipe connected to the lower end of the cylinder adapted to conduct fluid passed through the cylinder into the well.

14. A well treating apparatus adapted to be connected to the lower end of a string of well tubing and used with tubing plugs making a sliding sealing fit in the bore of the tubing string for spotting a fluid material in a well comprising a tubular member having a cylindrical bore extending therethrough adapted to receive cylindrical tubing plugs which are adapted to block the passage of fluid longitudinally through the tubular member when arrested therein, said tubular member having a lateral port near its upper end; a lower stop member fixed in the lower end of the said tubular member, said lower stop member having a longitudinal passage for fluid extending therethrough; an upper stop member releasably secured in the said tubular member a distance above the lower stop member equal to at least one tubing plug length, said upper stop member having a shoulder on its upper end adapted to seat thereon a tubing plug and a longitudinal passage for fluid extending therethrough, said longitudinal passage of said upper stop member being blocked upon the seating of a tubing plug upon the said shoulder, the said lower stop member being adapted to prevent the expulsion of the upper stop member from the lower end of the said tubular member when released; and a fluid passageway means exteriorly of and secured to the tubular member communicating with said lateral port adapted to convey fluid from the said lateral port into the well below the said tubular member.

15. A well treating apparatus adapted to be connected to the lower end of a string of well tubing for spotting a fluid material in a well comprising a cylindrical plug-catching chamber having a longitudinal bore extending therethrough adapted to receive cylindrical tubing plugs which are adapted to block the passage of fluid longitudinally through the chamber when arrested therein, said chamber having a lateral port near its upper end; a slidable sleeve valve slidable within the chamber adapted to form a releaseable closure for the said lateral port, said sleeve valve having a shoulder on its upper end adapted to seat thereon a tubing plug, and said sleeve valve having a longitudinal passageway extending therethrough, said passageway being smaller than that permitting the passage of a tubing plug, said longitudinal bore of said slidable sleeve valve being blocked by a tubing plug seating upon said shoulder; means releaseably holding the said sleeve valve in the position closing said port, said means releasing its hold on the sleeve valve upon the application of a sufficient predetermined pressure through a tubing plug seating on the said shoulder; a stop means in the lower end of said chamber adapted to prevent the expulsion of the sleeve valve from the lower end of the chamber when released from the port-closing position; and a fluid passageway exteriorly of and secured to the plug-catching chamber communicating with the said lateral port adapted to convey fluid from the said lateral port into the well below the plug-catching chamber.

16. A device of the character described connectable to a tubular string through which a flexible plug may be pumped, including a tube attached to said tubular string for receiving said plug, a tubular chamber larger than said plug secured to said tube, said tube projecting into said chamber in spaced relation to the inner wall of said chamber, said tube having a passage through its wall opening into said chamber, and a seat in said tube adapted for engagement by the plug.

17. A device of the character described connectable to a tubular string through which a flexible plug may be pumped, including a tube attached to said tubular string for receiving said plug, a tubular chamber larger than said plug secured to said tube, said tube projecting into said chamber in spaced relation to the inner wall of said chamber, said tube having a passage through its wall opening into said chamber.

JAMES D. HAYNES.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,791,874	Rodgers	Feb. 10, 1931
1,882,099	Trouth	Oct. 11, 1932
2,004,606	Halliburton	June 11, 1935
2,087,297	Pew	July 20, 1937
2,191,750	Brown	Feb. 27, 1940
2,310,483	Wickersham	Feb. 9, 1943